SCOTTISH CANCER MORTALITY: A COMPARISON OF URBAN AND RURAL RATES FOR VARIOUS TUMOUR LOCATIONS, 1931–7, AND A SURVEY OF RECENT TRENDS

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(With 4 Figures in the Text)

Introduction

It is a well-known fact that in rural areas the mortality rate from cancer, as from many other causes of death, is appreciably below that in the urban areas. Thus, in the *Supplement to the Seventy-eighth Annual Report of the Registrar-General for Scotland*, published in 1936, it is shown that for the period 1921–30 the cancer mortality rates, adjusted for age and sex, for the landward areas, the small burghs, and the large burghs, were respectively 1200, 1330, and 1480 per million. The large burghs show an excess of about 23% over the landward areas. It has been suggested that the urban excess may in large measure be due to more accurate certification of deaths, and it is a matter of interest to obtain some idea as to how far this factor accounts for the observed excess and how far there may be a real excess of deaths due to cancer in the more urban and industrialized areas.

In 1893 King & Newsholme suggested that differences in cancer mortality depending on inaccuracies of certification might be brought to light by analysing the available data in respect of the various sites of the malignant growth. Certain sites, such as the breast or the buccal cavity, are relatively accessible, and diagnostic error is likely to be small. Other sites, such as the digestive tract, are more difficult to diagnose, and so it might be expected that for these sites the number of cancers reported as causes of death would vary with the accuracy of certification. King & Newsholme applied the method in order to try to ascertain whether the apparent increase in cancer as a recorded cause of death might not be due to better diagnosis, but, if the method is valid, it can obviously be applied to differences such as we are concerned with here, namely, those between urban and rural areas. If these differences are due to more accurate certification in urban areas, then it would be expected that they would be most pronounced in inaccessible, and least in accessible sites.

This method has already been applied by Russell (1931) to the cancer deaths in Scotland over the years from 1923 to 1928 inclusive. In this work,

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however, the analysis was carried out by whole counties, including large burghs, small burghs, and landward areas. No attempt was made to separate the more rural and more urban districts of each county, presumably because the reports of the Registrar-General for Scotland for this period do not contain the necessary data. The conclusions reached by Russell may be quoted from his summary:

"The counties possessing the best equipped hospitals have a greater amount of inaccessible cancer than might be expected to occur.... As regards the two accessible sites—breast and buccal cavity—there is no defined localization in the mortality, as the number of deaths in each county, with possibly two exceptions, Renfrew for breast cancer, Midlothian for buccal cavity, approximately follow a normal distribution."

These conclusions are in marked contrast to those reached by the Registrar-General for England and Wales in his Decennial Supplement, 1921. In this comprehensive investigation of the medical statistics for the period 1911–20 a section deals with the cancer deaths in relation to both site of tumour and geographical distribution. Among the conclusions are the following (Part III, p. cxix): "...it can scarcely be doubted that the city excess for cancers so little likely to be overlooked at the time of death as those of the buccal cavity (43% tongue and 26% jaw in 1911–20, lip 'mouth' and tonsil furnishing the rest) is a real one, and not merely a consequence of fuller recognition". He also states that "for females it [the urban excess] is relatively high for cancer of the sex organs including the breast, though in their case the risk of oversight must be comparatively small".

From 1931 onwards the reports of the Registrar-General for Scotland contain a statement of the recorded deaths from cancer by location for the various Public Health Districts, i.e., each large burgh as defined in the Local Government (Scotland) Act, 1929, and each county exclusive of large burghs. This makes it possible to compare by sites the cancer mortality rates in the large burghs, representing the more urban areas, with those of the rest of Scotland. In view of the apparent inconsistencies of the conclusions derived from previous Scottish and English experience, it was considered desirable to analyse the more recent data. Furthermore, the new data, which cover the period from 1931 to 1937 inclusive, allow of comparison with the results published in the *Supplement to the Seventy-eighth Annual Report of the Registrar-General for Scotland* (Tables M and N). This volume deals with the decennial period 1921–30, and, in addition to the tabular matter, it contains a useful commentary by Dr P. L. McKinlay.

Data and methods of analysis

The data employed in the present investigation have been extracted from the seven Annual Reports of the Registrar-General for Scotland from 1931 to 1937 inclusive. These reports give the number of certificated cancer deaths registered in each year, arranged according to location, sex, and age in Table 28,

and according to location and Public Health District in the General Registration Summary. The locations are those employed in the Revised International Long List. Each location includes a number of particular sites, the classification being as follows:

(1) *Buccal cavity, etc.* Lip, Mouth, Tongue, Jaw, Salivary Glands and Parotid, Tonsils, Pharynx.

(2) *Digestive organs, etc.* Oesophagus and Gullet, Stomach and Pylorus, Intestine, Rectum, Anus, Liver and Gall Bladder, Pancreas, Peritoneum with Omentum and Mesentery.

(3) *Respiratory organs.* Larynx, Lung, Pleura, Mediastinum.

(4) *Uterus.* Cervix, Uterus.

(5) *Other female genital organs.* Ovary and Fallopian Tube, Vagina and Vulva.

(6) *Breast.*

(7) *Male genito-urinary organs.* Kidney, Bladder and Urethra, Prostate, Testis, Penis, Scrotum.

(8) *Skin.* Ear, Nose, Scalp and Face, Skin.

(9) *Other or unspecified organs.* Pelvis, and Sacrum, Rib and Sternum, Skull and Spinal Column, Arm and Leg, Thyroid, Throat, Heart, Thorax, Kidney (Females), Suprarenals, Bladder (Females), Spleen, Abdomen, Brain, Eye and Orbit, Spinal Cord, Lymphatic Glands, and Others unspecified.

To avoid ambiguity we shall use the term *site* in the rest of this paper to refer to a particular site, such as lip or tongue, and the term *location* to refer to one or other of these nine groups of sites.

It was necessary to decide upon a series of geographical regions suitable for the purpose in view. The separate counties were obviously too small, for the few deaths recorded in certain of these for particular locations involve a large sampling error. The choice of areas is limited to some extent by the form in which the data are presented in the Registrar-General's Reports. In every county we are given the data for each large burgh and for the rest of the county (excluding large burghs), and it is not possible to separate the small burghs from the landward areas. The following regional groupings were ultimately decided upon:

(1) The four cities (Glasgow, Edinburgh, Dundee, and Aberdeen).
(2) The other twenty large burghs.
(3) The rest of Scotland (including small burghs and landward areas).
(4) Glasgow.
(5) Edinburgh.
(6) Dundee.
(7) Aberdeen.
(8) Northern counties (excluding large burghs).
(9) West-Central counties (excluding large burghs).
(10) East-Central counties (excluding large burghs).
(11) Southern counties (excluding the large burgh of Dumfries).

The counties in each of the four divisions are those used by the Registrar-General in the Census Report for 1931. Thus the West-Central division includes Ayr, Dumbarton, Lanark, and Renfrew; the East-Central, Clackmannan, East Lothian, Fife, Midlothian, Stirling, and West Lothian; whilst the Northern division includes all counties to the north and west; and the Southern division all those to the south and east.

The general plan of the work was to calculate a series of standardized cancer mortality rates, each referring to a particular location and to a particular area. In order that significant differences might be readily recognized, estimates of standard errors have also been recorded.

It is well recognized that the crude death-rate is a very unsatisfactory index by which to measure the incidence of a disease at any particular place and time. It is necessary to make allowance for the varying age and sex distribution of the population. This may be done by the device of standardizing the rate according to one or other of the recognized methods. For the present purpose of comparing the incidences of the disease in the various regions, it is most convenient to apply the indirect method, fully described in the Registrar-General's Decennial Supplement, 1921 (Part III, p. xxxiii). The direct method is inapplicable in view of the fact that the returns in the General Registration Summary, classified in respect of both location and region, are not subdivided in respect of age and sex. Consequently it is not possible, for a particular location and region, to calculate the specific death-rates for various age groups. For the whole of Scotland, however, the specific death-rates for each of the nine locations can be calculated, from Table 28, for each sex at various ages. With a knowledge of the age and sex distribution of the population in each region a factor can then be obtained for this region for each location, and the standardized rate is found by multiplying the crude regional rate for the location by the appropriate factor. For the purpose of comparing the figures of the Scottish report for 1921–30 with those of the period 1931–7, the former rates have been standardized on the basis of the 1934 population, by this indirect method, and the results are to be found in Table V.

It often happens that deaths under 65 or 70 are much more serious, both from a social and individual point of view, than deaths at older ages. Consequently, in considering changes in the rates of incidence of a disease, it may be desirable to concentrate attention on these younger ages. In the case of cancer very few deaths occur below the age of 25, and so it is here often very useful to have a measure of the incidence of the disease over the age group 25–65. For this purpose the "equivalent average death-rate", discussed by Yule (1934) (cf. Pearl, 1930), has been employed by the English Registrar-General in his more recent reports. This index is the simple average of the quinquennial or decennial specific death-rates over the age range 25–65. In the comparison of cancer mortality during the period 1931–7 with that of 1921–30 this equivalent average death-rate (25–65) proves a useful instrument.

In order to calculate the specific death-rates for the whole of Scotland, the population for various age groups is required for each sex for the central year 1934. The estimated figures were kindly supplied to us by the Registrar-General for Scotland. For the purpose of calculating the regional correction factors the age distributions for each region are needed. These distributions for 1931 are available in the Census Report for that year. It was considered that the error resulting from the use of these regional 1931 age distributions, instead of the 1934 figures, would probably be negligible, especially as only the relative, and not the absolute, values are important. Regional populations for 1934 could, in any case, only be obtained from estimates of doubtful value, and so we had little hesitation in employing, instead, the 1931 census figures. The crude regional rates are, of course, obtained by dividing the average number of deaths per year (1931–7) by the estimated total populations of the regions for 1934.

In locations affecting one sex only, such as the uterus, the obvious course would be to state all rates in terms of this sex alone, and not of the total population. The published data, however, make it impossible to obtain the crude local rates except in terms of the whole population, as the local male or female populations in 1934 are not available. It can be shown, however, that the relative rates in terms of Scotland as a whole are the same, whether based on total populations or female populations alone. The same considerations apply to the breast, where the incidence in male cases is very small as compared to that in females (about 1 to 100). As a result of stating all rates in terms of persons, the four locations breast, uterus, male genito-urinary organs, and other female genital organs, will be found in the tables below to have rates approximately one-half those usually stated.

The standard errors given in the table are calculated from the approximate formula S.E. $= R/\sqrt{N}$, where R is the rate in question, and N is the number of deaths from which this rate has been calculated. This formula, in the first instance, applies to the unstandardized rates, but it is also approximately true for the standardized rates, as the sampling error in the correction factor is a relatively small one.

RESULTS

The results obtained are presented in Tables 1–4 and Figs. 1–4. Table 1 shows the specific death-rates for the period 1931–7 for cancer of each location, and for all locations combined, each sex being given separately. The rates for all locations combined for males and for females, and for females excluding breast and uterus, are represented graphically in Fig. 1. The principal results of the investigation are given in Table 2, in which will be found the standardized death-rate for each location in each of the eleven geographical regions mentioned above, as well as in Scotland as a whole. This table also contains the various regional standardizing factors; these may be validly applied in analogous work over a period of years. The most important feature of this table, namely, the contrast between urban and rural areas, is illustrated in Fig. 2,

in which the urban rates (the aggregate of the four cities) are expressed as percentages of the rural rates (landward areas together with small burghs). The changes which have occurred between the period 1921–30 and 1931–7 are shown in Tables 3–5 and Figs. 3 and 4, the rates for 1921–30 being derived from the decennial report of the Registrar-General for that period (Tables M and N).

Discussion

(*a*) *General*

In the discussion of the distribution of cancer as revealed by the statistics published by the Registrar-General, it is to be remembered that such statistics are derived from the information recorded on death certificates. The cause of death is that set down by the certifying doctor, and, where two or more causes are entered, cancer, in general, is given precedence. When the certification is made, the whole course of the disease, including its fatal termination, is of course already known. The problem of early diagnosis is not here of importance, except, perhaps occasionally, in connexion with assigning the location of the primary tumour.

Some of the features of cancer mortality are well known. As will be seen from Table 1 and Fig. 1, for both males and females the rates are almost inappreciable below the age of 25, rising steeply after 55. At the younger ages the female rate exceeds the male, but after the age of 55 the reverse is true. In women cancer of the breast and uterus is a very important cause of death, and it happens that cancer is particularly liable to attack these two sites during the age period 35–65. Cancer of the breast or uterus is a danger peculiar to the female, and there is no corresponding hazard in the male. Though the prostate or testis is sometimes affected, the incidence of cancer in these organs is small compared with that of breast and uterine cancer in women. If the incidence in all sites other than breast and uterus in females be compared with the total rate in males, it is found that in all age groups the female rate is substantially below that of the male, the excess in the latter being of the order of 40%. It is well known that the male organism is, in general, subject to higher death-rates than the female, a peculiarity shown in respect of most diseases and at all ages (Crew, 1937). It is, perhaps, reasonable to look upon the male excess in cancer of locations other than breast and uterus as a further expression of this greater instability of the male organism.

Before discussing the various locations separately, reference may be made to the English Registrar-General's Decennial Supplement, 1931, part of which deals with occupational mortality, and, *inter alia*, discusses the effect of social class on disease (pp. 19–75). Although some diseases, such as angina pectoris and cirrhosis of the liver, affect the well-to-do much more than the poor, most maladies behave in the opposite way, and work most havoc where economic distress is most severe. For all diseases combined, the mortality among unskilled labourers (aged 20–65) is about 23% greater than that among the

professional classes. Cancer follows the general rule. For males aged 20–65 the mortality (after standardization to correct for differences between sex and age distributions) is 39 % greater among unskilled labourers than among the professional classes; for females the excess is less, being only 10 % for married women and approximately 20 % for single women.

For brevity we shall speak of a normal social gradient when the death-rate increases in passing from the well-to-do to the poor, and of an inverse gradient when the reverse is the case. The English statistics bring out the fact that certain locations have very characteristic social gradients. The skin, buccal cavity, and alimentary tract down to the pylorus have a well-marked normal gradient. For organs of the digestive tract below the pylorus there is little or no gradient. Of the sex organs, the uterus has a normal, and the female breast, ovary, and testis an inverse gradient. These facts are to be borne in mind in the discussion of our results in as far as they refer to the various locations.

The buccal cavity, the first location which we shall discuss, includes sites which are, for the most part, highly accessible, so that we might expect the recorded figures to correspond closely to the actual facts. For this location we find the incidence in males much higher than in females, and also the incidence in towns substantially higher than that in the country. The greater incidence in males is in accordance with the general principle that, in the case of sites common to both male and female, the incidence in the male is usually higher. The higher rates in town as compared with country for this very accessible location would seem to argue an important influence of environment. There would seem to be little doubt that part of the urban cancer of this location is preventable in the sense that, if the same persons had been living in a rural environment, the incidence of mortality from cancer of the buccal cavity would have been considerably less.

A comparison of the death-rates at various ages for the periods 1921–30 and 1931–7 shows that, whereas in the age groups over 65 the rates have remained substantially constant, in the younger age groups the rates have actually become less. It is probable that this decrease is a real one, and no doubt is, in part, to be attributed to improvement in surgical and radiological treatment. However, it has to be borne in mind that a widespread improvement in conditions set in during the latter part of the nineteenth century, resulting in a general decrease in the death-rates of the people who grew up in these improved surroundings, as compared with earlier generations (Kermack, McKendrick & McKinlay, 1934, 1935), and it is probable that the reduction in the death-rate from cancer of the buccal cavity is, in part at least, a result of the better environment. It is, perhaps, not too optimistic to hope that these generations will carry their lowered cancer death-rate along with them, as they have done their general death-rate, and that subsequent generations will progress to a still lower level of mortality.

A location which shows a number of similarities to the buccal cavity, in

respect of the incidence of tumours, is the uterus. The difference between the urban and rural rates is of the same order—an urban excess of 30 % for the buccal cavity and 26 % for the uterus. The uterus resembles the buccal cavity in being, from the point of view of cancer diagnosis, a relatively accessible organ, and for this, as well as for other reasons, a location in which diagnosis is likely to be relatively accurate. In both locations, too, for the age groups under 65, substantially lower rates have been recorded for the period 1931–7 as compared with those of 1921–30 (see Tables 3, 4, and Fig. 4). The change may be regarded as having occurred during an interval of 8½ years, that is, between 1925·5 and 1934, the mid-points of the two periods.

One other point of similarity between the locations has already been referred to. According to the report by the Registrar-General on occupational mortality, both these locations show a very marked normal social gradient. Of the five social classes into which the population of the country is divided, the lowest, Class V, shows, for both locations, about double that for the highest, Class I. For uterine cancer this statement applies to married women, but a similar gradient, though not so pronounced, is also observed for single women.

In sharp contrast to the buccal cavity and the uterus is the other important accessible site, the female breast. For this site there is no significant excess in urban as compared with rural areas. It has been clearly shown by the English Registrar-General that for this site there is a steep inverse social gradient, that is to say, the higher the social class the higher the incidence of recorded deaths. Cancer of this site also differs from that of the buccal cavity and the uterus in showing no improvement, even over the age group 25–65, during the 8½ year interval between 1921–30 and 1931–7. It is also in marked contrast to uterine cancer in being more common in single than in married women. It may be mentioned that, in the report dealing with the mortality from cancer in England and Wales for the period 1911–20, the only other comparable British investigation apart from that of Russell referred to above, a slight but definite and consistent urban excess of breast cancer was found, the magnitude of the excess being about 10 %. Our own results, showing a 4 % excess, are consistent both with the existence of an urban excess of 10 %, and also with the assumption that there is no real urban excess. The relative uniformity may be related to the fact that cancer of the female breast is brought about by pre-eminently intrinsic causes, and so is much less dependent on environment than, say, that of the buccal cavity. Comparison of the specific age rates, or of the equivalent average death-rates, for the two periods, shows that not only has there been practically no change in cancer of the breast below the age of 65, but at higher ages there has even been a slight increase, the largest, one of 16 %, being at ages 75–85. This failure of breast cancer to show any substantial decrease is perhaps surprising in view of the fact that surgical treatment of particular cases is often successful. The matter is discussed by Dunlop (p. 100), who found, up to 1928, an increase in breast cancer not explicable by the older age distribution of the population. Though,

in an accessible site such as breast, the result of better diagnosis is likely to be small, it has been suggested that it may have the effect that a certain number or primary cancers of the breast, with secondaries elsewhere, will now be returned as cancers of that organ, whereas, in the past, they would have been referred to the secondary site.

About the other accessible location in the classification, namely skin, no definite conclusions can be drawn from the results, because of the smallness of the numbers. The figures are consistent with an absence of urban excess, but are also consistent with a real urban excess of, perhaps, 12%. It may be remarked that, on the basis of the England and Wales experience, the skin is to be classed with buccal cavity and uterus in showing a normal social gradient, and, in harmony with this, we find, on the whole, an improvement during the $8\frac{1}{2}$ years, though, in consequence of the small numbers, the changes for particular age groups show considerable variation.

The location digestive organs is the most important of all from the quantitative point of view. In Scotland, for example, it includes over 55% of all deaths certified as due to cancer. Of this large group about 45%, i.e., about a quarter of all cancer deaths, are due to cancer of the stomach and oesophagus. Most of the organs classified under this location are to be regarded as inaccessible, in contrast to the buccal cavity, uterus, and breast. In spite of this inaccessibility, the urban excess for the digestive organs is only 16%, actually less than that for the buccal cavity and uterus.

There is some reason for believing that we may here be dealing with a location where better diagnosis may, in some measure, tend to reduce, rather than to increase, the number of certified deaths included within it. Where diagnosis is inexact, tumours having their primary site in such organs as the prostate, kidney, or breast, may be reported as cancers of the digestive tract. With more accurate certification these would be removed from this category and put in their proper locations. This tendency, of course, does not exclude the possibility of a fictitious urban excess due to the recording in the towns of cases of cancer of the digestive organs which would be ascribed to some quite different cause in the country. However, any urban excess, whether produced in this way or dependent on a real difference in incidence, would thereby tend to be diminished.

These observations are also to be borne in mind when considering the changes which have occurred during the $8\frac{1}{2}$ years in the rates of incidence in this location. The equivalent average death-rate (25–65) shows a slight fall for each sex, whilst the standardized death-rate (Table 5) remains unchanged. It seems likely that, in this inaccessible location, part of the fall, at least, is due to increased accuracy of diagnosis resulting in some transfer of certified deaths from this to other locations. At the same time it is possible that some of the improvement may be real.

As remarked above, about 45% of the cases are cancer of the stomach and oesophagus, sites which show a normal social gradient. Below the pylorus,

however, there is, for the digestive organs, little or no social gradient—in marked contrast to the alimentary tract above the pylorus. Thus the whole location has a definite, though not very large, normal social gradient. Consequently, an improvement in the general standard of life is likely to be accompanied by some decrease in the incidence of cancer in this location, quite apart from any reduction of the death-rate consequent on treatment. The figures presented, though consistent with this tendency, are not sufficiently definite to be considered as demonstrating it.

The greatest urban-rural differences are found in cancer of the respiratory tract, where the urban excess is in the neighbourhood of 90%. This location is also peculiar in showing an extraordinary increase in the number of recorded deaths during the $8\frac{1}{2}$ years under review. The increase in the female equivalent average death-rate (between 25 and 65) is 26%, whilst the corresponding figure for males is 75%, that is to say, it is about three times as great for men as for women. It has been suggested that this may be dependent on the fact that employed men, being within the scope of the National Health Insurance Scheme, are more likely to report any incapacitating illness, and to be subjected to thorough efforts at diagnosis. If the patient is a worker under conditions rendering him liable to inhale fumes, dusts, etc., the question of possible compensation may ensure the medical examination being still more thorough. The fact that in the age group 65–75 the rates of increase for male and for female are substantially equal supports this view. In the age group 75–85 the recorded number of deaths is small, and, in consequence, the apparent excess in the male rate of increase is probably not significant. There would seem to be little doubt that the substantial increases in deaths from cancer of this location are, to a large extent, to be accounted for by more complete diagnosis, as new methods have been developed and brought into use.

It has been shown, in the report of the Registrar-General for England and Wales dealing with occupational mortality during the period 1930–2, that cancer of the larynx shows a very pronounced normal class gradient in males, but not in females. This suggests that cancer of this site is largely of occupational origin. On the other hand, cancer of the lung does not show a similar marked class differentiation in either sex, though in males and females the rate in Class V, which contains unskilled industrial labourers, is about 20% and 10% higher, respectively, than that of Class IV, which includes the bulk of agricultural labourers. This is in accordance with our finding, and, indeed, the large urban excess suggests that the difference between Classes IV and V may be a secondary one—that, in this instance, the distinction between urban and rural areas is the more fundamental. This is, of course, consistent with the view that the difference in recorded death-rates may be dependent on diagnosis, as the newer methods might be expected to be more readily available to those within easy reach of the larger hospitals.

However, we hesitate to attribute the regional differences wholly to incomplete certification, because of the differences found amongst the larger

towns. In particular, we note a standardized rate for Glasgow of 152 and for Edinburgh of 116. The difference is 36 and the standard error of this difference 7·5, so that it is probably significant.

The two locations, female genital organs other than the uterus, and the male genito-urinary tract, though not exactly comparable, may conveniently be considered together. Both groups of locations are somewhat heterogeneous, and include certain sites which may be considered accessible, and others which are relatively inaccessible. They do not, therefore, shed light on the primary object of the present investigation, the reality of the urban excess. Actually, the urban excesses for both these locations are nearly equal (9% and 14%, respectively), though it is very doubtful if the female excess is significant. During the period of $8\frac{1}{2}$ years there was an increase in the reported cancer death-rates for both locations. It is of interest to note that, for the ovary, there is an inverse social gradient, and that, for the prostate, the social trend, though less decided, is in the same direction.

Little need be said about the remaining location, which includes all sites not already classified, and so is very heterogeneous, except that the urban excess, though highly significant, is less than that found for the accessible locations buccal cavity and uterus. This is in spite of the fact that the miscellaneous sites which go to make up this location are, for the most part, relatively inaccessible. It may be noted that, in the interval between 1921–30 and 1931–7, a fall occurred in both sexes in cancer of this location (Tables 3–5).

(*b*) *Comparison with Russell's findings*

As mentioned above, our results, though in general agreement with those found for England and Wales by the Registrar-General for the years 1911–20, appear to diverge from those of Russell for Scotland for the period 1923–8. It is to be observed, however, that the findings of Russell, in as far as they bear on the present problem, are of a negative character. Thus, in the case of the buccal cavity, he states that in only one county (Midlothian) out of thirty-three is the observed number of cancer deaths significantly greater than the calculated number (though the figures given in the paper indicate that, in both East Lothian and Forfar, the excess of actual over expected deaths is probably significant). As he treats each county separately, he is working with relatively small units, in some of which the expected number of deaths for any one location is often very small. The sampling error is, therefore, big, and so it is possible for significant results to be overlooked. Under these conditions, the fact that the observed distribution of deaths is consistent with the assumption of uniformity does not show that there is, in reality, such uniformity, and that there is no urban excess.

The figures given by Russell were further analysed as follows. An index of industrialization was found for each of the thirty-three counties (including the large burghs in each county). This was calculated from the Census Report for 1931, which lists twenty-two different Industry Orders, giving the numbers

engaged in each in the various counties. The first two of these industries, which we shall call Group A, are predominantly non-urban, namely, I, Fishing, and II, Agriculture. The next twelve on the list (Group B) cover most of the typical industrial occupations:

III. Mining and Quarrying.
IV. Manufacture of Bricks, Pottery, Glass, etc.
V. Manufacture of Chemicals, etc.
VI. Manufacture of Metals, Machines, etc.
VII. Textile Industry.
VIII. Manufacture of Leather and Leather Goods.
IX. Clothing Manufacture.
X. Manufacture of Food, Drink, and Tobacco.
XI. Wood Working.
XII. Paper and Stationery Manufacture: Printing.
XIII. Building and Contracting: Decorating.
XIV. Other Manufacturing Industries.

The remaining eight industries refer to activities common to both urban and rural areas:

XV. Gas, Water, Electricity.
XVI. Transport and Communication.
XVII. Commerce and Finance.
XVIII. Public Administration and Defence.
XIX. Professions.
XX. Entertainments and Sport.
XXI. Personal Service.
XXII. Other Industries or Industry not stated.

To some extent this division is an arbitrary one, but is convenient and suitable for practical purposes. The "index of industrialization" chosen is the ratio of those employed in Group B to those in Group A. Table 6 shows the counties in ascending order of industrialization.

By choosing some suitable point of division we may separate the counties into the more and less highly industrialized, and compare the expected with the actual number of cancer deaths in each division. We choose, somewhat arbitrarily, as dividing point, the index 4·95, which corresponds to the mean degree of industrialization of the whole of Scotland (the result is substantially the same whatever the dividing point chosen, over a wide range), and obtain Table 7.

Investigation of the goodness of fit by the usual formula gives $P = 0{\cdot}0038$ and 0·0010 for breast and buccal cavity respectively. According to this result, there is an excess, very probably significant, of breast cancer in the more industrialized counties, and a very definite excess of buccal cavity cancer. The latter result is what we have found for the later period. The breast cancer finding is consistent with the England and Wales experiences for the years 1911–20, and cannot be regarded as inconsistent with our own result, since,

as pointed out above, the absence of significant deviation from uniform distribution does not exclude the possibility of, say, a 10% difference between urban and rural areas. The urban excess, however, would seem to be less in the breast than in the buccal cavity mortality.

(c) *Recent changes in Scottish cancer mortality*

A fact of some significance is that during the interval between 1921–30 and 1931–7 improvement has been most pronounced at the younger ages. For all deaths from cancer, at ages 25–65, there was, in the case of women, a net improvement of 8%, whilst, in the case of men, the incidence remained almost exactly constant. At the same time, for ages 65–85, there was a considerable deterioration, an increase of 13% being found for men, and 6% for women. This may suggest that modern therapeutic methods are postponing death rather than curing the disease. Even though this were true, the postponement of many deaths from middle to old age would be a satisfactory achievement. It is doubtful, however, whether the statistical facts are wholly to be explained in this way. The people over 65 years of age in 1931–7 are not, in general, the same individuals as those under 65 years of age in 1921–30. The people, for example, who were 85 and over in 1931–7 must have emerged from the under 65 group before 1917. Up to this time little improvement had taken place, even in those under 65. To obtain a clear picture of the course of events, it would be necessary to study generation mortalities, that is, to follow the course of a particular generation throughout life, and thus to ascertain whether, for such a generation, a low mortality in middle age resulted in a higher mortality later on. The data at present available do not permit of this being done. It is to be remembered, however, that, in the case of the death-rate from all causes, the fall, apart from infant deaths, began in the younger age groups, and that the improvement was carried by the generation throughout life (Kermack, McKendrick & McKinlay). It may be considered optimistic to expect that a similar course will be exhibited in cancer mortality, and that the present fall in cancer deaths at younger ages will be followed, in a few decades, by corresponding falls at higher ages. The figures, however, are just as consistent with this interpretation as with the hypothesis of delayed deaths.

It might be anticipated that, where there is a normal social gradient, there will be a progressive improvement in death-rates, corresponding to the general rise in the standard of living. Where, on the contrary, the social gradient is inverse, a deterioration in mortality is to be expected, or, if other advantageous factors are having an effect, an improvement less marked than in the case of the locations with normal social gradients. How far this anticipation is realized is reflected in Table 8.

It will be seen that there has been improvement only where there is a normal social gradient, but that the reverse does not always hold, as, for example, in the case of the respiratory tract. As mentioned above, there has been a very rapid increase in the number of certified deaths from cancer of

this location. At the same time it shows but little social gradient, though what there is is normal in type. It has already been remarked, however, that much of the increase of cancer of the respiratory tract is unquestionably due to improvement in diagnosis, so that undue importance should not be attached to this location.

(*d*) *Reality of urban excess*

In interpreting these results, the known facts relating to the effects of industrial and social conditions on cancer must be borne in mind. The special liability of workers in particular occupations to develop cancers of the skin, etc., in consequence of subjection to carcinogenic agents, is now general knowledge. The greater liability of the poor to develop cancer of the buccal cavity and stomach, and of the skin and uterus, and their relative immunity from cancers of the breast, ovary, and testis, and, to a lesser extent, of the prostate, has been strikingly demonstrated in the two reports on occupational mortality by the Registrar-General for England and Wales for the years 1921–3 and 1930–2. The results seem too consistent and specific to be attributed mainly to variations in certification. Certain ways of life, perhaps certain types of diet, appear to promote or retard the development of cancers in particular sites. Such differences in habits of food, and in hygiene, in environment in the broad sense, undoubtedly exist as between town and country, and the observed differences would seem, in part, to be due to this. There is little doubt that some of the apparent urban excess is due to defective certification in rural areas, but the weight of the evidence is against the view that this is the whole explanation. An urban or industrial *milieu* would appear to be conducive to the development of cancers, and the identification of the particular elements of such an environment which are responsible, and their ultimate removal, would be an obvious means of reducing future cancer mortality.

Summary

1. In order to obtain evidence as to what extent the urban excess in cancer mortality is real, an analysis has been made, in respect of both location of tumour and geographical region, of the cancer mortality statistics for Scotland, 1931–7 inclusive.

2. Of the various locations, the greatest urban excess is shown by cancer of the respiratory tract; this is considered to be largely, though probably not entirely, due to better diagnosis and more accurate certification of deaths in the cities. Next come the buccal cavity and uterus; in both these locations certification is likely to be relatively accurate, so that a real excess would seem here to be present. The other accessible locations, the skin and the female breast, do not show significant urban excesses, but the numbers are small, and the existence of a real urban excess is not excluded. The results are in general agreement with those of the English experience 1911–20.

3. Further analysis of the data presented by Russell for Scotland, 1923–8, reveals an excess in the industrial counties of deaths for cancer of the buccal

cavity, and perhaps a smaller one for cancer of the female breast. These data are, therefore, not inconsistent with our findings.

4. As compared with the period 1921–30, the figures for 1931–7 demonstrate, for ages 25–65, a marked improvement in cancer of the buccal cavity and uterus. A recorded fall in cancer of the digestive organs may, in part, be due to more accurate certification in respect of the primary location. The failure of mortality from breast cancer to fall may be due to the same cause. The large increase in lung cancer is almost certainly due, in part, to better diagnosis. For all sites together, the cancer mortality between ages 25 and 65 remained constant for men, and fell by 8% in the case of women. The standardized rate for all ages and both sexes combined increased by 1·3%, a rise which is 2·2 times its standard error.

5. The urban excess cannot be entirely explained as due to incomplete certification in the rural areas. The implied effect of social and industrial environment in stimulating tumour growth is in harmony with the known facts regarding occupational and social cancer, and emphasizes the importance which the control of adverse environmental factors may have in the reduction of cancer incidence.

Table 1. *Death-rates per million from cancer of various locations, by sex and age, Scotland*, 1931–7

	All ages	–25	25–	35–	45–	55–	65–	75–	85 +
				Males					
All locations	1479	37	144	515	1691	4615	10197	14439	16272
Buccal cavity, etc.	140	2	5	13	107	472	1081	1462	2396
Digestive organs, etc.	929	10	73	300	1032	2984	6614	9057	8387
Respiratory organs	135	4	26	106	295	451	641	627	271
Breast	3	0	0	1	6	3	12	49	116
Male genito-urinary organs	150	5	16	33	112	377	1156	2009	2667
Skin	26	1	2	7	24	52	161	433	1353
Other or unspecified organs	96	15	23	54	116	278	533	801	1082
				Females					
All locations	1598	28	164	787	2152	4352	8394	12526	13733
All locations excluding breast and uterus	1161	26	105	415	1276	3066	6667	10325	11101
Buccal cavity, etc.	29	1	3	9	35	82	143	246	346
Digestive organs, etc.	857	6	59	255	818	2221	5227	8317	8070
Respiratory organs	63	3	11	40	119	197	294	241	191
Uterus	180	1	33	198	391	503	691	657	502
Other female genital organs	72	3	16	51	147	222	280	326	312
Breast	257	1	26	174	485	783	1036	1544	2130
Skin	20	0	1	4	9	25	86	333	970
Other or unspecified organs	121	13	14	56	149	319	638	865	1212

Table 2. *Crude and standardized death-rates per million from cancer of various locations, by geographical region, Scotland, 1931–7*

		All Scotland	The four cities (urban Scotland)	The other twenty large burghs	Landward areas together with small burghs (rural Scotland)	The four cities: Glasgow	Edinburgh	Dundee	Aberdeen	The four divisions of rural Scotland: Northern	West-Central	East-Central	Southern
All locations	Crude rate	1541	1575	1482	1531	1470	1746	1753	1615	1762	1351	1377	1728
	Factor	1·0000	1·0679	1·0969	0·9222	1·1608	0·9373	0·9739	1·0115	0·7599	1·1010	1·0626	0·8204
	Standardized rate	1541	1682	1626	1412	1706	1637	1707	1634	1339	1487	1463	1418
	Standard error	±6·6	±12	±18	±9·2	±16	±22	±37	±37	±14	±18	±20	±27
Buccal cavity, etc.	Crude rate	82·1	85·1	81·1	79·9	76·2	101	102	84·8	98·2	59·2	77·0	92·9
	Factor	1·0000	1·1058	1·0862	0·9033	1·1728	0·9925	1·0643	1·0715	0·7372	1·0937	1·0379	0·8194
	Standardized rate	82·1	94·1	88·1	72·2	89·4	100	109	90·9	72·4	64·7	79·9	76·1
	Standard error	±1·5	±2·8	±4·2	±2·0	±3·7	±5·6	±9·7	±9·0	±3·2	±3·8	±4·6	±6·2
Digestive organs, etc.	Crude rate	892	885	880	901	835	963	1012	875	1050	794	798	1004
	Factor	1·0000	1·0781	1·1019	0·9149	1·1767	0·9412	0·9810	1·0160	0·7445	1·1061	1·0627	0·8129
	Standardized rate	892	954	970	824	983	906	993	889	782	878	848	816
	Standard error	±5·1	±8·8	±14	±6·9	±12	±16	±28	±27	±11	±14	±15	±20
Respiratory organs	Crude rate	97·3	129	87·9	73·3	141	122	100	102	62·1	91·9	68·1	64·2
	Factor	1·0000	1·0392	1·0518	0·9531	1·0815	0·9531	1·0160	1·0302	0·8407	1·0694	1·0369	0·8706
	Standardized rate	97·3	134	92·5	69·9	152	116	102	105	52·2	98·3	70·6	55·9
	Standard error	±1·7	±3·2	±4·2	±2·1	±4·6	±5·9	±9·2	±9·5	±2·9	±4·6	±4·3	±5·5
Uterus	Crude rate	93·2	104	87·3	86·4	91·2	108	125	150	90·4	78·1	84·6	103
	Factor	1·0000	1·0078	1·0911	0·9660	1·1098	0·8784	0·8930	0·9630	0·8395	1·0951	1·0885	0·8465
	Standardized rate	93·2	105	95·3	83·5	101	94·9	112	144	75·9	85·5	92·1	87·2
	Standard error	±1·6	±2·8	±4·4	±2·3	±3·8	±5·1	±9·0	±11	±3·5	±4·3	±5·0	±6·8
Other female genital organs	Crude rate	37·6	39·3	32·0	38·0	31·0	58·1	41·9	39·9	41·3	32·2	36·6	50·5
	Factor	1·0000	1·0139	1·0958	0·9581	1·1193	0·8777	0·8798	0·9708	0·8206	1·0991	1·0925	0·8433
	Standardized rate	37·6	39·8	35·1	36·4	34·7	51·0	36·9	38·7	33·9	35·4	40·0	42·6
	Standard error	±1·0	±1·7	±2·7	±1·5	±2·2	±3·7	±5·1	±5·6	±2·3	±2·8	±3·3	±4·7
Breast	Crude rate	134	134	117	141	117	160	148	156	169	117	120	175
	Factor	1·0000	1·0275	1·1094	0·9458	1·1484	0·8755	0·8934	0·9596	0·7899	1·1141	1·0973	0·8284
	Standardized rate	134	138	130	133	134	140	132	150	133	130	132	145
	Standard error	±2·0	±3·3	±5·2	±2·8	±4·4	±6·2	±9·8	±11	±4·5	±5·4	±6·1	±8·7
Male genito-urinary organs	Crude rate	72·2	68·5	68·4	76·7	63·5	80·3	77·4	59·8	86·8	62·0	75·9	91·6
	Factor	1·0000	1·1317	1·0807	0·8878	1·1837	1·0388	1·1208	1·0875	0·7175	1·0875	1·0235	0·8056
	Standardized rate	72·2	77·5	73·9	68·1	75·2	83·4	86·7	65·0	62·3	67·4	77·7	73·8
	Standard error	±1·4	±2·6	±3·8	±2·0	±3·4	±5·2	±8·9	±7·7	±2·9	±3·8	±4·5	±6·1
Skin	Crude rate	22·8	19·4	20·2	26·6	17·2	23·8	25·0	16·6	32·0	22·3	20·6	36·8
	Factor	1·0000	1·1406	1·1466	0·8690	1·2807	0·9605	1·0379	1·0478	0·6499	1·1117	1·0896	0·8172
	Standardized rate	22·8	22·1	23·2	23·1	22·0	22·9	25·9	17·4	20·8	24·8	22·4	30·1
	Standard error	±0·8	±1·4	±2·2	±1·1	±1·9	±2·6	±4·7	±3·9	±1·6	±2·4	±2·5	±3·9
Other or unspecified organs	Crude rate	109	111	108	109	97·5	130	123	130	132	94·8	96·3	109
	Factor	1·0000	1·0555	1·0878	0·9301	1·1439	0·9367	0·9691	1·0124	0·7768	1·0890	1·0608	0·8346
	Standardized rate	109	117	117	101	112	122	119	132	103	103	102	91·0
	Standard error	±1·8	±3·0	±4·8	±2·4	±4·1	±6·0	±9·7	±10·6	±3·9	±4·7	±5·2	±6·9

The standard errors are those of the standardized rates.

Table 3. *Death-rates from cancer of various locations, by sex and age, in Scotland, 1931–7, as percentages of those in Scotland, 1921–30*

	All ages	–25	25–	35–	45–	55–	65–	75–	85 +
				Males					
All locations	118	123	104	105	101	98	108	117	130
Buccal cavity, etc.	95	100	100	41	51	78	99	98	102
Digestive organs, etc.	115	125	94	96	95	96	106	117	129
Respiratory organs	185	133	173	189	230	147	149	172	114
Male genito-urinary organs	142	100	145	122	138	114	121	132	199
Skin	104	100	50	100	104	118	89	82	108
Other or unspecified organs	110	125	96	102	84	99	103	110	130
				Females					
All locations	109	108	86	93	92	92	102	110	116
Buccal cavity, etc.	97	100	75	64	69	91	92	97	80
Digestive organs, etc.	109	100	92	94	88	88	99	113	126
Respiratory organs	147	150	138	125	125	126	156	120	303
Uterus	93	100	61	84	84	78	97	100	116
Other female genital organs	144	100	123	124	132	141	129	134	130
Breast	114	—	118	96	97	103	109	116	97
Skin	95	—	50	100	56	81	85	85	107
Other or unspecified organs	98	100	61	89	90	85	96	87	103

Table 4. *Equivalent average death-rates per million, at ages 25–65, from cancer of various locations, by sex, Scotland, 1921–30 and 1931–7*

	1921–30	1931–7	Rates in 1931–7 as percentages of those in 1921–30	Difference / s.e. of diff.
	Males			
All locations	1747	1741	100	0·3
Buccal cavity, etc.	212	149	70	9·1
Digestive organs, etc.	1150	1097	95	2·9
Respiratory organs	126	220	175	13·6
Male genito-urinary organs	113	135	119	3·8
Skin	19·5	21·3	109	0·8
Other or unspecified organs	124	118	95	1·1
	Females			
All locations	2031	1864	92	8·0
Buccal cavity, etc.	39·8	32·3	81	2·6
Digestive organs, etc.	950	838	88	7·5
Respiratory organs	72·8	91·8	126	4·3
Uterus	351	281	80	8·4
Other female genital organs	80·5	109	135	6·1
Breast	367	367	100	0
Skin	13·3	9·8	74	2·1
Other or unspecified organs	157	135	86	3·8

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Table 5. *Death-rates per million from cancer of various locations, for all ages and both sexes combined, Scotland,* 1921–30 *and* 1931–7

	1921–30 (standardized on basis of 1934 population)	1931–7 (actual)	Rates in 1931–7 as percentages of those in 1921–30	Difference / s.e. of diff.
All *locations*	1521	1541	101·3	2·2
Buccal cavity, etc.	98·1	82·1	84	7·6
Digestive organs, etc.	893	892	100	0·1
Respiratory organs	62·5	97·3	156	16·6
Uterus	110	93·2	85	7·3
Other female genital organs	28·5	37·6	132	7·0
Breast	130	134	103	1·5
Male genito-urinary organs	58·1	72·2	124	7·8
Skin	25·5	22·8	89	2·5
Other or unspecified organs	116	109	94	2·9

Table 6. *Degree of industrialization of Scottish counties*

County (including large burghs)	Index of industrialization	County (including large burghs)	Index of industrialization
Orkney	0·2	Aberdeen	1·4
Sutherland	0·3	East Lothian	1·4
Wigtown	0·4	Roxburgh	1·9
Banff	0·5	Peebles	2·4
Berwick	0·5	All Scotland	4·95
Caithness	0·5		
Kincardine	0·5	Ayr	5·8
Kirkcudbright	0·5	Fife	6·8
Nairn	0·5	Selkirk	7·0
Ross and Cromarty	0·5	Forfar	7·5
Argyll	0·7	Stirling	10·1
Inverness	0·7	West Lothian	10·1
Moray	0·7	Midlothian	13·0
Zetland	0·7	Dumbarton	17·7
Bute	1·0	Clackmannan	18·2
Perth	1·2	Renfrew	24·3
Dumfries	1·3	Lanark	32·1
Kinross	1·3		

Table 7

	Breast		Buccal cavity	
	Actual	Expected	Actual	Expected
Counties with index of industrialization less than 4·95	1009	1086	622	697
Counties with index of industrialization greater than 4·95	2442	2360	1529	1462

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Table 8

	Equivalent average death-rates (25–65) in Scotland, 1931–7, as percentages of those in 1921–30 (cf. Table IV and Fig. 4)		Standardized death-rates (35–65) in Social Class V as percentages of those in Social Class I, England and Wales, 1930–2	
	Males	Females	Males	Married women
Buccal cavity	70	81	195	—
Uterus	—	80	—	200
Other female genital organs	—	135	—	60
Digestive organs	95	88	140	155
Breast	—	100	—	60
Male genito-urinary organs	119	—	100	—
Skin	109	74	225	—
Respiratory organs	175	126	110	100

For some locations the figures in the last two columns are only approximate, being obtained by weighting the values for the constituent sites.

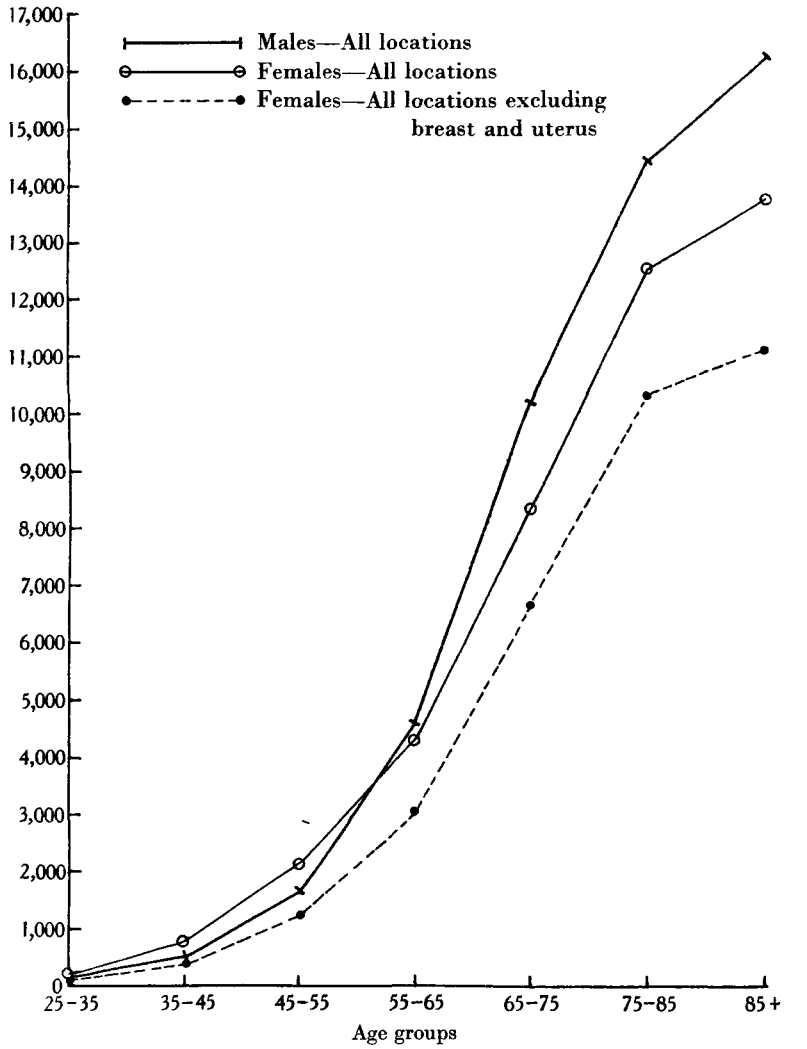

Fig. 1. Death-rates per million from cancer, by sex and age, Scotland, 1931–7.

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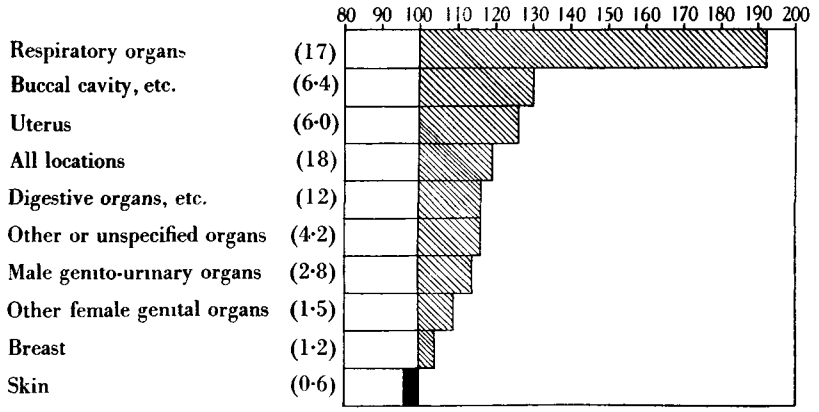

Fig. 2. Standardized death-rates from cancer of various locations in urban as percentages of those in rural Scotland, 1931–7. "Urban Scotland" includes the four cities, Glasgow, Edinburgh, Dundee and Aberdeen; "Rural Scotland" includes the landward areas and small burghs. The figure given in brackets for each location is the ratio of the difference between the urban and rural rates to the standard error of the difference.

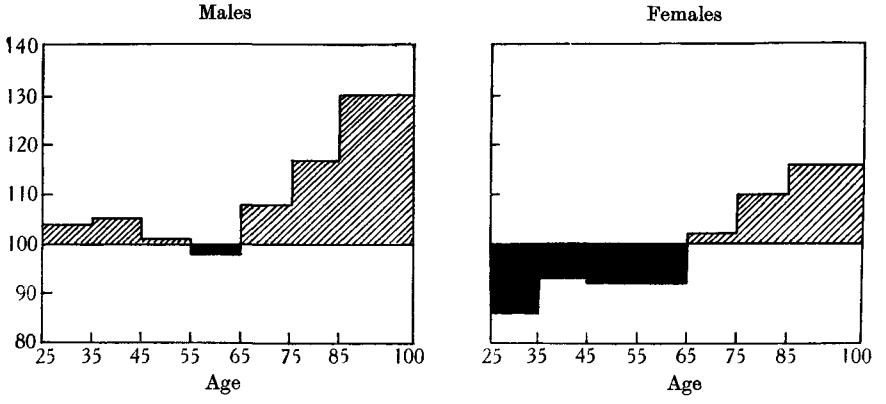

Fig. 3. Death-rates from cancer, by sex and age, in Scotland, 1931–7, as percentages of those in Scotland, 1921–30.

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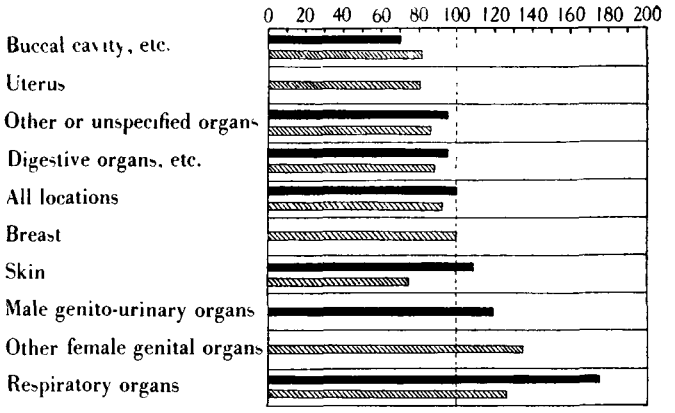

Fig. 4. Equivalent average death-rates, at ages 25–65, from cancer of various locations in Scotland, 1931–7, as percentages of those in Scotland, 1921–30. The black columns refer to males, the shaded columns to females.

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