COMPARISON BETWEEN THE DIRECT AND INDIRECT OCCUPATIONAL RISK IN MORTALITY FROM PULMONARY TUBERCULOSIS

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INTRODUCTION

IT has long been recognized that there is a relationship between environment and health and examples of this association are easy to cite—overcrowding tends to spread infection. But our knowledge of the exact part played by occupational as distinct from economic and social environment is as yet imperfect. The liability of the worker to ill-health, apart from any inborn constitutional weakness, is determined broadly by two factors. The first is the influence of the type of work directly upon the worker, an influence inherent in the actual occupation and the conditions under which the work is done. This might be regarded as the direct occupational risk. The second is the economic and social environment conditioned by the occupation followed: this might be termed the indirect occupational risk. This distinction was recognized by the Registrar-General who stated that both factors are essentially components of the total occupational risk since 'If a man is obliged by his place of work and his rate of pay to live in an insanitary area, the extra risk of death involved is, in a wider but very real sense, part of the occupational risk'. The purpose of the present paper is to try to disentangle the parts played by each in determining the occupational mortality from a specific disease like tuberculosis. The difficulty which previously presented itself was the absence of a standard which could be regarded as a measurement of the indirect occupational risks. The Registrar-General, in his last *Occupational Mortality Supple-*

ment, has provided an approximate index, by publishing data on the mortality of males following particular occupations and also that of their wives. His viewpoint was. ' . .for no trade could longer be regarded as directly prejudicial to health if it were found to entail as much excess risk for the wife as for the husband. In such a case excess mortality would evidently be in the main attributable to the social conditions implied.' Greenwood likewise stated that 'the wives share the social and geographical advantages of their husbands' occupation but, with relatively unimportant exceptions, are not exposed to their specific occupational risks'.

PREVIOUS INVESTIGATION

The comparison between the effects of direct and indirect occupational risks as expressed in terms of mortality was first attempted by Hay. As bearing on the infectiousness of phthisis he was interested to ascertain whether there was a high mortality from tuberculosis among wives and families of men working at occupations with a high phthisis death-rate. He examined the trends in Aberdeen for the period 1900–9. It should be pointed out, however, that the male phthisis mortality was not confined to married men but to all males over the age of 21 years. There were other imperfections, the principal being that no allowance was made for age variation between the populations in the different occupations. These detractions he recognized. His results were.

City of Aberdeen, Occupational Mortality, 1900–9

		Average annual death-rate for 1000 persons above 21 years of age (excluding employers) for		
		Phthisis	Tuberculosis	
	Estimated average annual number of persons above 21 years of age employed	(1)	(2) Wives and widows	(3) Unmarried children
Occupation		Males		
(i) Stonecutters and masons	1750	5·7	1·8	4 7
(ii) Stone polishers	420	2 5	1 6	5 5
(iii) Joiners, sawyers, etc.	1420	1 8	1·8	3 7
(iv) Painters	420	2 1	1·7	4 5
(v) Tailors	620	3 2	1·6	2·7
(vi) Bakers	360	1 4	1·9	4 4
(vii) Engineers, riveters, etc.	2600	1 8	1·6	3 9
(viii) Printers and lithographers	380	4 5	1·1	1 6
(ix) Combmakers	345	4 3	2 0	3 2
(x) Carters	1450	1·1	'1 8	4 7
(xi) Labourers	3600	2 3	2·1	4 4
(xii) Clerks	1220	3 8	1·1	0 7

From these rates it will be seen that the variation between occupations is less for the wives and widows than it is for the males themselves. In fact, if groups (viii) and (xii) are omitted from the discussion, the range of the rates for the wives and widows is 1·6–2·1 per 1000, while that of male phthisis is much greater, being from 1·1 to 5·7. Compared with these the range of the unmarried children's rate was 2·7–5·5. Stonecutters and masons (group (i)) showed the highest male mortality, 5·7 per 1000, while the lowest, 1·1 per 1000,

was that for carters (group (x)). Nevertheless, in spite of the disparity between the male rates from phthisis in the two occupations, the rates of the wives and widows and also of the unmarried children from tuberculosis were identical in the two occupations, being 1·8 and 4·7 per 1000. On the whole it would appear that, within the limited scope of his data, the occupational risk of phthisis is purely of a direct nature in those occupations where it appears to be excessive, since there is no concomitant excess in the married women's rates. From a study of his results Hay arrived at the conclusion that 'in the spread of tuberculous disease, or at least of fatal tuberculous disease, the presence of the seed is of less account than the character and condition of the soil'.

PRESENT INVESTIGATION

Hay's data were necessarily too restricted for a detailed examination of the problem; such is now possible upon a national scale. The present available records, published in the *Occupational Mortality Supplement*, consist of the mortality experience during the years 1930–2 for males in a series of occupational groups and for married women whose husbands follow certain of these occupations. As in Hay's inquiry the male mortality experience includes all males and is not confined to married men. The indices tabulated in this official report are standardized mortality ratios—the actual number of deaths in any occupation expressed as a percentage of an expected number obtained when the standard mortality rates at age periods are applied to the population of similar age groups in that occupation. The standard mortality rates for males are the death-rates at ages for all males in England and Wales; and for wives, the death-rates at ages for all married women in England and Wales. In dealing with a particular cause of death the standard rates naturally refer to that specific disease.

The method of calculation can be best expressed symbolically. If R represents the number of actual or registered deaths in a group and S the corresponding number of expected deaths obtained by the method explained above, then the standardized mortality ratio is represented as $100\,(R/S)$. The criterion of significance, of this ratio, as used in official publication, is

(i) Where the standardized mortality ratio exceeds 100 by as much or more than $250\,\sqrt{R/S}$ then that ratio is significantly in excess of that of all males or all married women as the case may be.

(ii) Where the standardized mortality ratio exceeds 100 by $150\,\sqrt{R/S}$ but not by as much as $250\,\sqrt{R/S}$ then that ratio is 'probably' significantly in excess.

(iii) Excesses of less than $150\,\sqrt{R/S}$ are insignificant.

A similar scheme is adopted for the ratios below 100.

Ratio according to social class

Before making a detailed examination according to particular occupations it seems of interest to examine the mortality ratios for phthisis by social class. They are set out on p. 466 for the five social classes, differentiated in respect of

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occupation followed by the males, for two age groups. Class I is the highest in the social scale and class V the lowest.

Standardized mortality ratios for respiratory tuberculosis

	Ages 20–65		Ages 35–65	
Social class	Males	Married women	Males	Married women
I	61	52	63	54
II	70	67	70	68
III	100	99	100	99
IV	104	106	107	109
V	125	132	132	135
All classes	100	100	100	100

The standardized mortality ratios for each social class except class III differ significantly from the average for All classes, when tested by the convention described above. Direct comparison between males and married women cannot be made from this table, as the ratios for each sex are compiled from different standards.

The influence of social conditions upon respiratory tuberculosis mortality is clearly demonstrated, and it would appear that the correlation is slightly better defined for married women than for males, the range of their ratios being the greater in each of the two age periods. It will be remembered that, when dealing with crude death-rates for Aberdeen, Hay found that between occupations the greater variation was shown by the male rates. There is no indication in the national records assembled according to social class that the male experience is widely different from that of the wives in general. But it must be admitted that the direct influence of any particular occupation may be hidden in the broad groups which constitute the social classes and hence a more detailed examination becomes necessary.

Ratio according to occupation

The Registrar-General has pursued the policy of omitting the calculation of standardized mortality ratios for groups in which less than twenty deaths were recorded. Imposing the same limitation there were forty-three occupational groups for the age period 20–65, for which standardized mortality ratios could be obtained. The use of this age period, as the Registrar-General points out, has evoked some criticism, chiefly on account of the paucity of numbers in the component age period 20–25 but also on the basis that occupational risk has rarely had sufficient time by age 25 to be inimical to health to the extent of causing death. Some critics prefer to concentrate on the age group 35–65, but we think that, on the whole, the wider age period is the more justifiable. The occupations have been divided into five groups with the degree of significance by which their male standardized mortality ratios from phthisis differ from the 'All Males' standard ratio of 100. Thus the five separate categories which are possible may have ratios which are:

(i) significantly greater than the all male ratio,

(ii) probably significantly greater,

(iii) insignificantly different,

(iv) probably significantly less,

(v) significantly less than the all male ratio.

A similar classification was made for females and then each separate category was made to form a combination series with the ratios for females. The results for some of the combinations are given in Tables 1 and 2.

Table 1. *Showing the* S.M.R.*s (standardized mortality ratios) from phthisis in occupations in which the males'* S.M.R.*s are* (i) *significantly and* (ii) *probably significantly in excess of the all males'* S.M.R. (*i.e.* 100) *and the* S.M.R.*s of the wives whose husbands follow such occupations.* 1930–2

	Age 20–65	
Occupations of the males	Males	Wives
(i) Male S M R significantly in excess of that of all males		
(1) Wives' S M.R. significantly in excess of that of all wives.		
Boot and shoe, etc.—workers and factory operatives	188	152
Water transport—dock labourers	186	150
General labourers, labourers and other unskilled workers	138	150
Road transport—horse drivers	124	133
(2) Wives' S.M R. probably significantly in excess of that of all wives.		
Warehousemen—textiles, clothing, drapery and hosiery	364	183
Waiters	178	129
French polishers	148	154
Iron and steel foundry furnacemen and labourers	139	132
(3) Wives' S.M.R. not significantly different from that of all wives.		
Metal glaziers, polishers, moppers and buffers	230	141
Barmen	212	109
Masons, etc.	179	102
Musicians	149	124
Inn and hotel keepers, etc.	148	107
Paper hangers, painters, etc.	114	99
(4) Wives' S.M.R. probably significantly less than that of all wives.		
Hairdressers, etc.	162	80
(5) Wives' S.M.R. significantly less than that of all wives.		
None		
(ii) Male S M.R. probably significantly in excess of that of all males		
(1) Wives' S M R significantly in excess of that of all wives.		
Metal moulders and die casters	112	141
Builders', bricklayers', plasterers' and masons' labourers	110	149
(2) Wives' S M R probably significantly in excess of that of all wives		
None		
(3) Wives' S.M.R. not significantly different from that of all wives.		
Salesmen and shop assistants—textile and other clothing	126	110
(4) Wives' S.M R. probably significantly less than that of all wives.		
Retail salesmen—dairy, meat, fish and greengrocery	110	80

Male ratio significantly in excess

Let us consider the occupations in which the male phthisis standardized mortality ratios are significantly excessive (Table 1). The most stringent test which could be applied to select the occupations where the direct is more important than the indirect influence would be an association of a significantly

excessive male mortality with a mortality for married women significantly in defect of that for all wives. No such occupation is recorded. In only one occupation is a significantly excessive male phthisis mortality associated with a standardized mortality for wives which is *probably* significantly smaller than that for all married women. This occupation is classified as hairdressers, etc., the standardized mortality ratios being 162 and 80 for males and wives respectively.

The group of six occupations, with significant male excesses and insignificant differences for the married women, might also be taken as indicative

Table 2. *Showing the* s.m.r.s *(standardized mortality ratios) from phthisis in occupations in which the males'* s.m.r.s *are (i) significantly and (ii) probably significantly less than the all males'* s.m.r. *(i.e.* 100) *and the* s.m.r.s *of the wives whose husbands follow such occupations.* 1930–2

	Age 20–65	
Occupations of the males	Males	Wives
(i) Male s.m r significantly less than that of all males		
(1) Wives' s m r. significantly in excess of that of all wives.		
Coal hewers and getters	84	134
(2) Wives' s m.r. probably significantly in excess of that of all wives.		
Boiler firemen and stokers	72	124
(3) Wives' s m r. not significantly different from that of all wives.		
Coal miners—workers below ground other than hewers and getters	72	107
Gardeners, nurserymen, seedsmen and florists	64	92
Railway guards·	49	94
Railway engine drivers	47	86
Railway officials, etc.	43	80
Railway signalmen	42	91
(4) Wives' s.m.r probably significantly less than that of all wives.		
Carpenters	76	91
(5) Wives' s.m.r. significantly less than that of all wives		
Retail proprietors	68	69
Professional engineers	58	53
Agricultural and gardeners' labourers, etc.	51	83
Teachers (excluding teachers of music)	51	57
Bank and insurance officials	46	39
Farmers and their relatives working on farms	35	63
(ii) Male s.m r probably significantly less than that of all males		
(4) Wives' s.m.r. probably significantly less than that of all wives		
Retail proprietors—dairy, meat, fish and greengrocery	93	84
(5) Wives' s m r. significantly less than that of all wives		
Commercial travellers	92	63

of rather more direct than indirect occupational influence. Of these the two groups (i) metal glaziers, polishers, moppers and buffers and (ii) barmen, have extremely high male ratios, 230 and 212.

Occupations which show significant excesses for males and married women from their respective standards can have little or no direct occupational risk distinguishable from the environmental influence of the worker's home. There are four such occupations. It is certainly true from the statistics in Table 1 that the inherent risk is indistinguishable from the home risk for factory

workers in the boot and shoe trades, dock labourers, labourers and unskilled workers, and horse drivers. It must be admitted, however, that the workers in the boot and shoe trades are recruited from the male and female population and they may thus have a common direct occupational risk.

Male ratio significantly in defect

The occupations with male standardized mortality ratios significantly smaller than that of all males are tabulated in Table 2. As will be seen there are six occupations in which the married women also had a significantly low mortality: wives of retail proprietors in grocery, etc., professional engineers, agricultural and gardeners' labourers, teachers (excluding music teachers), bank and insurance officials, and farmers and their relatives.

At the other end of the scale, however, the wives of coal hewers and getters have standardized mortality ratios significantly in excess of that of all married women, while *probable* significance is observed for the ratios of wives of boiler firemen and stokers.

Table 3. *Showing the* s.m.r.s *(standardized mortality ratios) from phthisis in occupations in which the males'* s.m.r.s *are not significantly different from that of all males (i.e. 100) and the* s.m.r.s *of the wives whose husbands follow such occupations.* 1930–2

	Age 20–65	
Occupations of the males	Males	Wives
Male s m r. not significantly different from that of all males		
(2) Wives' s m r. probably significantly in excess of that of all wives.		
Skilled workers in the gas service	126	150
Coal miners—'other' workers above ground	99	120
(3) Wives' s m r. not significantly different from that of all wives.		
Makers of alcoholic drinks	120	111
Water transport—bargemen and boatmen	110	125
Textile dyers	105	100
Furnacemen, rollers and their skilled assistants	104	118
Textile spinners—cotton	94	82

The large group of occupations for which the wives showed no significant difference from the average is composed largely of railway workers and coal miners other than hewers and getters. For the group of railway workers it is clearly not so much a case of domestic environment being the more harmful, but rather the probability that healthy males (since they are subjected to initial medical examination) employed in selected occupations marry equally healthy women.

Male ratio insignificantly different

The occupations not yet considered consist of those for which the male ratios are insignificantly different from the standard of all males. These are shown in Table 3 from which it will be seen that for the majority of the occupations there were insignificant differences between the wives ratios and their standard. There were only two occupations, skilled workers in the gas

service and coal miners ('other' workers above ground), in which the ratio for the wives exceeded the average, the respective values being 150 and 120, but these indices are only of borderline significance.

In view of the fact that only isolated occupations show ratios of any striking difference between male and married women it is of little immediate interest to examine the data as a whole or in broad groups of occupations. It would appear that phthisis is manifest only in a few occupations as the result of an inherent risk; this is evident both from the examination just made and also from the social class examination made earlier. That the presence of a direct risk distinguishable from the home risk is confined to a small number of occupations is further demonstrated by the correlation between the standardized mortality ratios of males and married women, the coefficients of which are:

$$\text{Ages 20–65} \quad \text{43 observations} \quad r = 0\cdot 644 \pm 0\cdot 089$$
$$\text{Ages 35–65} \quad \text{32 observations} \quad r = 0\cdot 628 \pm 0\cdot 107$$

DISCUSSION

In the previous pages an attempt has been made to separate the effects of the direct from the indirect risks in occupational mortality. Admittedly the index of the indirect risk—the mortality amongst wives whose husbands worked at particular occupations—is an approximate one but it is the best available for the purpose in view. In an investigation of this character the importance of selection must be borne in mind. Because the mortality in an occupation is excessive one cannot necessarily deduce that the trade or the specific processes it involves is dangerous to health. It is generally recognized that tin miners have a very high mortality from respiratory tuberculosis as a direct consequence of the inhalation of siliceous dust. On the other hand, costermongers have an excessive mortality from most diseases partly due to extreme exposure to weather but, in the main due to the particular type of persons who follow this occupation. They are mainly recruited from a particular class and their ranks are often augmented by men whose health deteriorated under the strain of more strenuous occupations. Furthermore, the men marry within their own social classification—an unhealthy one—and the wives engage in the occupation. They usually live in overcrowded and fetid conditions. Hence for this particular trade there is the aggregated experience of an unhealthy stock, an indifferent and precarious livelihood both superimposed on a poor domestic environment. Under these circumstances it is difficult to differentiate the respective contributions made by the direct and indirect risk.

The most stringent test which can be made to indicate the effects of the direct risk is an association of a male mortality significantly in excess of the average with that for wives significantly in defect of their standard. From the occupations studied in this paper there is none which fulfils this condition and only one, hairdressers, which approximates to this requirement.

The excessive mortality from phthisis of males and females is evident amongst dock labourers, unskilled workers and horse drivers, and reasons have been previously stated which would explain the circumstances governing the combinatory excess for this section of occupied workers.

There is one occupation, coal hewers and getters, in which the wives have a standardized mortality ratio significantly greater than that for married women, whereas that for males is subnormal. In 1931 hewers and getters formed 59·5% of the underground workers and 67·2% of those aged 25–55, that is to say they formed the largest proportion of those doing heavy manual work in the age groups in which married men with families would predominate. The period 1930–2 was one of severe economic depression and short time. It has often been said that when income is restricted and the bread-winner is engaged on heavy work, his wife tends to go short of necessary food that the children may be fed and the husband able to carry on. If this is so, a reasonable explanation of the excess mortality of wives from tuberculosis is provided. It is not possible to test the explanation further by means of the data under analysis, but nothing inconsistent with it has been found.

The mortality from phthisis in forty-three occupations has been given in some detail in the previous tables, but it is possible to represent succinctly the experience for males and wives in a table like the following in which the ratios for males significantly or probably significantly in excess of their standard (+), not statistically different from the standard (=), significantly or probably significantly in defect (−) were combined with a similar series for wives.

| | | Males | | | |
		+	=	−	Total
	+	10	2	2	14
Wives	=	7	5	6	18
	−	2	0	9	11
	Total	19	7	17	43

Of the nineteen occupations in which the male phthisis was in excess there were ten in which the wives had a similar experience and two in which the values for the wives were subnormal. In seventeen occupations the male experience was below normal and for fifteen of these the ratio for wives was either equal to their average or in defect of their specific standard.

CONCLUSION

From the data examined it would appear that the influence of the direct occupational risk is not readily distinguishable from that of the indirect in the causation of pulmonary tuberculosis. Possibly the available statistics are too imperfect to differentiate the respective risks. There are, however, two occupations in which a difference exists: hairdressers have an excessive phthisis mortality but that for wives of hairdressers is subnormal. The wives of hewers and getters in the coal fields have an excessive mortality but that for men is less than the average.

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