CARDIOVASCULAR DISEASE IN COTTON WORKERS: PART I

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Since 1891 the Registrar General for England and Walés has recorded high death rates from cardiovascular diseases among cotton workers. Although the health of the cotton worker has been the subject of numerous investigations, there is no other evidence of either excessive mortality or morbidity from cardiovascular disease in the cotton trades.

In this paper we attempt to elucidate this problem by a further analysis of the Registrar General's evidence. In another paper the results of a detailed clinical examination of more than 300 men employed in the cotton textile mills of Lancashire will be described.

A brief description of the processes used in preparing and spinning raw cotton must be given, so that the terms used to define occupational groups can be understood. Fine cotton dust has been suggested as the cause of this high cardiovascular mortality and the degree of exposure to dust of the different groups of workers will therefore also be discussed.

Preparation and Spinning of Raw Cotton

Raw cotton arrives in this country in tightly compressed bales, which are opened in the "cotton chamber" or "opening room". The cotton is then cleaned by removing short fibres, dust, and dirt by a pressure blowing process in the blowing room. The man in charge of this process is called the "blow room major", and those under his charge "blow room workers". They are exposed to fine dust and dirt emitted in the cleaning process. The cotton, now partially cleaned, passes in the form of a lap to the card room, where the cotton fibres are further cleaned and at the same time drawn out into parallel lines. This operation is done by a carding engine. The carder and his deputy (the under-carder) are in charge of the card room, in which the most important operative is

the stripper and grinder. He strips the dust and cotton fibre adhering to the wire teeth of the carding engine, and sharpens the wire teeth by means of revolving rollers covered with emery.

Carding engines, which are not usually enclosed, are continually emitting dust, but during the stripping process much more dust is given off (Figs. A and B). The stripper and grinder is, of all the cotton workers, the one most heavily exposed to fine dust. The carder and under-carder are nearly always promoted strippers and grinders. After carding the cotton is prepared for spinning, which in itself is not a dusty process. But spinning rooms of the raw cotton industry are sometimes continuous with card rooms, so spinners may be exposed to dust—but not to the same extent as card and blow room workers. Weavers handle only spun cotton and have little contact with fine cotton dust and dirt emanating from raw cotton.

Respiratory Disease Among Cotton Workers

Byssinosis, a respiratory disease suffered by cotton workers exposed to dust, will be briefly described because it has influenced cardiovascular mortality.

Greenhow (1861) was one of the first British observers to describe a respiratory disease in the cotton trade characterized by difficulty in breathing. He recorded that "card room workers were very apt to become asthmatical about middle life and that few were long lived". This disease was later named "card room asthma", or "strippers' and grinders' asthma". It is now called "byssinosis". It has three stages, which were defined in the Report of the Departmental Committee on Dust in Card-rooms in the Cotton Industry (1932).

The first stage, that of irritation, usually occurs after the worker has been exposed to cotton dust for five to 10 years. He notices tightness of his chest when he returns to work after a short absence. Characteristically it affects him after the week-end

FIG. A

FIG. B

FIG. A.—Photograph of strippers and grinders brush-stripping a carding engine by the modern method with exhaust ventilation locally applied to the brush. [Photograph by Cotton Board.]

FIG. B.—Strippers and grinders brush-stripping a carding engine by the old methods, which had no exhaust ventilation of the stripping brush. [From Legge's "Industrial Maladies", Oxford University Press.]

break and hence it has been called the "Monday feeling". The worker complains of dyspnoea, fatigue, and sometimes cough. By the next day he has recovered completely. This condition may persist without progression until he leaves the industry. Freed from exposure to dust, all symptoms cease and there is no residual disability.

In the second stage of byssinosis there is a gradual progression of symptoms, which appear on days other than Mondays, but symptoms cease when there is no exposure to dust. Many of those who reach the second stage become progressively worse and pass into the third stage—that of disabling byssinosis. Tightness of the chest and effort intolerance are now present every day and are so severe that the worker eventually has to give up his job. If he leaves it he usually has some relief, or at least the progress of the disease is checked, but effort intolerance remains a permanent disability. The aetiology of this disease is not fully understood, but the hypothesis which is usually advanced is that there is, in cotton dust, some protein allergen, either of vegetable origin, or derived from micro-organisms or fungi which are known to grow freely in the cotton and to be widely distributed in the atmosphere of card and blow rooms. The allergen, after a time, sensitizes the bronchial mucous membrane, and further exposure to dust elicits bronchospasm and possibly swelling of the bronchial mucous membrane. This condition is reversible, but in workers with a high degree of sensitivity, and after prolonged exposure, the cough and spasm give rise to emphysema, which is probably the main cause of the permanent disability.

Cardiovascular Mortality

The first reference made to cardiovascular mortality among cotton workers by the Registrar General is in his Annual Report for 1891. He found that, compared with occupied males, the mortality of cotton operatives showed an excess of one-fifth from circulatory diseases. Ten years later, in 1901, the Registrar General records a slight excess in the death rates of cotton workers from circulatory diseases and Bright's disease. Collis (1909) who was enquiring into the incidence of respiratory disease among card room workers in a clinical examination found that 91% of men working in the coarse grades of cotton were affected, but made no reference to diseases of the heart or allied conditions among these cotton workers. In his report for the triennium 1910–12, the Registrar General for the first time gives the deaths separately for two occupational groups within the cotton industry, strippers and grinders and blow room

hands, instead of putting all cotton workers together. This report, being delayed by the first world war, was published in brief, and the figures are given without any comment. A further analysis of these figures, shown in Fig. 1 reveals that for all cotton workers taken together there is significant mortality excess from cardiovascular disease and nephritis over all males at 45 years of age and above, but there is no significant difference between the rates for the three occupational groups inside the cotton industry.

In the 1921 Decennial Supplement which refers to the triennium 1921–1923, the Registrar General reports once again high death rates for cardiovascular disease and nephritis among cotton operatives. He makes this comment. "It appears that conditions of work in textile mills promote degenerative changes of the kidneys, heart and blood vessels". In his evidence to the Departmental Committee on Dust in Cardrooms (1932) Dr. Stevenson, representing the Registrar General, further emphasized the importance of circulatory disease as a cause of death among cotton operatives. Basing his evidence on the Registrar General's

FIGURE 1
DEATHS FROM CARDIOVASCULAR DISEASES & NEPHRITIS *
1910-1912
RATES PER 1000

* Includes acute nephritis, Bright's disease, cerebral haemorrhage apoplexy, V.D.H., angina pectoris, arteriosclerosis and other circulatory diseases.

Figures above columns are number of deaths upon which the rates are based.

reports for 1910-12 and 1921-23, he concluded that the circulatory type of disease rather than respiratory disease was the more important occupational risk for card and blow room operatives. No medical witnesses who came before this committee could express an opinion as to the inference which might be drawn from Dr. Stevenson's observations, and none apparently could support them with clinical evidence.

In the next Decennial Supplement for the triennium 1930-32, the latest published, the Registrar General reports the same trends in mortality rates for cardiovascular disease and nephritis, but he reminds his readers that these rates are high for all males resident in regions North III (York County Borough and West Riding of Yorkshire) and North IV (Lancashire and Cheshire) which contain 82% of all male textile workers (including woollen workers), but that the excess could not be explained by the presence of textile workers alone.

There have been two explanations given for the high death rates of cotton workers from cardiovascular diseases: both are apparently based on the occupational mortality statistics of the Registrar General. First, a leading article in the *British Medical Journal* (1947) contained a statement that "the inhalation of textile dusts is a steady source of death from nephritis and a group of conditions whose common factor is hyperpiesis". Second, Platt (1947a), examining the evidence on which this statement was based, suggests that the deaths from so-called nephritis are in all probability due to hypertension, and further suggests that a higher incidence of hyperpiesis could be as easily explained by hereditary factors operating in an inbred population in Lancashire cotton towns as they could by environmental influences. This suggestion is made on his own observations (Platt, 1947b), and those of others, that heredity is the most important factor in the aetiology of hypertension. In support of his thesis he points out that the increased incidence

of cardiovascular disease which would be expected in the surrounding population (North IV) from this mechanism is in fact recorded by the Registrar General.

The proposition that these deaths were predominantly due to hyperpiesis is plausible. In the early 1930s the general practitioner did not often take blood pressure readings, hence hypertension might have been missed, whether as a cause of death or sickness. Moreover, it may well be the commonest single cause of heart disease over the age of 45.

In addition, this hypothesis is supported by examining the death rates of cerebral vascular disease, which is more likely than any other disease to be the end result of hyperpiesis. There is a significant excess for strippers and grinders at ages 55-64 in the 1930-32 triennium (Table 1).*

Morbidity of Cotton Workers

There have been two important enquiries into the sickness experience of cotton operatives, that of Bradford Hill (1930) and of Harvey (1939). Bradford Hill compared the sickness records of strippers and grinders and other card room workers with those of warehousemen and ring-room men in the period 1923-27. After the age of 30 the sickness rates for respiratory disease of strippers and grinders and other card room workers were two to three times as high as those of the control group of men working in the same industry but not in the dusty rooms. When respiratory diseases were excluded, the card room workers had somewhat less sickness than male workers in the ring-room and warehouse. Harvey examined morbidity rates for 1935-36 and confirmed these findings of Bradford Hill. In neither enquiry was the sickness from circulatory diseases considered separately, but there was no evidence that it was excessive.

* For 1921-23 the rates for cerebral vascular lesions cannot be given separately.

TABLE 1
DEATHS FROM CEREBRAL VASCULAR LESIONS (NUMBERS AND DEATH RATES PER 1,000) IN 1930-32

Age	All Males		Social Class III		Cotton Weavers		Cotton Spinners		Strippers and Grinders	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
25-	154	0.0	72	0.0	1	(0.0)†	—	—	—	—
35-	735	0.1	350	0.1	4	(0.1)	3	(0.1)	—	—
45-	3291	0.5-	1427	0.5-	13	0.5	10	0.5	—	—
55-	10621	2.0	4503	2.0	60	2.4	49*	3.4	13*	6.4
65-69	9322	5.4	3933	5.7	51	7.4	34	6.9	2	(4.9)

† Rates are in brackets when based on less than 10 deaths. * Difference statistically significant ($P = .02$).

Further Analysis of the Registrar General's Mortality Figures for 1921-23 and 1930-32

Male Cotton Workers: Social Classes III and IV and All Males.—A comparison is made between the cardiovascular death rates for three principal occupations in the cotton industry for the triennia 1921-23 and 1930-32. They are compared with rates for all males and males of a corresponding social class.* Deaths from nephritis, cerebral vascular lesions, arteriosclerosis and all heart diseases have been considered together. Blow room workers could not be included as their death rates are not given separately for the triennium 1930-32 as they are for 1921-23. In the Appendix the populations, numbers of deaths and rates for each period and occupational group are given in detail (Table A). As the respective rates for the two periods show the same trends, the arithmetic means of the rates of the two triennia are given in Fig. 2 to simplify an elaborate table, but for both periods it must be stressed that the actual numbers of deaths of strippers and grinders are very small. From the age of 55 the three cotton groups have a significant mortality excess from cardiovascular disease over all males and males in Social Classes III and IV.† More interesting is the difference in the mortality rates of the three cotton groups: weavers, spinners, and strippers and grinders.

Weavers, who probably have the least exposure to dust of the three, tend to have the lowest death rates, while strippers and grinders, with certainly the greatest dust exposure, have the highest. This relation between dust exposure and death rates from cardiovascular disease makes the influence of heredity alone seem to be an unlikely cause of this high mortality. It strongly suggests an occupational influence.

In the triennium 1910-12 there is little difference between the mortality rates of strippers and grinders, blow room workers and a large group comprising the remainder of the cotton textile operatives. This appeared to be evidence against the influence of dust on mortality. When considering the development of measures for removing stripping dust, the Departmental Committee on Dust in Cardrooms reported that exhaust ventilation for stripping was introduced in some mills in 1909, but it was not until 1913 that exhaust ventilation was in general use. This may mean that dust in card

rooms was excessive in the years before 1910-12 and sufficient to spread to the adjacent spinning rooms and produce its ill effects on spinners and others working in the spinning rooms near the carding engines. Thus the advantage in cardiovascular mortality of the latter group over strippers and grinders, shown in later years, may be the result of reducing the stripping dust by exhaust ventilation and preventing it reaching the spinning rooms in sufficient concentrations to produce ill effects, but not reducing it sufficiently to favour the strippers and grinders, whose cardiovascular mortality rate actually rose between 1921-23 and 1930-32. This will be discussed later.

Cotton Workers and Their Wives.—A comparison of husbands' and wives' death rates is often used to measure the influence of occupation on health. For cotton workers it cannot be such a reliable index as for most other classes of worker, because the cotton operatives' wives usually work in the same industry as their husbands and are exposed to

FIGURE 2
DEATHS FROM CARDIOVASCULAR DISEASES & NEPHRITIS*
RATES PER 1000
MEAN OF 1921-3 AND 1930-2 RATES

* All these occupations are now graded by the Registrar General as Social Class III; formerly strippers and grinders were Social Class IV. Stripping and grinding is an apprenticeship trade, and at the present time is comparable financially with the other cotton groups. In the two periods considered, however, strippers and grinders' wages were lower, and hence Social Class IV is included for comparison with them.

† This is not statistically significant for weavers aged 55-64 for 1930-32.

* Includes nephritis, cerebral vascular lesions, arteriosclerosis and all heart diseases.

Note: The figures upon which this diagram is based are given in the appendix, Table A. The actual number of deaths in each triennium are small for cotton workers, particularly for strippers and grinders, and the above diagram should not be used without reference to Table A.

the same influences. But the stripper and grinder is more heavily exposed than any other worker, male or female.

In 1930-32 the rates for cardiovascular diseases for all males, cotton spinners, strippers and grinders, males in Social Class III and their wives, show that at ages 55-64 strippers and grinders appear to have a proportionally higher death rate over their wives than the other groups have over their wives. Details of these rates are given in Table B in the appendix.

Secular Changes in Death Rates.—Both respiratory and cardiovascular death rates for cotton operatives for different periods should be considered. If these deaths are directly or indirectly associated with the inhalation of dust, they should show a decline over a period of time during which dust exposure has been steadily and substantially reduced. It is well known that in the card rooms of the Lancashire cotton mills such a reduction in dust exposure has occurred from 1913 onwards. The older strippers and grinders and carders working today can remember the days when the stripper could hardly see his mate on the other side of the carding engine because of the thick clouds of dust emitted during the stripping process. They all speak of the great improvement in conditions resulting from fitting the stripping brush with an exhaust appliance, from vacuum cleaning, or from air conditioning.

Fig. 3 illustrates the secular changes in these death rates since 1910-12 for all males and strippers and grinders. Weavers' and spinners' rates can only be given for 1921-23 and 1930-32.

Respiratory deaths show a very marked decline for strippers and grinders between 1921-23 and 1930-32, while rates for all males were falling gradually. Weavers and spinners show higher rates than all males in 1921-23, but these rates had fallen to the same level as all males 10 years later. These figures seem to confirm that dust reduction has definitely had a beneficial effect on respiratory deaths of strippers and grinders. They also support the hypothesis that other cotton workers have benefited from dust reduction. Cardiovascular deaths, however, do not show the same trend. For all males, and strippers and grinders, rates rose between 1921-23 and 1930-32, but in the same period fell for weavers and spinners. Between 1910-12 and 1921-23 rates for all males were declining, while those for strippers and grinders were increasing.*

To sum up the main findings so far: the association between dust exposure and cardiovascular mortality for the triennia 1921-23 and 1930-32, and the significantly high death rates of strippers and grinders from cerebral vascular lesions, suggest that the inhalation of cotton dust may give rise to

* The rates for 1910-12 are not strictly comparable with the subsequent two periods, because "other circulatory diseases" as well as "heart diseases" are included in these years.

FIGURE 3

STANDARDISED DEATH RATES

STANDARDISED ON 1921 CENSUS ALL MALE POPULATION AGES 25-69 YEARS
RATES PER 1000

A. CARDIOVASCULAR DISEASES AND NEPHRITIS

B. RESPIRATORY DISEASES

The 1910-12 figures are not strictly comparable with the other years, being slightly overstated.

cardiovascular disease and this may be hypertensive.

It would be difficult to explain this higher mortality by heredity alone because of the significantly different cardiovascular mortality rates of strippers and grinders and the other cotton workers who are living and working in the same Lancashire towns.

But while respiratory death rates of strippers and grinders were declining over a period when methods of dust control were steadily improving, their cardiovascular death rates rose somewhat. This does not support the hypothesis that cotton dust causes cardiovascular disease.

The reliability of cardiovascular mortality rates and possible causes of this conflicting evidence must now be examined.

Sources of Unreliability in Mortality Rates

Many doctors certify multiple causes of death from which the Registrar General must select one for computing death rates for specific diseases. General practitioners often cannot verify their diagnoses either by necropsy or special investigation. Thus both the Registrar General and the general practitioner introduce possible sources of error into the mortality rates ascribed to specific diseases. And as the habit of multiple certification has become more common in recent years, the secular trends in the mortality rates of certain diseases may therefore be seriously misleading.

Multiple Certification.—When the medical practitioner gives more than one cause of death on the certificate the Registrar General selects one according to certain rules. In 1921–23 and 1930–32 any definite disease of the heart or kidneys was preferred to any disease of the respiratory system when both were mentioned together. In 1939 the Registrar General's selection rules were revised. Preference is now given to the disease which, as far as can be ascertained was, in the opinion of the certifying medical practitioner, the starting point of the sequence leading up to the immediate cause of death. The effect of adjusting bronchitis and cardiovascular death rates for 1921–23 and 1930–32 in the light of this revision cannot be shown accurately, but it is possible to get some idea of the likely change from two different sources—the Registrar General's statistics for 1939 (the year of change), when he classified all the death certificates according to both new and old rules, and from a study of the death certificates of card room workers, supplied by the trade unions. The latter is a source of information often available but seldom used.

The relevant conclusion of the Registrar General (1947) as regards our particular problem is :

“Bronchitis and asthma death rates have been affected considerably . . . by the increasing mention of myocardial degeneration as a contributory cause of death and consequent classification by the (old) rules of selection, of increasing numbers to heart disease.”

He gives conversion factors so that an estimate may be made of the number of deaths before 1939 from diseases of the myocardium among the general population which would be put back to respiratory deaths if the new selection rules applied. For bronchitis in *all* males there is added 0.237 times the number of deaths which were previously ascribed to diseases of the myocardium. But for groups with a high respiratory mortality a higher proportionate transfer should be made. There is, however, another method available for the very necessary interpretation of the Registrar General's rates of cardiovascular and respiratory mortality before 1939. But it must be emphasized that it is a highly tentative procedure. In 1939, when deaths were given classified under both rules, the bronchitis deaths under the new classification were increased by transference from disease of the myocardium, endocarditis, and arteriosclerosis from amounts varying from 30% at ages 25–34 to 114% at ages 65–69. If these age-specific conversion factors are applied at the appropriate ages, the death rates from cardiovascular causes in 1930–32 are reduced by the following amounts for ages 25–69 (Tables C and E).

Weavers	..	..	..	..	..	8%
Spinners	..	..	..	..	..	10%
Strippers and grinders	..	..	..	..	..	24%
All males	..	..	..	..	..	10%

We have assumed that practitioners combined bronchitis and heart diseases on their death certificates in much the same proportions in 1930–32 as in 1939 and that the practice was similar among practitioners in cotton areas as elsewhere.* We have no means of verifying these two proportions, but if our assumptions are reasonable, cardiovascular death rates for strippers and grinders would be reduced under the new system of classification by more than twice as much as the similar rates for all males and the other cotton groups.

Death certificates of 256 card and blow room workers, or known ex-card and blow room workers, of all ages in the Rochdale, Oldham, and Bury areas, obtained from the trade unions, were examined. These covered a period from 1941 to 1948. In Fig. 4 the effect of the change in methods of classification is shown for the 25–69 age group in which there were 164 deaths.

* As multiple certification continued to increase between 1930 and 1940 we may have overestimated the reduction.

FIGURE 4

**CLASSIFICATION OF CAUSE OF DEATH
OF 164 CARD AND BLOW ROOM WORKERS**

1941-1948

AGES 25-69

Of the 24 additional deaths from respiratory causes under the new system of classification, 19 were transferred from diseases of the myocardium, three from endocarditis, one from "other heart diseases", the remaining one coming from chronic rheumatism. This transference lowers the cardiovascular death rate for ages 25-69 by

$$\frac{23}{67} \times 100 = 34\% *$$

This compares with the 24% estimated by the other method.†

The Registrar General (1949) records that in the 1921-30 decennium 33% of all death certificates for non-violent deaths gave "multiple" causes. By 1935 this proportion in all death certificates had risen to 43%. It is reasonable to infer that there

* In addition to transferring 23 deaths from cardiovascular to respiratory causes, two other deaths were transferred to the cardiovascular group from other causes, giving a net loss of 21 deaths as shown in Fig. 4.

† For all ages, the transference lowered the cardiovascular death rate by 30%.

was a substantial increase in multiple certification between 1921-23 and 1930-32, which would mean that a higher proportion of respiratory deaths would be allocated to cardiovascular deaths in the latter than in the former triennium. This may be a possible explanation of the opposite secular trends in cardiovascular and respiratory mortality, and in fact both these death rates may have been falling.

The North IV (Lancashire and Cheshire) region in 1930-32 showed a mortality excess from respiratory diseases over all males at all ages. Some of the cardiovascular mortality excess for this region can be similarly explained. But, even after reclassification by the methods given above, death rates for heart disease and nephritis for males in North IV are still significantly greater than rates for all males at ages 45 and over, but spinners and strippers and grinders have higher rates than North IV at ages over 55 (Table D). These high cardiovascular death rates for North IV cannot be explained.‡

Errors in Diagnosis.—It is not possible to be certain about the effects on mortality rates of using vague terms to describe causes of death, or of frank errors in diagnosis. The cardiovascular group of diseases includes myocardial disease and degeneration which are vague labels used for diseases in which the exact pathology is not known. The use of "heart failure" as a cause of death is not favoured by the Registrar General, and for these diseases of uncertain pathology in which cardiac failure is the terminal result, the general practitioner undoubtedly uses "myocarditis" and the like in order to avoid enquiries about his certificates.

We have considered the reallocation to respiratory deaths of certificates on which both cardiovascular and respiratory causes are mentioned; but it is probable that there are some death certificates with no mention of respiratory disease, even though such a disease was the starting point of the pathological changes leading to death. And it is also probable that such an event occurs even more often among cotton workers exposed to dust than among all males or men of the same social class, for reasons which will now be discussed.

Byssinosis has been repeatedly described as a disease which closely simulates chronic bronchitis and emphysema, but O'Sullivan found that among 33 men suffering from disabling byssinosis 12 had no clinical evidence of bronchitis. Shaw Dunn, and Sheehan (1932) did necropsies on 10 cotton mill workers, nine of whom had been exposed to dust; while all of these nine had some evidence of

‡ It is of interest that in 1947-8 a similar excess for heart disease is still present, in spite of the new methods of classification.

chronic bronchitis and emphysema, six showed hypertrophy of the right ventricle, four of whom died of congestive cardiac failure. Thus cotton workers with disabling byssinosis, with its characteristic asthmatic symptoms, may present a clinical picture of cardiac asthma or congestive cardiac failure, which so masks the respiratory disease that it is not mentioned on the death certificate.

For nephritis it is possible to make more definite assumptions about mistakes in diagnosis.

Platt (1947a) suggests that most of the deaths assigned by the Registrar General to nephritis in the older age groups are not renal deaths at all. In his own 161 cases for which full records were available, the main incidence of deaths from nephritis was under the age of 45. The Registrar General's figures for age incidence are totally different, with the main mortality over the age of 45. Platt's own experience is that many cases of hypertensive cardiac failure with albuminuria are diagnosed by their general practitioners as chronic interstitial nephritis.

Nephritis death rates are particularly high in certain occupations. Greenwood and Russell (1938) showed that in the 1921-23 triennium the textile trades, pottery dippers and file cutters, all of whom had high nephritis death rates also had a high risk of dying from respiratory disease.

For all occupations there is a significant correlation between the standardized death rates for bronchitis and nephritis in 1921-23 (Table 2). In 1930-32 the same type of occupations appear to have high nephritis death rates—blow room workers and foremen, strippers and grinders, and cutlers—but for this period, as shown in Table 2, there is a significant correlation between the standard mortality ratios of bronchitis and nephritis only for Social Classes III and IV. A possible explanation for this relationship is that many of the men in these trades died of congestive cardiac failure caused by respiratory disease and were certified as nephritis deaths.*

Thus there is some evidence that medical practitioners may fail to distinguish renal disease from other diseases which in their terminal stages simulate

renal disease. It seems possible, therefore, that the mortality excess from nephritis in cotton workers may be due to deaths from respiratory disease, which terminates as congestive cardiac failure. If, however, occupational influences cause hypertension, as has been suggested, there will be another reason for high "nephritis" death rates in cotton workers.

Conclusions

In order to get a clearer picture of any occupational mortality excess due either to cardiovascular and respiratory diseases for the triennium 1930-32, cardiovascular and respiratory deaths are given in Fig. 5, added together, for the cotton trades, for all males, and for males of similar social classes to the cotton workers. The occupational hazard of the cotton trades, particularly of the stripper and grinder, is obvious. We know that most of this is respiratory and that in the past respiratory mortality of cotton workers has almost certainly been underestimated; but when a correction is attempted for the respiratory deaths allocated to the cardiovascular group of diseases, there still seems to be an excess of cardiovascular deaths for the cotton workers and particularly so for the strippers and grinders. Thus there may be a real excess of heart disease due to occupational influences. The latter possibility is so important in view of the very high national death rate from cardiovascular diseases and the absence of information on its relation to environmental factors that this clue must be followed up. As Morris (1951) said, cardiovascular disease of middle and old age is one of the darkest areas of vital statistics and at present the main source of information must be the mortality rates. In another paper the results of a clinical investigation of more than 300 men employed in cotton textile mills will be described.

* In the same paper Greenwood and Russell drew attention to the high nephritis death rates in barmen and inn and hotel keepers for whom an excess of alcohol is probable. In the triennia 1921-23 and 1930-32 there is a significant correlation between standardized death rates for nephritis and cirrhosis of the liver. It is possible that this correlation is due to some cases of cirrhosis of the liver which terminally have oedema being misdiagnosed as nephritis. Fishberg (1939) quoting his own experience and that of others is very sceptical of the role of alcohol in producing renal disease.

TABLE 2
CORRELATION BETWEEN NEPHRITIS AND BRONCHITIS (AGES 20-64 YEARS)

Nephritis and Bronchitis	<i>r</i>	No. of Groups	<i>P</i>
1921-23*	.38 ± .04	164	<i>P</i> < .001
1930-32†	.22 ± .12	71	Not significant
1930-32 (Social Class III-V)	.44 ± .13	59	<i>P</i> < .01

* From Registrar General's Decennial Supplement, based on C.M.F.'s of all trades and referring to chronic nephritis only.

† Based on S.M.R.'s of trades with 10 or more deaths, and referring to acute and chronic nephritis.

Summary

Since 1891 the Registrar General has recorded high death rates from cardiovascular diseases among cotton workers.

It has been suggested that this mortality excess may be due to hyperpiesis caused either by the inhalation of textile dusts or by inbreeding in Lancashire cotton towns.

In this paper the Registrar General's figures are analysed principally for the triennium 1930-32 (the last to be published). It is shown that in the three occupational groups studied, strippers and grinders, weavers and spinners, there is an association between mortality and the extent of dust exposure.

The significantly high death rate of the strippers and grinders (the occupation with the highest dust exposure) from cerebral vascular lesions supports the hypothesis that hyperpiesis may be the cause of this mortality excess.

Two sources of unreliability in mortality rates are discussed. (1) Since 1920 medical practitioners have entered multiple causes of death with increasing frequency on death certificates. The Registrar General makes rules for selecting one cause of death from certificates with multiple causes. Before

1939 these rules exaggerated cardiovascular mortality and reduced respiratory mortality. Since 1939 more reliable methods of selection have been used, and some of the cardiovascular mortality of cotton workers who it is known have high respiratory death rates from byssinosis can be explained simply by methods of book-keeping. (2) The use of convenient though vague terms such as "myocarditis" to describe causes of death, and errors in diagnosis, particularly of nephritis in the older age groups, may also exaggerate cardiovascular death rates.

When all possible corrections are made for the exaggeration of cardiovascular mortality through the erroneous allocation of respiratory deaths to it, there still remains an excess of cardiovascular mortality particularly for strippers and grinders. This may well be real and may be due to occupational influences.

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APPENDIX

In the Appendix which follows the information discussed in the text is tabulated and arranged for comparison with the figures given by the Registrar General.

Table A. Deaths from Cardiovascular Diseases and Nephritis, 1921-23 and 1930-32.

Table B. Deaths from Cardiovascular Diseases and Nephritis for Males Compared with Wives. 1930-32.

Table C. Deaths from Cardiovascular Diseases and Nephritis. 1930-32.

(a) As given by the Registrar General.

(b) After correction for new system of classification.

Table D. *Deaths from Heart Diseases and Nephritis. 1930-32.

(a) As given by the Registrar General.

(b) After correction for new system of classification.

Table E. Deaths from Respiratory Diseases. 1930-32.

(a) As given by the Registrar General.

(b) After transfer of cardiovascular deaths to respiratory deaths by applying correction for new system of classification.

* Heart diseases and nephritis are given so that the necessary comparisons can be made with North IV for which the Registrar General does not give all cardiovascular deaths.

TABLE A

DEATHS FROM CARDIOVASCULAR DISEASES AND NEPHRITIS (NEPHRITIS, CEREBRAL VASCULAR LESIONS, ARTERIOSCLEROSIS, HEART DISEASE, INCLUDING V.D.H.) IN THE PERIODS 1921-23 AND 1930-32

Age Group ..	25-		35-		45-		55-		65-69	
Years ..	1921-23	1930-32	1921-23	1930-32	1921-23	1930-32	1921-23	1930-32	1921-23	1930-32
All Males :										
Population ..	2621280	3062282	2496375	2512356	2133179	2302873	1382843	1765509	449363	577970
Deaths (3 Years) ..	4365	3249	7731	6705	16804	19213	33816	46020	25097	37023
Annual death rate (per 1,000) ..	0.6	0.4	1.0	0.9	2.6	2.8	8.2	8.7	18.6	21.4
Social Class III :										
Population ..	1176883	1575602	1075975	1220628	846809	1036087	504706	733163	153053	231536
Deaths (3 Years) ..	1860	1560	3014	3041	6014	8161	12126	18751	8845	15045
Annual death rate (per 1,000) ..	0.5	0.3	0.9	0.8	2.4	2.6	8.0	8.5	19.3	21.7
Social Class IV :										
Population ..	514558	568620	465707	413230	407169	375170	269545	300436	85742	98144
Deaths (3 Years) ..	852	621	1444	1176	3097	3114	6086	7602	4518	6266
Annual death rate (per 1,000) ..	0.6	0.4	1.0	0.9	2.5	2.8	7.5	8.4	17.6	21.3
Cotton Spinners :										
Population ..	9201	11720	7687	7159	6058	6353	3718	4819	793	1646
Deaths (3 Years) ..	34	15	31	18	52	50	133	178	78	135
Annual death rate (per 1,000) ..	1.2	0.4	1.3	0.8	2.9	2.6	11.9	12.3	32.8	27.3
Cotton Weavers :										
Population ..	11819	10729	10294	9537	9563	9071	5385	8230	1595	2310
Deaths (3 Years) ..	34	14	32	30	81	72	198	237	132	191
Annual death rate (per 1,000) ..	1.0	0.4	1.0	1.0	2.8	2.6	12.3	9.6	27.6	27.6
Strippers & Grinders :										
Population ..	1692	1426	1333	1462	907	1139	480	679	117	136
Deaths (3 Years) ..	4	2	4	3	14	12	19	40	18	20
Annual death rate (per 1,000) ..	(0.8)	(0.5-)	(1.0)	(0.7)	5.1	3.5	13.2	19.6	51.3	49.0

Population = Census population of 1921 or 1931. Death rate = Annual rate per 1,000 population. Deaths = Total deaths for the 3 years 1921-23 or 1930-32.

Significance (level taken $P < .05$)

1921-23

Strippers and Grinders significantly different from all groups except other cotton workers, at ages 45-, 55-, and 65-69 ($P < .01$). Strippers and Grinders not significantly different from spinners at age groups 55- ($.7 > P > .5$) or 65-69 ($.1 > P > .05$) or at these two ages together ($.1 > P > .05$).

Strippers and Grinders not significantly different from weavers at age 55- ($.8 > P > .7$) but is significant at ages 65-69 ($.05 > P > .02$). Weavers significantly different from non-cotton groups at ages 55- and 65-69 ($P < .01$).

Spinners significantly different from non-cotton groups at ages 55- and 65-69 ($P < .01$). Spinners and weavers not significantly different at any age.

1930-32

Strippers and grinders significantly different from all groups at ages 55-, 65-69 ($P < .01$).

Spinners significantly different from non-cotton groups at ages 55- and 65-69 ($P < .01$). Weavers significantly different from non-cotton groups at ages 65-69 ($P < .01$), but not significantly different from non-cotton groups at ages 55-64 (e.g., all males ($.2 > P > .1$)). Spinners and weavers not significantly different at any age group except 55-64 ($P < .01$).

TABLE B

DEATHS FROM NEPHRITIS, CEREBRAL VASCULAR LESIONS, ARTERIOSCLEROSIS, HEART DISEASE (INCLUDING V.D.H.) IN THE PERIOD 1930-32 COMPARED WITH DEATHS OF WIVES

Age Group	All Males		All Married Women		Social Class III		Cotton Spinners		Strippers and Grinders	
					Males	Wives	Males	Wives	Males	Wives
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
25-	3249	0.4	2751	0.4	1560	0.3	15	0.4	2	(0.5-)
35-	6705	0.9	5595	0.8	3041	0.8	18	0.8	3	(0.7)
45-	19213	2.8	13088	2.3	8161	2.6	50	2.6	12	3.5
55-	46020	8.7	23775	6.5	18751	8.5	178	12.3	95	9.2
65-69	37023	21.4	15011	15.7	15045	21.7	135	27.3	76	32.4

The figures for weavers' wives are not available. Number of deaths = total for 1930-1932. Rate = annual rate per 1,000.

TABLE C

DEATHS FROM CARDIOVASCULAR DISEASES AND NEPHRITIS AND DEATH RATE PER 1,000 POPULATION IN THE PERIOD 1930-32

	Age	(a) Cardiovascular and Nephritis Deaths as in the Registrar General's Decennial Supplement		Number Transferred to Bronchitis*	(b) Cardiovascular and Nephritis Deaths after Transference	
		Number	Rate	Number	Number	Rate
All Males	45- 55- 65-69	19213 46020 37023	2.8 8.7 21.4	1861 4423 4082	17352 41597 32941	2.5 7.9 19.0
Social Class III	45- 55- 65-69	8161 18751 15045	2.6 8.5 21.7	752 1735 1628	7409 17016 13417	2.4 7.7 19.3
Social Class IV	45- 55- 65-69	3114 7602 6266	2.8 8.4 21.3	371 955 886	2743 6647 5380	2.4 7.4 18.3
Spinners	45- 55- 65-69	50 178 135	2.6 12.3 27.3	7.8 11.6 20.6	42.2 166.4 114.4	2.2 11.5 23.2
Weavers	45- 55- 65-69	72 237 191	2.6 9.6 27.6	6.4 18.4 17.1	65.6 216.6 173.9	2.4 8.8 25.1
Strippers and Grinders ..	45- 55- 65-69	12 40 20	3.5 19.6 49.0	1.4 8.7 5.7	10.6 31.3 14.3	3.1 15.4 35.0

* Based on assumptions mentioned on page 83 in the text.

TABLE D

NUMBER OF DEATHS AND RATES PER 1,000 FROM HEART DISEASES AND NEPHRITIS IN THE PERIOD 1930-32

Age	All Males		Social Class III		North IV, 1931-1932		Weavers		Spinners		Strippers and Grinders	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
(a) As given by the Registrar General												
25-	3088	0.3	1484	0.3	392	0.4	13	0.4	15	0.4	2	(0.5)
35-	5927	0.8	2665	0.7	734	0.9	26	0.9	14	0.7	3	(0.7)
45-	15592	2.3	6579	2.1	2007	2.8	58	2.1	40	2.1	11	3.2
55-	33907	6.4	13662	6.2	4088	7.5	173	7.0	123	8.5	24	11.8
65-74	54381	19.0	22044	19.3	5998	22.5	291	26.8	193	26.8	22	31.5
(b) After re-classification*												
25-	2985	0.3	1442	0.3	373	0.4	12	0.4	15	0.4	2	(0.5-)
35-	5439	0.7	2461	0.7	653	0.8	24	0.8	10	0.5-	2.5	(0.6)
45-	13760	2.0	5838	1.9	1696	2.4	52	1.9	32	1.7	9.6	(2.8)
55-	29667	5.6	11999	5.5	3462	6.3	155	6.3	112	7.7	15.6	7.7
65-74	47562	16.6	19231	16.8	4837	18.2	256	23.6	163	22.7	15.4	22.0

* Re-classification based on assumptions mentioned on page 83 in the text. North IV significantly different from all males for all age groups 45 and over ($0.1 > P > 0.01$). Spinners significantly different from North IV for age groups 55-64 ($0.1 > P > 0.01$), and 65-74 ($0.5 > P > 0.1$). Weavers significantly different from North IV for age group 65-74 ($0.1 > P > 0.01$). Strippers and grinders not significantly different from North IV for all separate age groups or for age groups 45-74 together ($P > 0.5$).

TABLE E

DEATHS FROM RESPIRATORY DISEASES (EXCLUDING RESPIRATORY TUBERCULOSIS) IN THE PERIOD 1930-32

Age	(a) As Given by the Registrar General				(b) After Transference* from Cardiovascular Diseases			
	All Respiratory Diseases		Bronchitis		All Respiratory Diseases		Bronchitis	
	No. of Deaths 1930-32	Rate per 1,000 per Year	No. of Deaths 1930-32	Rate per 1,000 per Year	No. of Deaths 1930-32	Rate per 1,000 per Year	No. of Deaths 1930-32	Rate per 1,000 per Year
All Males :								
25-	3148	0.3	339	0.0	3251	0.4	442	0.0
35-	5889	0.8	1012	0.1	6377	0.8	1500	0.2
45-	10357	1.5	2632	0.4	12218	1.8	4493	0.7
55-	13180	2.5	4569	0.9	17603	3.3	8992	1.7
65-69	7897	4.6	3571	2.1	11979	6.9	7653	4.4
Social Class III :								
25-	1392	0.3	137	0.0	1434	0.3	179	0.0
35-	2596	0.7	424	0.1	2800	0.8	628	0.2
45-	4307	1.4	1064	0.3	5059	1.6	1816	0.6
55-	5501	2.5	1792	0.8	7236	3.3	3527	1.6
65-69	3088	4.4	1424	2.1	4716	6.8	3052	4.4
Social Class IV :								
25-	678	0.4	71	0.0	700	0.4	93	0.1
35-	1104	0.9	214	0.2	1207	1.0	317	0.3
45-	1891	1.7	525	0.5	2262	2.0	896	0.8
55-	2538	2.8	987	1.1	3493	3.9	1942	2.2
65-69	1527	5.2	775	2.6	2413	8.2	1661	5.6
Spinners :								
25-	12	0.3	1	(0.0)†	12.3	0.4	1.3	(0.0)
35-	21	1.0	8	(0.4)	24.9	1.2	11.9	0.6
45-	29	1.5	11	0.6	36.8	1.9	18.8	1.0
55-	25	1.7	12	0.8	36.6	2.5	23.6	1.6
65-69	36	7.3	18	3.6	56.6	11.5	38.6	7.8
Weavers :								
25-	15	0.5	4	(0.1)	16.2	0.5	5.2	(0.2)
35-	29	1.0	3	(0.1)	30.4	1.1	4.4	(0.2)
45-	38	1.4	9	(0.3)	42.4	1.6	15.4	0.6
55-	55	2.2	19	0.8	73.4	3.0	37.4	1.5
65-69	26	3.8	15	2.2	43.1	6.2	32.1	4.6
Strippers & Grinders:								
25-	2	(0.5-)	0	(—)	2	(0.5-)	0	(—)
35-	4	(0.9)	1	(0.2)	4.5	(1.0)	1.5	(0.3)
45-	7	(2.0)	2	(0.6)	8.4	(2.5-)	3.4	(1.0)
55-	18	8.8	9	(4.4)	26.7	13.1	17.7	8.7
65-69	5	(12.3)	5	(12.3)	10.7	26.2	10.7	26.2

* In 1939, when deaths were given for both systems of classification, bronchitis deaths under the new system were increased by transference from disease of the myocardium, endocarditis, and arteriosclerosis by the following amounts: 25-, 30.5%, 35-, 48.2%; 45-, 70.7%; 55-, 96.8%; 65-69, 114.3%. These are the conversion factors used here.

† The rates in brackets are based on less than 10 deaths.