SOME OBSERVATIONS ON THE DISTRIBUTION OF CANCER IN THE SEVERN VALLEY.

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While research on the immediate cause of cancer is being pursued with tireless zeal by many earnest investigators it seems that there is still some work to be done on the nature of what may be termed the secondary or accessory causes, those external or environmental factors or conditions which predispose to, or favour the onset of the disease in the presence of the determining cause, whether this be chronic irritation of some kind superadded to an inborn tendency and special susceptibility in the patient or the activity of some micro-organism. These secondary causes, while admittedly less important than the other, are also of considerable interest as an increase of knowledge in regard to them may afford some explanation of the well-recognised inequality in the incidence of the disease in different districts and may aid ultimately in elucidating the problem of the actual causation of the disease, the more so as there appears to be more than a suggestion in evidence produced that there need not necessarily be only one specific cause.

The work of Haviland (1892), on the geographical distribution of disease in Great Britain in which he devotes special attention to the incidence and causes of varying prevalence of cancer in the Lake District, in the Thames Valley, and in England and Wales generally seems to indicate that these secondary causes are not without significance and to suggest the desirability of ascertaining if a similar peculiarity in distribution occurs in other districts in Great Britain, whether the causes he advanced to explain this distribution in the Lake District and Thames Valley prevail in the former as well and also whether the incidence of the disease can be shown to have an association with any environmental factors other than those considered by him.

The region selected as most suitable for the investigation is what may be generally described as the Valley of the Severn. By this term is indicated the region traversed or drained by the Severn itself as well as that in relation to its tributaries, the Avon, the Teme, the Wye, the Usk and Bristol Avon, and includes the counties of Somerset, Gloucester, Worcester, Shropshire, Hereford, Monmouth, Glamorgan, Brecknock, Radnor, Montgomery and parts of Wiltshire, Warwickshire, Leicestershire, Staffordshire and Carmarthenshire. This region seemed to be sufficiently extensive for the purpose of investigation and presented such considerable diversity in natural and economic features as to render it singularly suitable for an attempt to determine whether any

relationship obtained between excessive incidence of the disease in its several areas and the variations in the environmental factors therein.

The data relating to cancer for such an investigation are somewhat limited and at the present time are practically restricted to the death returns published by the Registrar-General for the registration counties, registration districts and county boroughs. Records of hospital cases, the only other possible source of data, are not available and, moreover, they would be unsuitable as they are records of selected cases which it would be impossible to bring into appropriate relation with the population from which they are derived or with the environment to which they have been subject. The death-rates which are used in the investigation are based on the mortality returns for the registration districts and it seems necessary to make some reference to the reliability of these returns. It must be admitted and is to be expected that they contain inaccuracies. Unequal skill in diagnosis and varying accuracy in certification or completeness of registration are known to have had a considerable influence in producing the divergencies in the recorded death-rates from cancer found in different countries at similar times, notably that shown in Ireland on the one hand and England and Wales on the other. The same factors are known to have been responsible in a large measure for the apparent increase in the recorded death-rate from cancer in recent years. Though there is now considerable evidence for the view that an actual increase in the prevalence of the disease has occurred this is not yet admitted by some authorities and it is certainly not so extensive as is frequently asserted or popularly believed. The relatively large number of deaths that can be traced as being due to cancer, in addition to those actually recorded as such by the medical department of the Registrar-General through the institution of direct inquiries to the certifying medical practitioners in cases where the cause of death is obscurely or incompletely stated, shows what great possibilities there are of more accurate certification leading to an increase in the recorded rates, while Bashford (1906), from a comparison of hospital statistics showing the clinical diagnosis and that at subsequent operation or pathological examination, has furnished evidence that, even under the most favourable conditions for obtaining a correct diagnosis, a very definite proportion of malignant tumours in inaccessible situations may be clinically unrecognizable as cancer. It is thus possible, indeed probable, that varying skill and care in diagnosis and varying accuracy in certification may have had some influence in exaggerating or diminishing the differences in the number of cases of cancer recorded in the several districts of the region under investigation and that this disturbance may be more evident in rural than in urban districts. The data, however, cover the same period and should on the whole be similarly affected by improvements in diagnosis or certification with the progress of time. While these factors might be very important if one desired to determine the absolute incidence of cancer in any special district they are less important in an investigation such as this where an approximate measure of the relative

incidence of cancer in closely related districts is all that is necessary. In such an area it may be assumed that the above-named factors, while their possible existence cannot be disputed, will influence more or less similarly all the component districts; at least there is no evidence that medical skill and methods were less efficient 10 or 20 years ago in South Wales and Somerset than in the rest of Wales. On the whole it may be accepted, from the wide range in value shown, that the rates are, to a significant extent, expressive of real differences in the relative mortalities in the several districts and they are *utilised as, in spite of possible imperfections, they are the only data for cancer* available.

Much of the difficulty in dealing with and interpreting death-returns from different places in former times has been due to the absence of a really reliable criterion of comparison, and it has become obvious that the ordinary death-rates recorded in different places can not be made the basis for the deduction of any reliable conclusions regarding the incidence of the disease in these as they are influenced by certain factors for which no allowance is made. While due allowance for the age and sex constitution of the population in different areas—extremely important factors in the case of cancer investigation—can be made by the calculation of a standardised or corrected death-rate for each sex—the age distribution in the population of England and Wales being the standard usually selected, although King and Newsholme (1893), in their inquiry into the alleged increase of cancer, used a life table population for England and Wales, in the present investigation another criterion of the mortality from the disease has been utilised. This is the life table death-rate from the disease at a certain age—the death-rate of the whole population above that age as obtained from a life table population constructed for each district. The amount of work entailed in calculating the necessary life tables for many districts has rendered this method of comparison impracticable hitherto but the description by Brownlee (1921) of a relatively accurate, easy, and rapid method of calculating those necessary to enable the corresponding life table rates to be estimated has made it readily available.

The region to be investigated, the basin of the Severn, as described above, comprises 107 registration districts and for each of these the numbers of deaths from cancer in age groups from 15 years and upwards for the two sexes separately for the decennial period, 1901–10, were extracted from the supplement to the 75th annual report of the Registrar-General. The deaths from all causes in the same age groups and the mean populations at the different ages for the corresponding period were obtained from the same source. These deaths from cancer are to be regarded as including all forms of malignant new growth without distinction of variety or site and were chosen because it was desirable to have as large numbers as possible and because the figures for special sites were not readily available. Moreover, since Bashford and Murray (1905), the investigators under the Imperial Cancer Research Fund, have come to the conclusion that sarcomata and carcinomata are but manifesta-

tions in different tissues of essentially similar processes, and that sarcoma increases in frequency as life advances in a manner exactly parallel to that long recognized as characteristic of carcinoma, there seemed to be no adequate reason for differentiation of these two types.

Before the figures for the different districts, thus extracted, could be utilised, it was necessary to make certain corrections in the recorded deaths. The mortality returns relate to the decennium, 1901–10, and it was only in 1911 that the Registrar-General began to relegate deaths occurring in hospitals or other institutions in any district to the districts to which the cases really belonged. This procedure is especially necessary in the case of deaths from malignant disease since so many cases go into hospitals in towns or urban districts from adjacent or country districts to be operated on, with a resultant apparent higher death-rate in the former. Through the courtesy of the department of the Registrar-General, permission was obtained to extract from the records full particulars of all cases of death from malignant disease for the 10 years, 1901–10, in all hospitals within the districts to be investigated and in adjacent districts which did not belong to, or were not permanent residents in the districts in which the hospitals were situated. These deaths were carefully distributed to the districts to which they belonged, the necessary deductions being made in the returns from districts with hospitals.

As some of the registration districts were comparatively small in area with relatively small populations and few deaths from cancer and as it was desired to avoid unnecessary labour in constructing life tables without impairing the value of the data it was decided to reduce the number of areas to be compared by associating some of the registration districts together in groups. The basis on which this grouping was made was height above sea level, as varying elevation above sea level has been frequently alleged to have some relation to varying mortality from the disease. The grouping was done in the following way. The outlines of the registration districts in the registration counties shown in the special maps published by the Ordnance Survey were superimposed on the corresponding counties in the maps by Gross for the same regions drawn to the same scale and showing the physical features. In this manner it was possible from the different coloured areas on the latter maps corresponding to a colour index of height to form an approximate opinion as to the height above sea level of the several registration districts and, with the aid of the census figures in doubtful cases, to estimate approximately the elevation at which the majority of the people in each lived. By associating together in certain cases, registration districts which were adjacent to one another and which appeared to present a similar elevation, the original 107 registration districts comprising the area were reduced to 40 groups. Many of the districts in the Welsh counties which presented very irregular features and which it seemed difficult to associate in regard to height with adjacent districts were taken separately. The data for the several districts were now associated together in correspondence with this grouping of registration dis-

tricts and summed so that there were 40 groups of districts showing in each group for the separate sexes *the corrected number of deaths from cancer.* the deaths from all causes and the mean populations at different age groups from 15 years and upwards for the decennial period, 1901–10. From the data thus described two life tables one for males and one for females from age 15 years and upwards were constructed for each of the 40 groups of registration districts—making 80 tables in all—in the manner described by Brownlee. The cancer deaths at the different ages in the several districts were applied to the life table or stationary populations calculated for the corresponding districts and the life table death-rate from cancer at age 15 years for each sex was thus calculated for each district group. This death-rate, the life table death-rate, as has been shown by the above named author is apparently the best criterion of comparison of the mortality from cancer available, and will be mainly used in the present investigation as an index of the actual mortality from, as well as the prevalence of, cancer in the different districts. From the same data, however, the standardised death-rates based on a standard population in arithmetical progression have been calculated for the purposes of comparison. There is still another index of the relative mortality from cancer in the several districts which may be derived from the life tables calculated for these. This is the number in each district, out of any number, say 10,000, who attain the age of 15 years, destined to die of cancer, and is obtained from the ratio found by dividing the life table death-rate for cancer at age 15 in each district by that of the life table death-rate at age 15 years from all causes in the corresponding districts. These figures have been calculated and are shown in Table I in association with the life table death-rates and the standardised death-rates for the several district groups.

The life table death-rates for cancer at age 15 amongst males in the several districts showed a range in value from 0·97 to 1·86 with a coefficient of variation of 15 per cent., and for females a range from 1·46 to 2·46 with a coefficient of variation of 11 per cent. With such a range of values for each sex it seemed possible that some association might be discovered between the incidence of cancer and environmental factors in the different district groups. A brief inspection of the death-rates for males and females shows that there is a general relationship between the variations exhibited in those for the two sexes in the different districts. Where the life table death-rate for males is above the average, as a rule, although there are districts that are exceptional, the female death-rate is also high. This is shown more precisely by the correlation found to exist between the rates for the two sexes, the coefficient being + 0·596 suggesting that, on the whole, excessive incidence is determined in the two sexes by similar factors.

The principal external or environmental factors which have been suggested by others or seemed to suggest themselves by the peculiarity of distribution of cancer shown in the different districts of the area under investigation as possibly having some influence as predisposing causes of the disease are the

Table I.

Groups of Registration Districts	Average elevation above sea level	Males: Life table death-rate from cancer at age 15	Males: Standardized death-rate from cancer at age 15 years and upwards	Males: Number out of 10,000 in district who attain age 15 destined to die of cancer	Females: Life table death-rate from cancer at age 15	Females: Standardized death-rate from cancer at age 15 years and upwards	Females: Number o of 10,000 in distric who attai age 15 de tined to d of cance
1. Williton, Bridgwater, Axbridge, Long Ashton, Wells, Langport, Taunton	0–100	1·6097	1·0562	786	1·8368	1·1376	960
2. Wellington, Chard, Yeovil	100–200	1·5532	·9954	790	1·8887	1·1486	1005
3. Wincanton, Shepton Mallet, Frome, Clutton, Mere, Warminster	250–500	1·5414	·9485	788	1·9386	1·1261	1035
4. Bath, Keynsham	0–100	1·8509	1·2061	907	2·2020	1·3686	1157
5. Westbury, Melksham, Bradford on Avon	100–250	1·6560	·9885	853	2·2122	1·3330	1174
6. Devizes, Calne, Chippenham, Malmesbury	100–250	1·6771	1·0395	839	1·9691	1·2357	1006
7. Bristol, Barton Regis, Thornbury	0–100	1·7293	1·2148	818	2·0900	1·3728	1053
8. Gloucester, Wheatenhurst, Tewkesbury, Newent ...	0–100	1·5943	1·1384	750	2·0653	1·3472	1042
9. Chipping Sodbury, Tetbury, Dursley, Stroud ...	100–250	1·5867	·9663	796	1·9756	1·1441	1053
10. Alcester, Stratford-on-Avon, Shipston on Stour, Evesham, Warwick	100–250	1·5619	1·0330	767	2·1118	1·2685	1099
11. Coventry	250–500	1·7029	1·1572	822	1·9732	1·3415	994
12. Cheltenham, Winchcombe	100–250	1·8598	1·2176	917	2·1620	1·2949	1143
13. Foleshill, Rugby, Southam, Lutterworth	250–500	1·5955	·9699	820	2·2375	1·3427	1174
14. Worcester, Droitwich, Upton on Severn, Pershore ...	0–100	1·4381	·9800	689	2·3211	1·4446	1182
15. Bromsgrove, Kings Norton, Stourbridge, Dudley, Solihull	250–500	1·5815	1·0550	776	2·0762	1·3423	1067
16. Wolverhampton, Shifnal	250–500	1·3773	1·0102	648	1·8811	1·3266	934
17. Kidderminster, Martley, Tenbury	100–250	1·6638	1·0964	816	2·1836	1·4056	1133
18. Cleobury Mortimer, Church Stretton, Ludlow ...	250–500	1·6119	·9360	835	2·1062	1·3272	1119
19. Bridgnorth, Madeley	250–500	1·4831	·9600	733	2·4579	1·5222	1277
20. Market Drayton, Wem.	250–500	1·7218	1·0548	883	2·1355	1·2767	1142
21. Atcham, Wellington, Newport	100–250	1·5473	1·0774	737	2·2318	1·4564	1112
22. Ellesmere, Oswestry	300–400	1·6779	1·0883	828	2·2061	1·4438	1133
23. Hereford, Ledbury, Ross	100–200	1·5836	1·0685	770	2·1020	1·3027	1087
24. Bromyard, Kington, Weobley, Leominster	200–300	1·5296	·9098	771	1·9106	1·1838	1008
25. Westbury on Severn, Chepstow	200–300	1·5499	·9989	771	1·7180	1·1536	886
26. Newport	0–100	1·3976	·9333	673	2·0411	1·4920	1000
27. Pontypool	500–600	1·0158	·6732	500	1·8053	1·2131	898
28. Abergavenny	100–200	·9669	·7456	432	1·4649	1·1457	666
29. Monmouth	600–700	1·4308	·8624	707	1·7633	1·2268	850
30. Cardiff	0–100	1·5169	1·1524	705	1·9442	1·4389	936
31. Pontypridd	500–600	1·1552	·8635	540	1·6801	1·2831	815
32. Bedwellty, Merthyr Tydfil, Crickhowell	700–800	1·1223	·8509	510	1·6899	1·3187	778
33. Bridgend	400–500	1·0812	·8095	489	1·6338	1·2420	744
34. Neath, Pontardawe	0–100	1·1738	·8327	560	1·6492	1·1919	808
35. Swansea, Gower	100–200	1·7201	1·2608	793	1·8493	1·3192	900
36. Llanelly	0–100	1·2667	·8944	616	1·9353	1·3570	954
37. Brecknock, Hay, Builth, Rhayader	400–500	1·8090	1·3523	881	2·2250	1·4507	1101
38. Knighton, Clun	500–600	1·7296	·9761	870	2·1932	1·2316	1138
39. Newtown...	300–400	1·3919	·9027	687	2·2666	1·5447	1131
40. Forden, Llanfyllin	200–300	1·4969	·9822	741	1·8764	1·1964	948

following: (*a*) elevation of the district above sea-level; (*b*) nature of soil and underlying geological formation of the district; (*c*) presence, intensity, or absence of industrial activity in region; and (*d*) occupation of inhabitants in district, and discussion will be devoted mainly to these.

The life table death-rates for cancer at age 15 for the two sexes separately in the 40 groups were first correlated with the height or elevation above sea-level of the several areas—the basis on which the registration districts were originally grouped—and the coefficients found were $-0{\cdot}267 \pm {\cdot}099$ and $-0{\cdot}179 \pm {\cdot}103$ respectively for males and females. These coefficients while both negative in sign and suggesting on this account that cancer is more prevalent in low-lying districts, a view that has already gained considerable popular support, cannot, however, be regarded without question as significant in value in view of the magnitude of their probable errors. Neither value is greater than three times its probable error. If the values of the coefficients may be considered of sufficient magnitude to warrant the suggestion that there appears to be a tendency for higher altitudes to be associated with diminishing incidence of cancer and conversely, no conclusion more definite than this can be formulated from the data for the region under investigation although, in regard to this conclusion, it should be borne in mind that the real influence of elevation may be obscured by other and perhaps more potent factors having an influence in producing variations in the cancer death-rate. It is well known, however, that excessive incidence of cancer is occasionally a feature of low-lying districts notably those extending inland from the Fen region of the east coast of England and also of those in the valley of the Thames. It has also been pointed out by Haviland (1892), that the low-lying areas in the Lake District show a mortality from the disease which is decidedly in excess of that found in the more elevated areas in that region and a similar association between excessive incidence of cancer and low-lying areas has been described for some districts on the Continent. The special factors that have been suggested as possibly influential in producing this relative excess of the disease in low-lying areas will be discussed later after reference has been made to the geological features of the region under investigation.

An approximate estimate of the predominant geological formation in the several districts of the Severn Valley was made by superimposing the maps published by the Geological Survey of England and Wales showing the geological features on the maps drawn to the same scale showing the registration counties and districts. Unfortunately geological maps on the same scale for the deeper formations, the "solid" edition, are alone available for the region under consideration, "drift" maps not having yet been published except on a larger scale for a few areas in South Wales. In the main, however, the bed below gives its character both chemical and physical to the soil and the ordinary rough classification of soils into sands, clays, etc., follows closely the nature of the underlying geological stratum. This will be the more likely in some of the districts under investigation as they lie at a comparatively high

level. In the case of many of the districts, however, the information derived from the maps has been supplemented by details derived from local reports on their geology which will make it possible to give due consideration to the probable presence and nature of "drift" strata that may exist in the less elevated regions.

In reviewing the distribution of varying mortality from cancer in the several districts in its relation to the predominant geological formation in these, the life table death-rate for the female sex at age 15 is taken as the criterion of comparison in order that the findings may be more truly comparable with those obtained by Haviland in his analysis of the distribution of cancer in the Lake District. The latter chose the death-rate amongst females mainly because it was higher than that among males. As has already been mentioned the distribution of areas showing excessive or defective incidence in cancer mortality in the Severn Valley for the two sexes shows a general similarity but there are some appreciable differences to which reference will be made later. Haviland's principal conclusions based on his data for the Lake District and stated to be corroborated by the data for other districts were that the groups of high mortality districts were coincident with low-lying areas either traversed by or contiguous to fully formed rivers that seasonally flood the tertiary, post tertiary and alluvial land adjacent while the districts with the lowest mortality had a high average level, were situated on or near the water partings where rivers derived their sources and where the rock base under their soils consisted of the older geological formations such as the Cambrian, Silurian, old red sandstone, and mountain limestone or of the more recent chalk and where floods were impossible or temporary. The distribution of the several districts in the Severn Valley showing extreme values in the life table death-rates for females seems on the whole to afford little or at most equivocal evidence in support of such conclusions being applicable to this region. The relatively low correlation already shown to exist between the death-rate for females and elevation above sea-level seemed to oppose them. It must be admitted that the highest rates found in the Severn Valley occur in one group including the registration districts of Bridgnorth and Madeley, both of which are traversed by the Severn, and another group including the registration districts of Worcester, Droitwich, Upton on Severn and Pershore also traversed by the Severn and in part by its large tributary the Avon and in close proximity to, though not containing, the junction of the two rivers, an area which will probably be the site of floods, but the adjacent group of districts in which the river junction actually occurs, which is low-lying, traversed midway by the Severn and nearer the mouth of the river, does not show an excessive death-rate from the disease. The groups of districts lying still nearer the mouth of the river and those abutting on its estuary and on the upper part of the Bristol Channel, which are also in general low-lying, show a death-rate either below or in the vicinity of the mean value. The remaining groups of districts showing a death-rate in excess of the mean of the rates for all the

districts are distributed around the upper parts of the Severn, its tributaries, the Avon, the Teme, the Wye and the Usk and the upper part of the Bristol Avon, though the majority of these districts except those related to the last named river are moderately elevated. None of the districts containing the mouths and lower parts of the courses of the last three rivers shows an excessive death-rate, the values being either below or in the neighbourhood of the mean.

The distribution of districts with a relatively low mortality, *i.e.* in defect of the mean, is peculiar in that it is with two exceptions confined to the districts in South Wales and Monmouth on the one hand and those in the county of Somerset on the other, that is in the two regions abutting on the estuary of the Severn and the upper part of the Bristol Channel. The areas with low mortality that are found in addition to these two regions are the group comprising Wolverhampton and Shifnal and that comprising Forden and Llanfyllin, the latter high-lying and near the source of the Severn. The uniformity in the prevalence of a low rate of mortality from cancer in the districts of South Wales and Monmouth is the striking feature and at once arrests the attention when a map showing the areas with different rates of mortality in different colours is examined.

The geological strata underlying the districts with the lowest rates of mortality are mainly the upper carboniferous or coal measures and the old red sandstone, the latter being the predominant formation in Abergavenny, the registration district which shows the lowest mortality rate of all and in the registration districts of Monmouth and Pontypool although the latter shows also the Silurian and carboniferous strata. The former or upper carboniferous formation comprising sandstone and shales bearing the coal seams is extensively found in the following district groups, Pontypridd, Bedwellty and Merthyr Tydfil, Neath and Pontardawe, Swansea and Gower, and Bridgend. On the other hand, the district group comprising Forden and Llanfyllin which is near the source of the Severn and, as has been mentioned, also shows a relatively small mortality rests on the Silurian formation, but that this stratum and the old red sandstone, though in many cases high-lying, are not invariably associated with a relatively low death-rate from the disease is shown by the high mortality rates obtaining in the groups comprising Brecknock, Hay, Builth and Rhayader, and Knighton and Clun both resting on the Silurian and old red sandstone, Newtown resting on the Silurian; Cleobury Mortimer, Church Stretton and Ludlow on old red sandstone and Silurian, and Hereford, Ledbury and Ross on old red sandstone. The districts just described as having an excessive death-rate from cancer, though based on the older formations—old red sandstone and Silurian—and lying at a high elevation also contain the source and the upper part of the course of many large rivers including the Usk, the Wye, the Teme and the Severn itself. This indicates that the relationship, if any, that exists between excessive cancer mortality and geological formation in this region is more complex than appears

from Haviland's findings in his investigation into the incidence of the disease in the Lake District and that high and low death-rates from the disease are not invariably associated with any particular geological formation.

The distribution of districts with high and low life table death-rates for males presents, as described above, a general resemblance to that described for females. The relatively low death-rates are still mainly localised in the districts of South Wales, and the principal differences from the distribution of the disease for the female sex that are seen consist in an extension of the central area occupied by districts that have mortality rates in the vicinity of the mean with a relative fall in the mortality rates in the districts adjacent to the Avon and a relative rise in the rates found in the registration districts in Somersetshire and the adjacent parts of Gloucestershire and Wiltshire. The rates for the group including Worcester, Droitwich, Upton on Severn and Pershore and that including Bridgnorth and Madeley which show the highest mortality rates for females have, for males, rates in the neighbourhood of the mean. While the relatively high death-rate for males found in low-lying districts as those of Somersetshire may appear contradictory, the distribution of the varying death-rate amongst males in the several districts on the whole seems to supply further evidence in support of the view expressed above that the reasons assigned by Haviland to explain the varying prevalence of the disease in the different areas of the Lake District do not suffice to explain adequately the varying prevalence in the Valley of the Severn. In this connection it may be mentioned that Butlin (1885) has drawn attention to the infrequency of cancer in certain well-watered districts and the occurrence of areas of low mortality along the course of rivers which appear to predispose to cancer and the immense difference in incidence that may be observed on the opposite banks of certain rivers, while Hirsch (1886) has pointed out that the data for Norway and also for Mexico provide evidence opposed to Haviland's generalisations.

The relationship shown between the incidence of excessive mortality from cancer and industrial activity as shown in the several districts of the Severn Valley is of considerable interest. It has been suggested by Maynard (1909) and others that the increased prevalence of cancer in recent years is primarily associated with the increased stress and strain of modern life, "the pressure of modern civilisation and the strain of modern competition or some factor allied to these," as Maynard expresses it, while others including Collis and Greenwood (1921) have furnished evidence in favour of the view that where industrialism is more pronounced the cancer death-rate is excessive. It is possible to sub-divide fairly accurately, by reference to a map of England and Wales showing industrial areas, the registration districts in the river valley under investigation into two groups, (*a*) those in principal industrial regions; (*b*) all others. The first class comprises 19 groups of districts and includes many of those in South Wales. The list is shown in Table II. It will be readily seen that as judged by the life table death-rate amongst males—

the sex more closely associated with industrial activity—excessive incidence of cancer is not invariably or even as a rule associated with the industrial regions but rather the reverse. With a few exceptions the life table death-rate for cancer in the districts in industrial areas is below the average of the death-rates for all districts. Thus, while the mean value of the life table death-rates for cancer at age 15 years for males for all the groups of districts investigated is 1·52, and for the non-industrial districts 1·60, the mean value of the ratio in the districts adjudged industrial is 1·42 and the mean value for the districts in the industrial area of South Wales is only 1·24. This would appear to indicate that, so far as the data available for the districts under investigation may

Table II.

Principal Industrial Districts	Males: Life table death-rate from cancer at age 15	Females: Life table death-rate from cancer at age 15
Cardiff	1·5169	1·9442
Newport	1·3976	2·0411
Pontypool	1·0158	1·8053
Pontypridd	1·1552	1·6801
Abergavenny	·9669	1·4649
Bridgend	1·0812	1·6338
Neath and Pontardawe	1·1738	1·6492
Swansea	1·7201	1·8493
Llanelly	1·2667	1·9353
Merthyr Tydfil, Bedwellty, Crickhowell	1·1223	1·6899
Atcham, Wellington, Newport	1·5473	2·2318
Kidderminster	1·6638	2·1836
Bristol	1·7293	2·0900
Bath, Keynsham	1·8509	2·2020
Coventry	1·7029	1·9732
Wolverhampton	1·3773	1·8811
Dudley, Stourbridge, Bromsgrove, Solihull ...	1·5815	2·0762
Gloucester, etc.	1·5943	2·0653
Stroud, Dursley, etc.	1·5867	1·9756
Mean of life table death-rates for all districts (40)...	1·5150	2·0050
Mean of life table death-rates for non-industrial districts (21)	1·5956	2·0780
Mean of life table death-rates for industrial districts (19)...	1·4237	1·9143
Mean of life table death-rates for industrial districts in South Wales (10)	1·2417	1·7693

be accepted as reliable for calculating an index, pronounced industrialism has no definite nor consistent relationship to the incidence of an excessive death-rate from cancer. It may be noted that the life table death-rates for cancer found for districts containing large towns, although there are notable exceptions, are in a number of cases above the average. This is shown especially in Bristol, Bath, Coventry, Cheltenham and Swansea. In this connection it should be mentioned that it has been found by Brownlee (1921) that the life table death-rates at age 15 for cancer calculated for the three divisions, county boroughs, urban districts and rural districts of all England and Wales for the period 1911–14 are practically identical.

It now remains to discuss very briefly the last of the environmental factors put down for consideration, namely occupation. One of the most striking features in the distribution of the disease, as has been mentioned, is the concentration of the relatively low death-rates from cancer in the districts of South Wales and it may be suggested that this diminished incidence has some association with the predominant occupation of the people in that region, namely coal mining. Cancer appears to be less prevalent in coal miners as a class than in people engaged in many other occupations, as is shown by the comparative mortality figures for occupational groups published by the Registrar-General for the period 1900–2. While the comparative mortality figure for all occupied males was 63 and for all occupied males in industrial districts 68, the figure for coal miners in all parts of England and Wales was 51, and that for the coal miner in South Wales and Monmouth only 46. That this circumstance can have much influence in determining the peculiar incidence of the disease seems to be negatived by the fact that the relatively low death-rates for females are also mainly found in the same districts in the region.

Though the investigation has not been very productive in striking positive results it has at least shed further light on the peculiar incidence of cancer as determined by a really reliable criterion of comparison of the only data that are available, defective though they may be, for the districts of a fairly extensive region of England and Wales and seems to suggest the need for modification of some of Haviland's generalisations on the alleged causes of unequal prevalence of cancer in different districts and the desirability of local and more detailed research in the districts where very high or very low death-rates have been found to prevail. It appears permissible to draw the following conclusions:

1. That the variations shown in the life table death-rates for the several districts in the Severn Valley indicate to a significant extent real differences in incidence of cancer and are not to be ascribed as wholly due to varying skill in diagnosis or accuracy of certification in these areas.

2. That while the correlation found to exist between the life table death-rate for cancer amongst males and elevation above sea-level in the several districts would appear to suggest a tendency for increased incidence of cancer to be associated with diminution of elevation in the region investigated, it is only a tendency and insufficient to permit the deduction that cancer exhibits a special preference for low-lying areas.

3. That a low mortality from cancer in the Severn Valley is not invariably or even generally found in districts resting on the older geological formations, Silurian and old red sandstone, though these may be high-lying and closely related to the sources and upper parts of the courses of rivers, nor a high mortality necessarily coincident with areas adjacent to a large river though they may have a clayey soil, be low-lying and presumably subject to inundations.

4. That while the death-rates are undoubtedly high in certain districts containing large towns the average of the rates for the industrial districts is below that of all the districts and that of the non-industrial districts in the area investigated. This is principally due to the relatively low rates in the districts in South Wales and would appear to indicate that the relationship between excessive incidence of cancer and pronounced industrialism is not so direct nor so specific as has been recently suggested.

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