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THE PREVALENCE OF COALWORKERS' PNEUMOCONIOSIS: ITS MEASUREMENT AND SIGNIFICANCE

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The British medical public have in the past been so well served by the Registrar-General's mortality data that there has been little interest in other medical indices. They may, too, have been unnecessarily discouraged by imagined difficulties associated with the measurement of such other indices as prevalence and attack rate. As, however, interest in the acute killing diseases subsides and increases in the chronic disabling diseases, it is becoming slowly apparent that mortality rates are insufficient. The Registrar-General, for instance, has to disregard rheumatoid arthritis, and information about excess mortality due to coalworkers' pneumoconiosis can be gleaned only by complicated deductions from death rates from other better-known respiratory diseases.

The prevalence rate is not in itself, from a theoretical point of view, a very satisfactory index in that it is a secondary and not a primary epidemiological measurement. It varies directly with the attack rate and indirectly with the case fatality rate. It is thus possible for similar prevalence rates to represent very different attack and case fatality rates. Prevalence is, however, important for two reasons. In the first place, it measures better than any other index the actual load on the community socio-medically as well as from an administrative point of view. It measures the size of a problem. Secondly, a prevalence study is a necessary first step for "forward-looking" studies designed to measure attack rates and progression rates and the factors influencing them. Both these reasons have led the epidemiological section of the Pneumoconiosis Research Unit (P.R.U.) to carry out measurements of the prevalence of pneumoconiosis in many different populations. The results are summarized in this article. The results of investigations into other aspects of pneumoconiosis have been, or are being, summarized in other papers, *e.g.*, the relationship between radiological category and disability (Gilson and Hugh-Jones, 1955; Carpenter, Cochrane, Gilson, and Higgins, 1956); the correlation between simple pneumoconiosis and exposure to dust (Roach, 1953); the relationship between radiological category and expectation of life (Carpenter and Cochrane, 1956); the factors influencing the attack rate of progressive massive fibrosis (P.M.F.) (Cochrane and Miall, 1956); the factors influencing the radiological progression of P.M.F. (Cochrane and Carpenter, 1956); the tuberculous infectivity of P.M.F. (Carpenter *et al.*, 1956); the effect of exposure to coal dust on the attack rate of tuberculosis (Cochrane *et al.*, 1956); and the relationship between simple pneumoconiosis and bronchitis (Higgins, Oldham, Cochrane, and Gilson, in the press).

Methodology

Terminology.—It has not been necessary to invent any new epidemiological indices. "Death rate", "prevalence rate", and "attack rate" are used in the customary and well defined senses. Only two points deserve comment. The word "incidence" has not been used at all, and "attack rate" has been preferred to "inception rate". "Incidence" is, we think, an excellent word, but its original meaning has been so blunted by regular misuse that to use it is to risk being misunderstood. Stocks (1949) suggested that "attack rate" should be reserved for the rate of appearance of infectious illnesses of short duration, but it seems, in general, a pity to have two designations, attack rate and inception rate, for

what is actually the same rate, and of the two "attack rate" is definitely the more usable. The word "lapse" has been used to describe any member of a defined population about whom some required piece of information was not obtained.

Criteria for the Diagnosis of Pneumoconiosis.—The axiom first propounded by the Miners' Phthisis Prevention Committee at Johannesburg in 1916 that "the radiographic appearance in cases of silicosis affords the most reliable single piece of evidence in establishing the existence and actual stage of the disease in any particular case" is certainly true of coalworkers' pneumoconiosis. When our investigations were started, no simple and valid method for the measurement of disturbances of respiratory function which could be used in the field was available, and in any case disability was known to be a relatively late consequence of pneumoconiosis. Moreover, there are numerous other causes of respiratory disability whose prevalence amongst miners might be quite unrelated to that of pneumoconiosis. We therefore decided to make our measurements of the prevalence of pneumoconiosis solely on radiological grounds. For this purpose, we needed a method of categorizing miners' radiographs which was as "simple, repeatable, discriminating, and as valid" as possible (Gilson and Hugh-Jones, 1955).

Details of the P.R.U. classification have been published on several occasions (Davies, Fletcher, Mann, and Stewart, 1949; Fletcher, Mann, Davies, Cochrane, Gilson, and Hugh-Jones, 1949; Cochrane, Chapman, and Oldham, 1951; Cochrane, Davies, and Fletcher, 1951; Fletcher, 1955a), and it has recently been combined with the French classification to form the basis of the provisional European classification. It therefore requires no detailed discussion here. It consists essentially of (1) a division into simple pneumoconiosis and complicated pneumoconiosis, and (2) a further subdivision into three categories, 1, 2, and 3 of simple pneumoconiosis, and four categories, A, B, C, and D, of progressive massive fibrosis (P.M.F.).

We are here chiefly concerned with the value of the classification in relation to the criteria mentioned above.

Although the apparatus is complex and expensive to construct, the taking of a radiograph is essentially a simple matter, but the question of "repeatability" is rather more complex than usual. There are two different types of repeatability involved—technical repeatability and observer repeatability.

The basic question technically is whether a man can be radiographed on two occasions (several years apart) in such a way that the two films when compared together on one screen will be so similar technically that the radiological readings for change will not be biased in any way by slight differences in technique. It cannot be said that this ideal technique has been achieved yet but great strides have been taken towards it, chiefly by means of (1) the "iontomat", (2) the automatic processing unit, and (3) a powerful generator. This subject has been discussed in greater detail elsewhere (Clarke, 1953 and 1955). The subject of observer repeatability has recently been reviewed by Fletcher (1955a) and requires no further discussion here. Fig. 1 illustrates the sort of repeatability achieved by readers in the P.R.U.

1ST. READING

		1	2	3	A	BCD	Total
	269	10					279
1	15	66	9				90
2		8	73	4	1		86
3			1	21	0		22
A			1	2	23	1	27
BCD						48	48
Total	284	84	84	27	24	49	552

FIG. 1.—Comparison between two independent readings of a 1 in 10 sample of all P.R.U. films of miners and ex-miners in the Rhondda Fach. Identical readings = 500 (90·4%).

Discriminating, from the point of view of radiological classification, refers: (*a*) to the ability of the classification to distinguish those exposed to dust from those not so exposed, *e.g.*, its specificity; and (*b*) to the number of groups into which an unselected group of miners, who have been exposed to dust, can be divided at a predetermined level of reproducibility.

The second criterion has already been discussed in connexion with repeatability where we showed that it was possible to subdivide a complete population of miners and ex-miners into six groups at a 90% level of repeatability (Fig. 1). Further subdivision is possible, *e.g.*, into nine groups (0, $\frac{1}{2}$, 1, 2, 3, A, B, C, D), but the repeatability falls below 90%. We consider, however, that the six groups are sufficient for our purpose.

The first point has been fully investigated by Fletcher (1955a). He concluded that the radiological appearance which has been diagnosed as category 1 simple pneumoconiosis is one which is very seldom read by experienced observers in men without dust exposure and that our radiological category 1 does represent an abnormal appearance attributable to dust exposure.

As the classification was based on follow-up studies of coal-miners, the various categories do represent progressive stages in the radiological manifestations of pneumoconiosis, but more detailed enquiry is necessary to discover its relationship to other methods of assessing the severity of the disease.

The relationship to pathological changes has also been dealt with by Fletcher (1955a). In general, it can be said that the rough correlation is good, but difficulties arise when detailed analysis is attempted owing to the selected nature of necropsy material. Work is in progress at present to see what relationship exists between radiological category of simple pneumoconiosis, the category of simple pneumoconiosis as determined from the lung section, and the amount of dust in the lung. Only subjects killed in accidents are being used.

The relationship with disability has been discussed by several authors recently (Gilson and Carpenter, in the press; Hugh-Jones, 1952; Gilson and Hugh-Jones, 1955). The work has proved particularly difficult as the results obtained depend very much on the population sampled and the interpretation of the results is complicated by difficulties inherent in prevalence data.

Some generalizations are, however, possible. All the results agree in suggesting that P.M.F. is a seriously disabling disease, particularly in the higher age groups, while simple pneumoconiosis only causes very slight disability. The most recent work on random samples of populations suggests that categories 1, 2, and 3 in the 55-64 age group correspond, on the average, to increasing amounts of slight disability although some other factor, unrelated to radiological category of simple pneumoconiosis, appears to cause disability in this group (Carpenter *et al.*, 1956). The validity of the radiological classification thus receives general support.

The relationship of the radiological category to expectation of life has been investigated and discussed by Carpenter and Cochrane (1956). In brief, it can be said that there is little evidence that simple pneumoconiosis shortens life but some that P.M.F. does so. The effect of the latter is probably less than previous work had led us to expect. The results do, however, support the " two-disease " hypothesis (Fletcher, 1955b).

Criteria for Diagnosis of Tuberculosis in Presence of Pneumoconiosis.—The great difficulties of accurate and consistent diagnosis of tuberculosis have been clearly demonstrated and fully investigated (Birkelo, Chamberlain, Phelps, Schools, Zacks, and Yerushalmy, 1947; Yerushalmy, Harkness, Cope, and Kennedy, 1950; Garland, 1949 and 1950; Clayson, Frew, McIntosh, McWhirter, McKinlay, and Stein, 1955), and we have confirmed that the British error is of the same order of magnitude as the American (Cochrane and Garland, 1952). The film reading technique which we adopted in our surveys was the same as that recommended by Yerushalmy, so that our errors in the diagnosis of the presence or absence of shadows suggesting tuberculosis or P.M.F. should be as small as reasonable endeavour can ensure. But the diagnosis of tuberculosis in coal-miners is especially difficult because of the presence of opacities due to simple pneumoconiosis and because shadows due to early P.M.F. have also to be diagnosed, and if possible, distinguished from tuberculous shadows. The appearance of early P.M.F. closely resembles tuberculosis of the reinfection type, and one widely accepted hypothesis suggests that P.M.F. is actually a modified form of tuberculosis. Thus, it may be asked whether it is legitimate or logical to attempt to make the distinction. Mann (1951) argued that the distinction could be made and that it was justified by the different progression shown by opacities which he diagnosed as unmodified tuberculosis compared with those which he diagnosed as P.M.F.

We agree that this distinction can be made if there is a high proportion of healed, inactive reinfection type tuberculosis shown on the films diagnosed as tuberculosis. Cochrane and Garland (1952) have shown that the distinction between " clinically significant "* and " inactive, healed " tuberculosis is one which can be made with reasonable consistency and reproducibility in films of non-miners by experienced observers. In our reading of films of miners without simple pneumoconiosis or category 1, we have therefore classified tuberculosis shadows in this way. On the other hand, in films of miners with category 2 or 3 pneumoconiosis, the distinction between clinically significant tuberculosis and P.M.F. is often impossible. We have therefore combined these two groups under the heading of category A (P.M.F.). The justification of such a procedure is that there is a much higher prevalence

*This term indicates that the tuberculous shadow is one which might be active and whose presence indicates that the subject should at least be kept under observation.

(Cochrane, 1954b) and attack rate (Cochrane and Miall, 1956) of such shadows associated with categories 2 and 3 than with categories 0 and 1, and those shadows associated with categories 2 and 3 behave in general as regards their natural history like P.M.F. Those associated with categories 0 or 1 behave in general like tuberculosis (Mann, 1951). Thus, in summary, the convention we have used for the classification of tuberculosis and P.M.F. is the following:—

	P.M.F.	Clinically Significant Tuberculosis	Inactive Tuberculosis
Miners without simple pneumoconiosis or with category 1 simple pneumoconiosis ..	−	+	+
Miners with category 2 and 3 simple pneumoconiosis ..	+		+

We have already shown in Fig. 1 that the consistency of diagnosis of early P.M.F. according to the above convention by the two observers responsible for all our film readings was reasonably satisfactory. It might be suggested that clinical examination or special tests, such as sputum examination, sedimentation rate, or Middlebrook's agglutination test, might assist in the differentiation of tuberculosis and massive fibrosis. The investigators of the American Public Health Service made this distinction in their survey of American anthracite and bituminous miners (Sayers, 1936; Flinn, Seifert, Brinton, Jones, and Franks, 1941) on clinical grounds and this is also the custom of German investigators (Boehme, personal communication, 1950), but we have not found it of value. The only reliable subdivision appears to be into those with tubercle bacilli in their sputum and those without.

The diagnostic convention we have used is convenient for our own comparative purposes, but it is important to realize that our results on the prevalence of tuberculosis and P.M.F. are certainly not comparable with those of other workers. It is also, of course, true that other workers' results are not comparable with each other, nor can they be made comparable until some system of classification of pneumoconiosis and tuberculosis receives international recognition.

The Choice of Population.—The choice and definition of the population in which the epidemiology of pneumoconiosis is to be investigated are of the greatest importance.

Several different types of population have been used by different investigators: (1) Hospital populations of miners; (2) populations of "pensioned" or "certified" miners; (3) selected members of colliery populations; (4) populations of "underground" workers at a particular colliery; (5) populations of "underground and surface" workers at a particular colliery; (6) mining communities where the majority of the adult males are miners; (7) random samples of such communities.

It would seem scarcely necessary to discuss the fallacies involved in the use of the first two populations, but they have been used by reputable authors. Theodos and Gordon (1952), for instance, used what was apparently a hospital population to investigate the prevalence of positive sputum amongst miners. Cazamian (1947) similarly used a population of miners in receipt of pensions for a very detailed epidemiological study, and others have used them for more limited purposes.

The technique of radiographing only certain members of a colliery population was successfully employed by Hart and Aslett (1942) and their team to obtain groups of "home colliers", and it is clearly a valid technique which saves a considerable number of radiographs. However, it involves taking the industrial histories of all miners at the colliery first and then selecting those whom one wishes to radiograph. We were unable to do this as we were "rewarding" those who gave us their industrial histories by taking their chest radiographs and advising them about the findings. We were therefore unable to select only those who had "pure" industrial histories. We have, of course, made use of the "home collier" idea in our subsequent analyses under the term "pure face workers".*

The choice between the remaining four populations depends to some extent on what one wishes to do, where one is working, and how much money and staff are available. A colliery population is always a survivor population and when the disease one is investigating is an important cause of people leaving the colliery, it becomes as important to radiograph those who have left as those who remain. Theoretically, one should aim to radiograph everyone still alive who has ever worked at the colliery under investigation in order to assess the damage done by work in that colliery. This, however, presents major problems in terms of defining and tracing the population, but we probably approached close to this ideal during the Rhondda Fach surveys. A community survey in a mining area is, in fact, the only practical method of estimating the exact prevalence of pneumoconiosis, particularly in areas where its prevalence is high. Such surveys also have advantages in follow-up studies where it is as important to radiograph those who have left the

* A "pure face worker" is a miner who has worked on the coal face at one colliery only and has not been exposed to any other dust risk, apart from his work on the face, likely to cause pneumoconiosis.

colliery as those who remain; in studies of the effect of social conditions on the progression of the disease; in studies of a particular characteristic of a particular type of disease (*e.g.*, the prevalence of positive sputa amongst cases of progressive massive fibrosis); and as providing a defined population which can be sampled when other characteristics of miners and ex-miners requiring more elaborate techniques can be investigated (*e.g.*, physiology). Such work is, however, laborious. In areas where the prevalence of pneumoconiosis is low, and the main object is the search for " 10-year pure face workers " a survey of the underground population is probably sufficient.

Our own technique has been to radiograph the " defined underground population " when we were interested primarily in correlating dust measurements with pneumoconiosis in areas of low prevalence, *e.g.*, England. In Wales (with one exception, where the prevalence of pneumoconiosis was low) we have radiographed the surface and underground populations or done community surveys which will, of course, include both.

Table 1 shows the difference in the prevalence of

TABLE 1

% PREVALENCE OF PNEUMOCONIOSIS IN VARIOUS POPULATIONS

Radiological Category	Populations				
	Defined Underground Population at Colliery K	Surface Workers at Colliery K	Ex-miners Living in Town K	Hospital Population at Llandough Miners' Ward	100 Consecutive Cases at Cardiff Panel
	75·8	74·3	62·3	12·0	0·0
1	12·1	9·2	13·7	7·0	0·0
2	5·7	4·6	9·0	8·0	34·0
3	3·9	5·5	3·7	8·0	25·0
P.M.F.	2·5	6·4	11·3	65·0	41·0

pneumoconiosis in miners and ex-miners: (1) In a defined underground colliery population; (2) in the " surface " population of the same colliery; (3) amongst the ex-miners in the town in which the colliery stands; (4) in a hospital population of miners and ex-miners serving this town amongst others; (5) amongst 100 consecutive miners accepted as eligible for pensions by the Ministry of Pensions and National Insurance Pneumoconiosis Medical Panel in that area. The differences are so striking that comment is unnecessary.

When dealing with colliery populations, the only problem is that of the definition of individuals. Lists supplied by the management of collieries are in general slightly inaccurate. The apparently simple task of supplying an alphabetical list of the men working at the colliery at a particular date, together with their initials, date of birth, address, and registration number, has so far defeated all the collieries that we have visited. This has not been due to any lack of good will on the part of the management and their staff. Two of them went to an enormous amount of trouble in an effort to get a perfect list, but even then they failed. There are many reasons for this: the excessive number of Jones, Williams, Davies, and Edwards in Wales; the rapidity with which miners change their addresses and the slowness with which they inform the management of such changes; the difficulty the management have in discovering why a man is absent—he may be ill or " resting ", or he may be away hop-picking, in Canada, in prison, or even dead. Our experience in tidying up the nominal lists supplied by managements has made very clear to us the difficulties in differentiating between voluntary and involuntary absenteeism. After our first survey we were so discouraged by this problem that we carried out preliminary surveys to define the population at the next two collieries during which only anthropometric data were obtained. As our understanding of the problem increased and our " tidying up " technique improved, we were finally able to do it during the course of the radiological survey.

In community surveys, after the area has been defined geographically, nominal definition can be carried out either by a private census or by progressively correcting electoral rolls and lists of school leavers. The male population can be further subdivided into those who have been exposed to coal dust and those not so exposed by questions at the time of radiographing and by visiting at home those who refuse to be radiographed. The technique in either case is laborious. It is discussed in greater detail in the Rhondda Fach reports (Cochrane, Cox, and Jarman, 1952 and 1955).

The populations referred to in the text consist of 12 colliery populations, designated by the letters A-L. A is an anthracite colliery. The men working there were radiographed by Hart and his radiographs have been re-read to make the readings comparable with ours. B, C, E, and K are collieries in the Rhondda Fach, and D, F, G, and H are collieries in a neighbouring valley. I is an anthracite colliery selected because the dust conditions were thought to be good. J and L are collieries in north-west England selected because the dust conditions were thought to be bad. Many of these colliery populations were radiographed on more than one occasion. The number after the letter signifies the number of the survey at that particular colliery. In addition, use is made in the paper of two other populations, the ex-miners living in the Rhondda

Fach and the random sample of miners and ex-miners living in Town M in the north-west of England.

Percentage of the Population Studied.—The problem presented by those who refuse to cooperate in surveys is both of great interest theoretically and of great practical importance. The time and expense of radiographing the last 10% is equal to that of the first 60%. There would, therefore, be little justification for radiographing more than 50% of the population if we were only interested in prevalence measurements and if the miners came up to be radiographed in a random order. Unfortunately, the measurement of prevalence was often only of secondary interest on these occasions; we were mainly interested in establishing large unselected populations for the purpose of follow-up studies, or in eliminating tuberculosis from an area, and for both these reasons it was necessary to achieve 100%

TABLE 2

PERCENTAGE OF DEFINED UNDERGROUND POPULATION AT 12 BRITISH COLLIERIES RADIOGRAPHED DURING P.R.U. SURVEYS

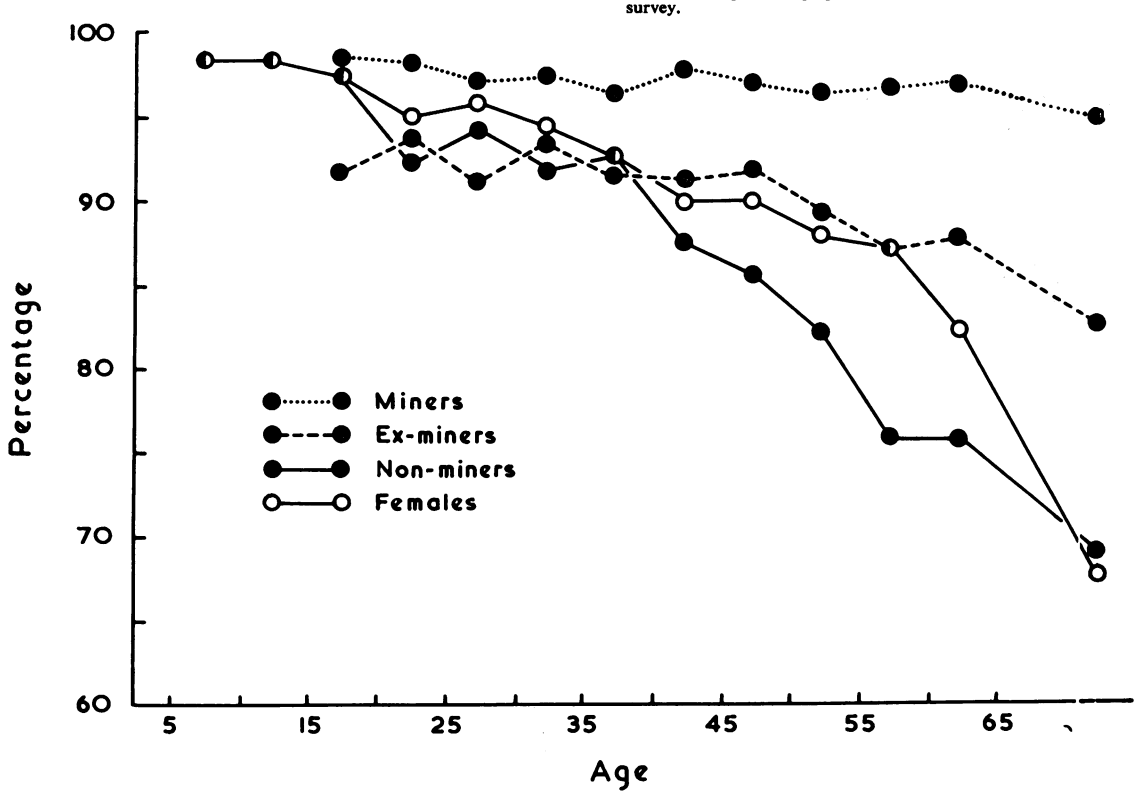
Colliery	No. in Defined Underground Population	No. Radiographed	Percentage Radiographed
A	403	403	100·0
B	707	706	99·9
C_1	536	406	75·7
C_2	560	560	100·0
C_3	554	546	98·6
D	545	544	99·8
E	741	740	99·9
F	532	524	98·5
G	763	754	98·8
H	314	312	99·4
I	502	501	99·8
J	1,247	991	79·5
K	157	157	100·0
L	596	596	100·0

TABLE 3

PERCENTAGE OF MINERS WORKING ON THE SURFACE AT EIGHT BRITISH COLLIERIES RADIOGRAPHED DURING P.R.U. SURVEYS

Colliery	No. of Surface Workers	No. Radiographed	Percentage Radiographed
B	196	195	99·5
C_3	219	215	98·2
D	118	118	100·0
E	244	243	99·6
F	127	124	97·6
G	196	194	99·0
H	90	90	100·0
K	110	109	99·1

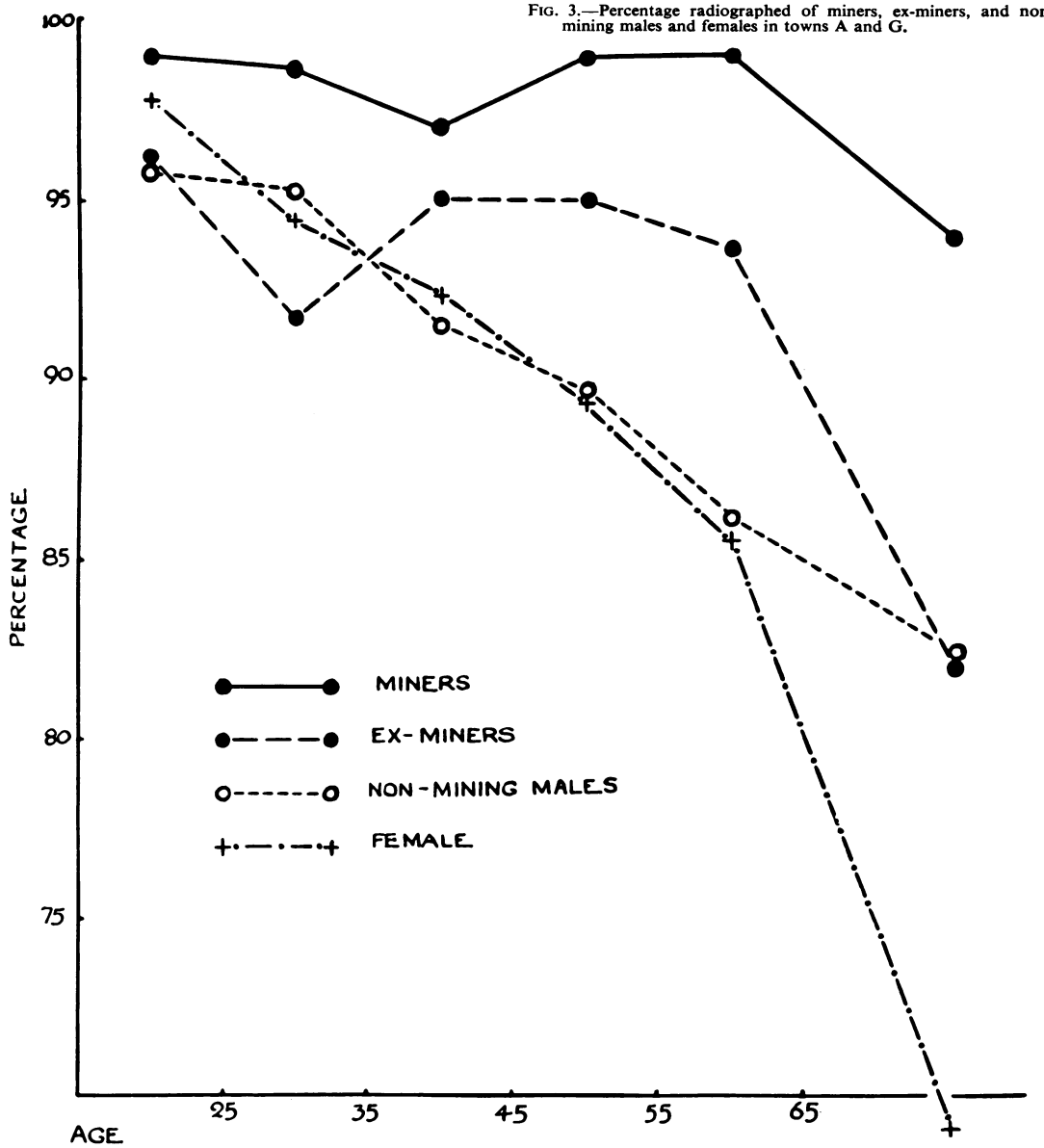
FIG. 2.—Percentage radiographed in the second Rhondda Fach survey.



coverage, if possible. In addition, evidence has been accumulating that people in general, and miners in particular, do not come to be radiographed in random order. The evidence about this has recently been summarized by one of us (Cochrane, 1954a). Pneumoconiotics tend to come up earlier, and those with tuberculosis later, than those with normal films. The first 50% to come up will therefore not give a true measure of prevalence.

There seemed, therefore, every reason to " push " a survey as far as possible, and we have in general been able to keep our lapse rates low. Tables 2 and 3 show the percentage radiographed at 14 surveys of the underground populations and eight of the surface populations. Our results compare favourably with those claimed by other authors. McCallum and Browne (1955) radiographed 89·4% of the surface and underground populations of four Durham collieries; McCallum (1952), when summarizing the results of mass radiography at eight

FIG. 3.—Percentage radiographed of miners, ex-miners, and non-mining males and females in towns A and G.



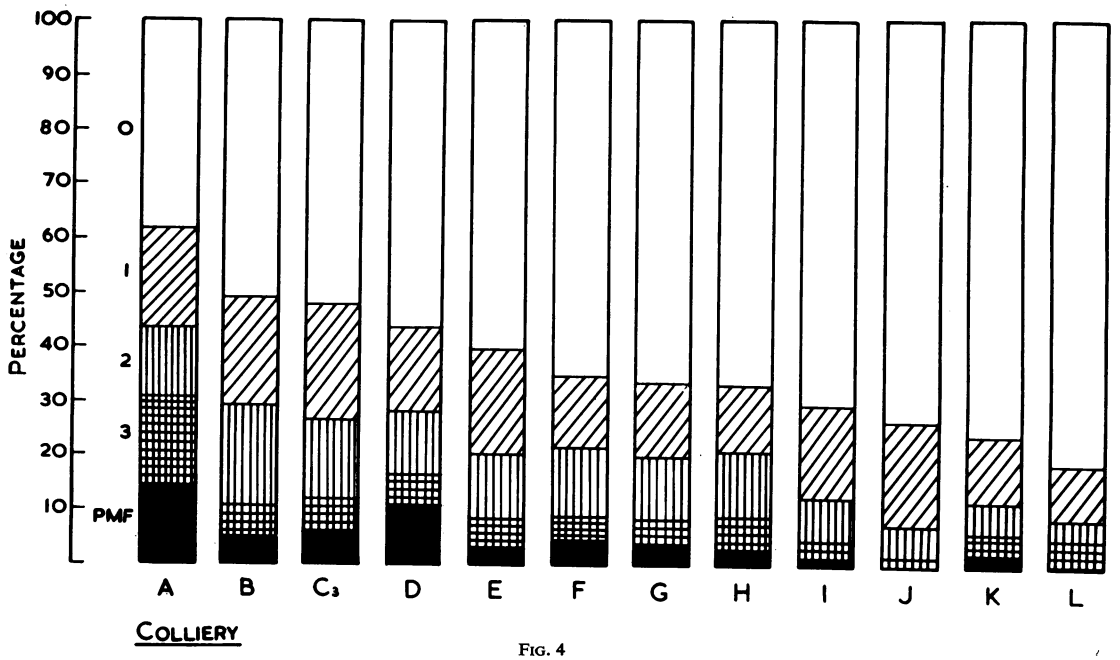


FIG. 4

Northumberland collieries, estimated the percentage radiographed to be 51·7, and Watkins (1950) gives a figure of 67·1% for 10 Midland collieries. The results of attempting to radiograph a complete mining community have been published elsewhere (Cochrane *et al.*, 1952 and 1955). Figs. 2 and 3 are taken from their report.

Results

The figures given in this section are based on

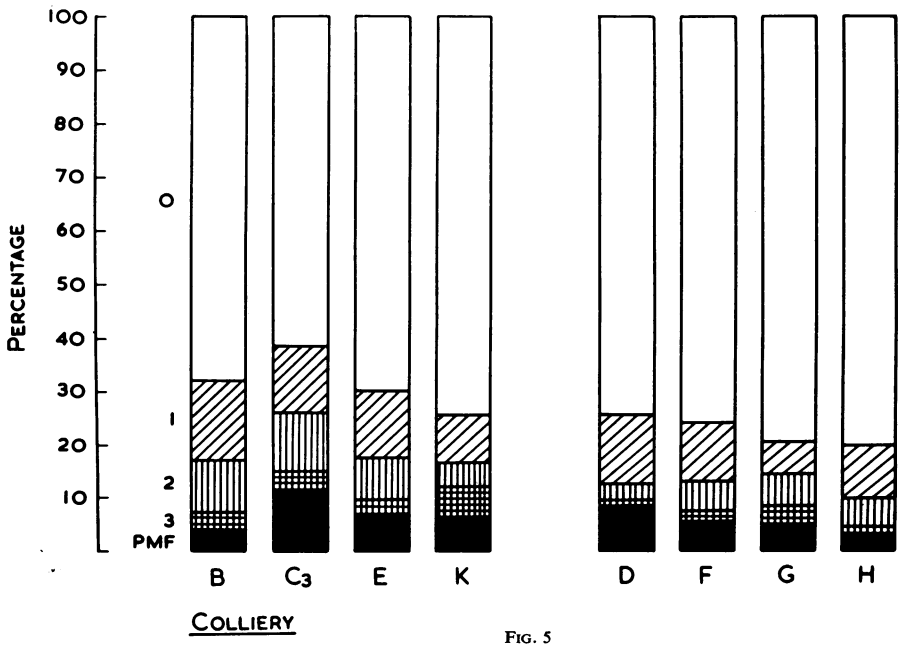


FIG. 5

FIG. 4.—The prevalence of pneumoconiosis amongst miners working underground at 12 British collieries.

FIG. 5.—The prevalence of pneumoconiosis amongst surface workers at eight Welsh collieries.

duplicate readings of large-size films by A.L.C. and I.D., except where other readers are mentioned. Many of the films have been read on several different occasions, sometimes alone, and sometimes with other films for progression readings. In this way, small discrepancies in the figures will be noticed. Although our observer error in film reading is small, it is by no means negligible.

The results of the various prevalence studies can be conveniently grouped as follows:

Prevalence in Defined Underground Population of 12 British Collieries.—Fig. 4 shows the prevalence of disease in 12 British collieries. It demonstrates the general high prevalence of radiological abnormality, and the wide inter-colliery variation.

Prevalence in Defined Surface Population in Eight British Collieries.—Fig. 5 shows the prevalence of pneumoconiosis in the only eight collieries where the surface population was radiographed. It confirms the findings of Hart and Aslett (1942) that there is considerable disease amongst surface workers.

Comparison with Other Published Data.—The dangers of comparing these figures with those of other workers are serious. Different terminologies, different radiological techniques have been used, and different populations have been surveyed. The closest approximations to our figures are possibly those of McCallum (1952) and McCallum and Browne (1955), who not only used our classification but also compared their readings with those of P.R.U. readers. Their figures suggest a somewhat lower prevalence of simple pneumoconiosis and a much lower prevalence of P.M.F. Possible explanations of these differences are discussed in their second paper.

In Ireland, Deeny, Walsh, and Conran (1952), again using our classification, reported the prevalence in two Irish collieries. In one, they found 6·5% simple, and 2·1% complicated, pneumoconiosis, and in the other 1·5% simple and no cases of P.M.F. They used a Schonander miniature *x*-ray set which probably caused them to miss some of the early stages of simple pneumoconiosis, but even so their findings suggest that the prevalence of pneumoconiosis is lower in Ireland than in South Wales.

There have been several publications from France, but comparison is even more difficult as, in the past, they tended to concentrate their studies on miners exposed to stone dust, and to use miniature films and a different terminology. The different history of industrial disease legislation in the two countries also introduces difficulties. British miners, when certified as suffering from pneumoconiosis, were for many years forbidden to work in the collieries while there was no comparable law in France. This causes the British prevalence, in particular the prevalence in Welsh collieries, to be artificially low when compared with the prevalence in French mines.

Martin and Roche (1944-45) radiographed 609 miners selected from a large mining area on the grounds that they had been exposed to stone dust. They considered that 16·7% had " images silicotiques " (simple pneumoconiosis) in their radiographs and that 4·9% showed " images pseudo-tumorales " (P.M.F.). The paper is important as being the first in France to draw attention to the fact that exposure to coal dust as well as to stone dust causes radiological changes.

The same authors (Martin and Roche, 1945) published the results of the first systematic radiological survey on large films of miners in France. In 1947 Perret and Mattei (1947) published the results of a radiological survey on small films in the Lamure collieries. The figures, however, refer to a population of 600 underground workers and 1,355 surface workers, which is such an unusual proportion that no comparison is possible with the results of other workers. Their figure for the prevalence of " images pseudo-tumorales " (corresponding roughly to the British B, C, D) is so low (0·6%) as to make it improbable that the prevalence of P.M.F. is high even amongst the underground workers there. Champeix and Thevenoux (1949) surveyed two collieries, and their careful analyses by " years underground " make this a most valuable French contribution. Foubert (1948) added the results of 35 mm. surveys at four collieries in the north of France. Declercq, Balgairies, Flouquet, and Morel (1949) gave the results of seven more collieries from the same region. Neither of the last two papers gave any analyses by " years underground ".

Exact comparisons are difficult, but on the basis of the results of the duplicate readings which were carried out between the Douai group and P.R.U. a comparison has been attempted in Fig. 6. Considerable errors are introduced in making these estimates, but two of them will at least counteract one another. The French use of 35 mm. film will tend to make them underestimate the prevalence of simple pneumoconiosis, and the fact that many miners were " certified " before 1948 and had to leave the mines will have a similar effect on the British figures. It seems permissible to conclude that there is a similar prevalence of pneumoconiosis in France as is found in Britain.

In Belgium, the system of radiological classification has been clearly described by Belayew (1950).

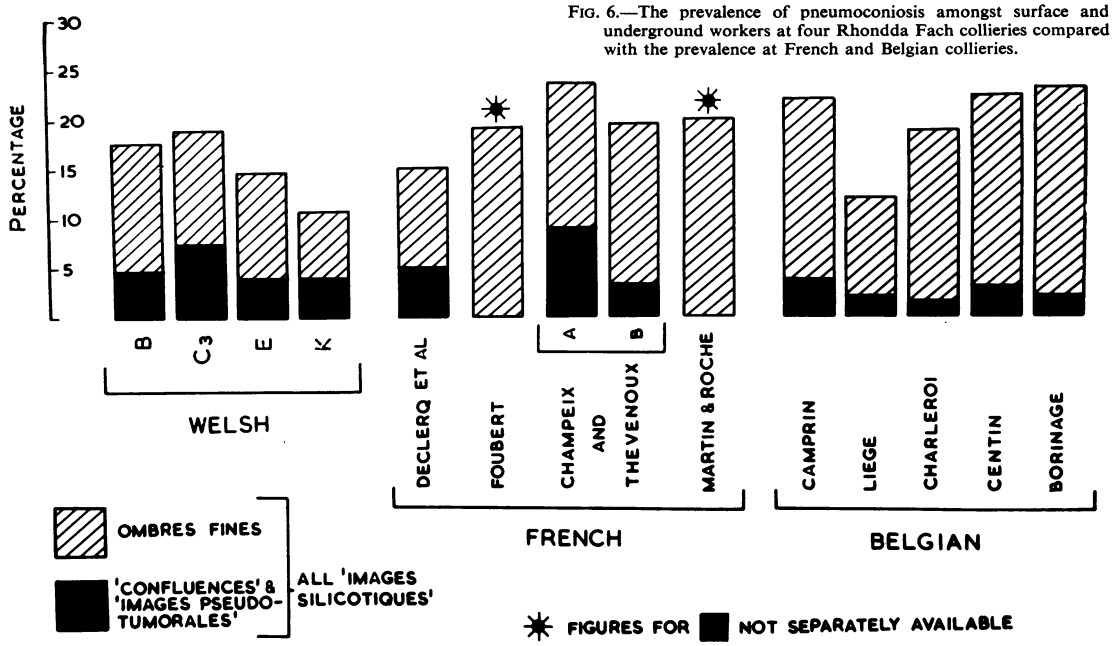


FIG. 6.—The prevalence of pneumoconiosis amongst surface and underground workers at four Rhondda Fach collieries compared with the prevalence at French and Belgian collieries.

We have not, unfortunately, had an opportunity of reading a large number of films in duplicate with them, but we are informed by our French colleagues that the Belgian categories M, P, and N correspond very closely with the similarly designated French categories (Balgairies, personal communication, 1952). It therefore seems reasonable to translate our figures for pneumoconiosis into the Belgian terminology by using the same indices as for the French.

Fig. 6 also shows a comparison between the Belgian figures (van Mechelen, 1951) for the prevalence of pneumoconiosis and our own prepared in the same way as for the French figures. The most striking feature is the relatively high percentage of simple pneumoconiosis combined with a low percentage of P.M.F. This is possibly due to the fact that the Belgian miners go on to the coal face later than Welsh miners.

In Germany there are many papers giving the prevalence of disease amongst those exposed to stone dust (Boehme, 1933; Reichmann, 1949; Zorn, 1949; Worth, Schiller, and Dickmans, 1951), but there are no references to the prevalence in complete colliery populations. This is particularly unfortunate as, owing to the cooperation of our German colleagues in re-reading our radiographs, we are able to translate the German figures with reasonable accuracy.

The only paper referring to the prevalence of pneumoconiosis amongst coal-miners in Holland is that of Appelman (1949), who gives figures for the prevalence of the disease amongst underground mineworkers at Limbourg. It is not clear from his paper whether the 625 miners represent the complete underground population, or if not, how they were selected. He apparently did most of the diagnoses by means of radioscopy and only used films for the severest cases. It is certain, therefore, that his prevalence figure is an underestimate of the real prevalence. His classification is difficult to interpret with any exactitude and particularly his use of the term " reticulation ", but it is clear that the prevalence of P.M.F. at Limbourg is certainly not lower than it is in South Wales.

There have been no new publications dealing with the prevalence of pneumoconiosis amongst coal-miners in the United States or the U.S.S.R., and we have no means of interpreting the data quoted by Hart and Aslett (1942) in terms of our readings.

More Detailed Analysis of Prevalence Data.—The crude prevalence data which have been considered up to the present are clearly unsatisfactory for accurate inter-colliery comparisons. The collieries vary as regards the age distribution of miners working there (Fig. 7), and according to the distribution of the types of employment in the colliery. There may, for instance, be more work on stone with its risk from stone rather than coal dust in some collieries than in others. To make the com-

parisons fairer, various types of analyses can be carried out on the prevalence data. They can, for instance, be broken down by real age, or by industrial age, years underground, years on the coal face, or years on stone. Alternatively, various groups can be excluded from the analyses, *e.g.*, those who have worked for more than a certain length of time at other collieries. None of these tricks is altogether satisfactory, although occasionally illuminating. There are basically only two worthwhile comparisons. The first is the comparison between the " dose response " curves for various collieries (Roach, 1953). This would enable one to compare the risks of getting pneumoconiosis associated with the same dosages of different dusts. The difficulties of obtaining dose response curves for individual pits is, however, very great indeed. The second valid comparison is that of the social and medical damage done by coal dust in different areas. This is best carried out by community surveys so that ex-miners will be included. Such surveys, if the lapse rate is low and they can be analysed by age, give a very fair picture of the damage. Unfortunately, this is only available for one area (Cochrane, *et al.*, 1952). We must therefore content ourselves for the moment with less satisfactory comparisons.

Another point should be noted. Simple pneumoconiosis has had in the past in Wales a relatively high radiological attack rate. Its radiological recovery rate is nil as far as we know and the case fatality rate is very low in comparison with the attack rate. The prevalence rate thus becomes nearly proportional to the attack rate. At the same time, as the technique of analysis becomes more and more refined, *e.g.*, by " years underground and years on the coal face ", the " X " axis becomes more and more closely related to dust dosage, and we slowly approach the dose response curve (Roach, 1953).

It would, however, be tedious to give analyses of all the colliery and community populations by all the possible techniques as the evidence is essentially similar for all, so a few illustrative examples are given of each technique.

FIG. 7.—Age distribution of all underground workers at 12 British collieries.

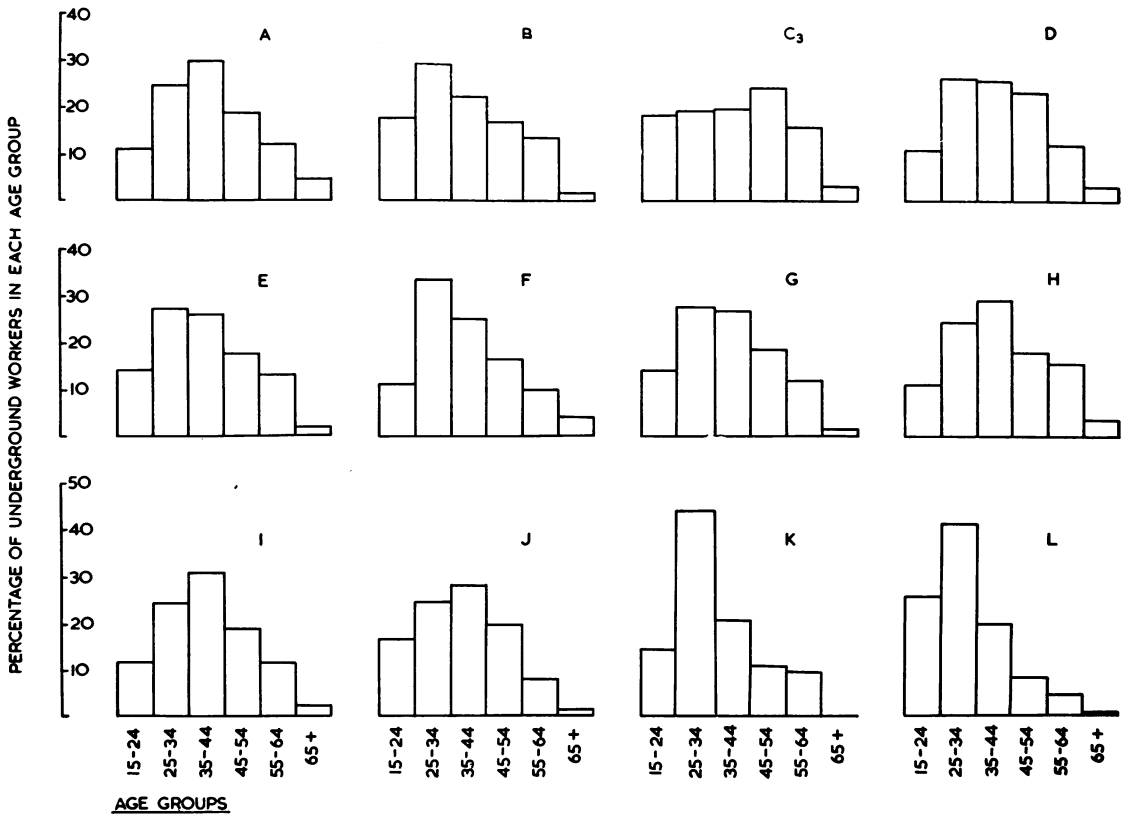


FIG. 8

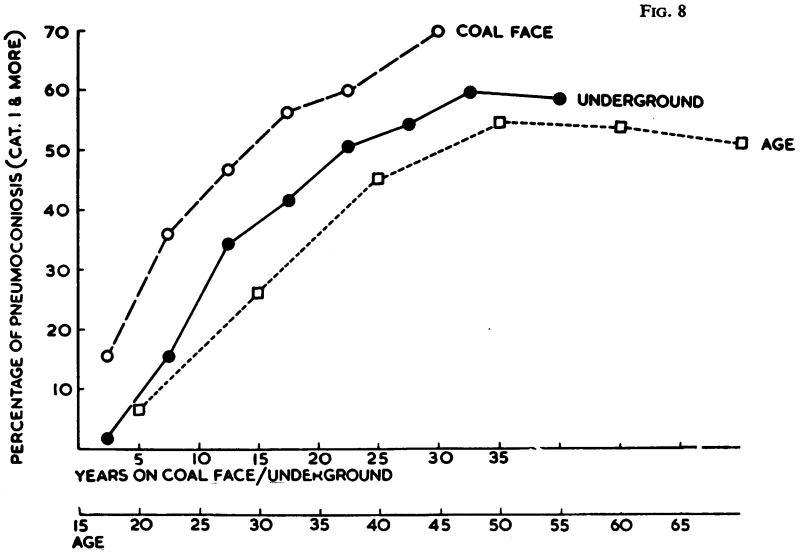


FIG. 8.—Prevalence of pneumoconiosis (category 1 and more) in the underground populations of 12 British collieries.

FIG. 9.—The prevalence of coal-workers' pneumoconiosis amongst those radiographed of the miners and ex-miners in the Rhondda Fach in 1950/51 and 1953.

Analyses by Age.—Fig. 8 shows an analysis of all the 12 underground populations by age and radiological category. It will be seen that after the age of 50 there is very little correlation between age and radiological status. This is probably due to several factors: (*a*) the fact that men with the more advanced radiological categories tend to leave the underground population, so that we are, in fact,

FIG. 9

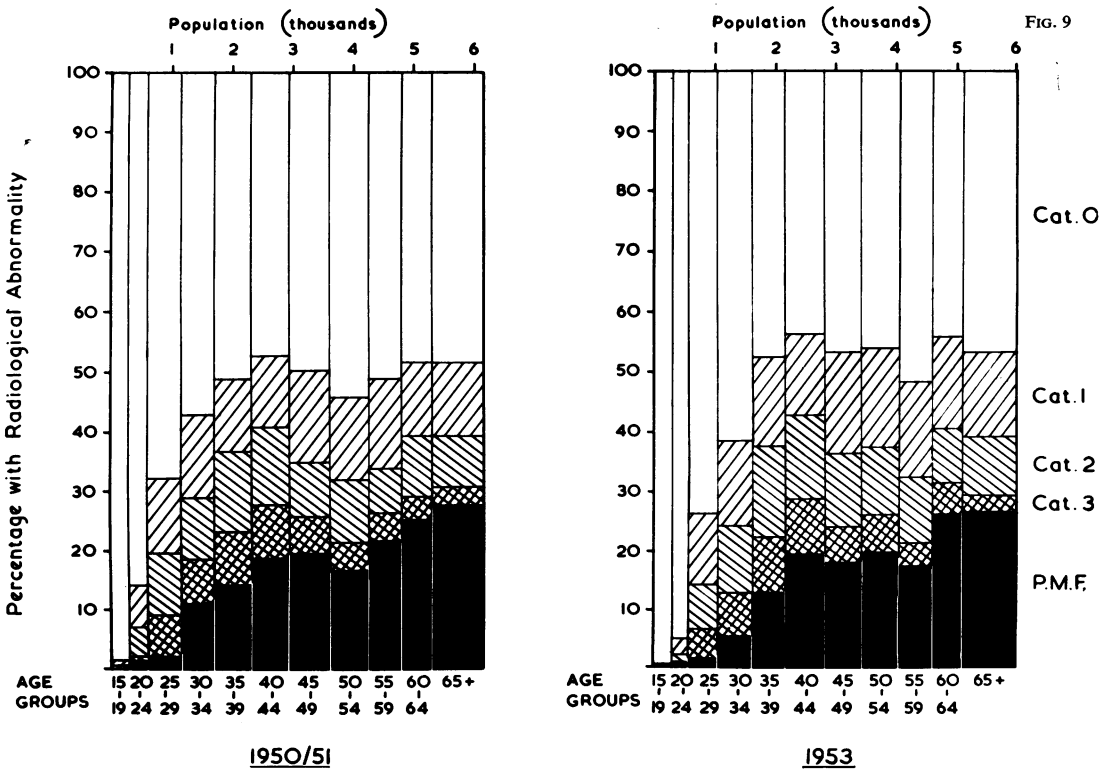
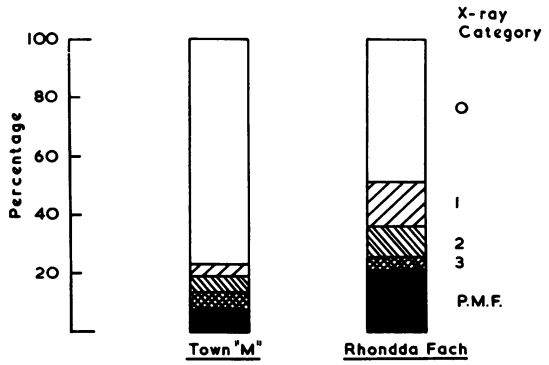


FIG. 10.—The prevalence of coalworkers' pneumoconiosis amongst those radiographed in a random sample of the miners and ex-miners age 55-64 in town M compared with those in the same age-group in the Rhondda Fach.



dealing with a survivor population in those age groups; (*b*) the tendency of miners to leave the coal face at that age and take up some occupation with a lower dust risk; (*c*) the fact that dust concentrations were almost certainly much lower 40 years ago. Fig. 8 also confirms our assumption that our radiological category mirrors the natural history of the disease.

In Fig. 9 the total population of miners and ex-miners living in the Rhondda Fach has been analysed by age and radiological status. As already mentioned, we believe that a total population of this kind is the best index for comparisons when the social and administrative aspects of pneumoconiosis are the main interest.

We also have figures for the prevalence of pneumoconiosis in the town of M, but only in the age group 55-64. The figures are based on a random sample of men of this age living in the town. The total size of the sample was 245, of which 145 were miners or ex-miners (using the same definitions as were used in the Rhondda). Of these 145, 134 (92·4%) were radiographed and the prevalence of pneumoconiosis is shown in Fig. 10, where it is compared with the same age group in the Rhondda Fach. The town M was in a mining area where the prevalence of pneumoconiosis was believed to be low, but there is probably a considerable amount of P.M.F. all over the country in the mining areas.

Analysis by Years Underground.—This is clearly rather more closely related to dust dosage than age, and as a result, a slightly better relationship with radiological category is found (Fig. 8).

Analysis by Years on the Coal Face.—This index is even more closely related to dosage than the previous one. Fig. 8 shows a much smoother relationship with radiological category, and suggests that the attack rate of pneumoconiosis on the coal face has been very high in the past.

Changes in Prevalence.—Several colliery populations have been radiographed on more than one

FIG. 11.—The prevalence of pneumoconiosis categories 1 and more in the radiographed underground population of colliery L in 1949 and 1952.

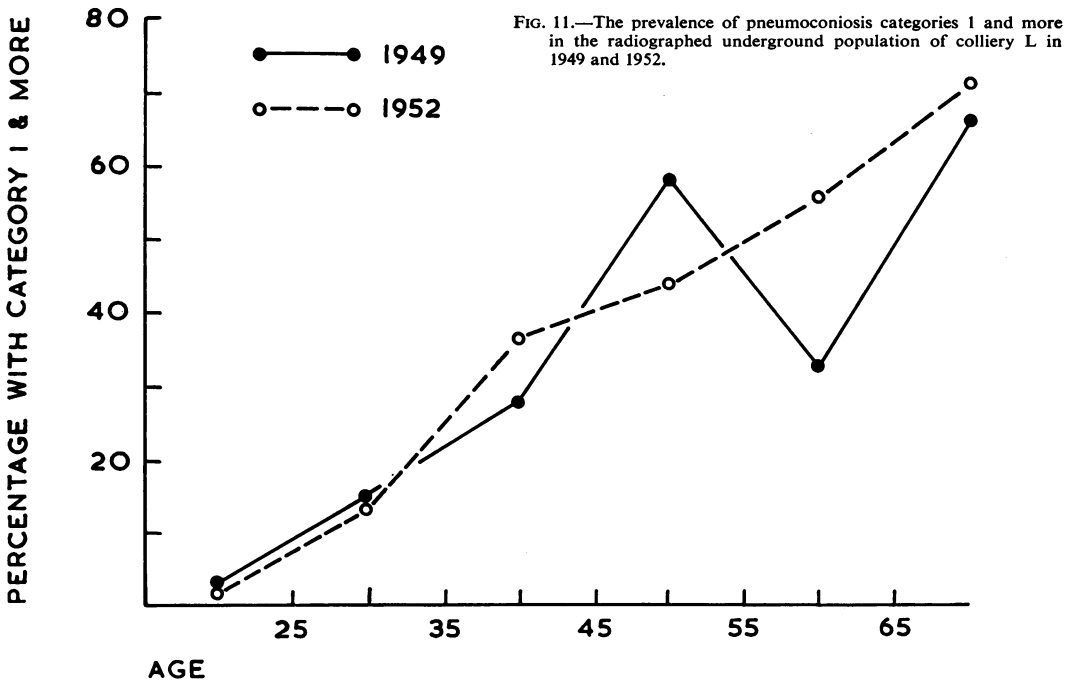
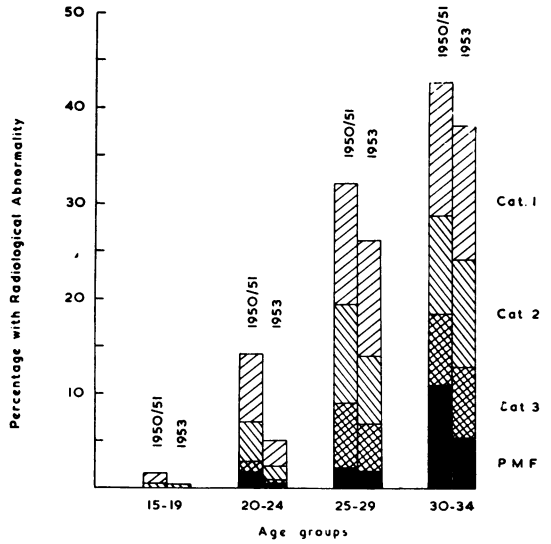


FIG. 12.—The prevalence of coalworkers' pneumoconiosis amongst the younger age-groups of the miners and ex-miners radiographed in the Rhondda Fach in 1950/51 and 1953.



occasion and the prevalence figures can be compared. The great problem is their interpretation. A marked increase in prevalence may be due to: (1) more miners without than with pneumoconiosis leaving the colliery; (2) a high attack rate of simple pneumoconiosis inside the colliery; (3) miners, entering the colliery between the surveys, having a higher prevalence of simple pneumoconiosis than those who left; (4) a systematic change in the level of reading radiographs.

In Fig. 11 the prevalence of pneumoconiosis in Colliery L in 1949 and 1952 is compared. Superficially there appears to be very little difference, but when the material was analysed in detail it was clear that definite progression occurring amongst the pneumoconiotics was being balanced by the number of miners with pneumoconiosis who had left the colliery.

Changes in the prevalence of pneumoconiosis amongst whole communities are somewhat more reliable. The prevalence amongst miners and ex-miners in the Rhondda Fach at the time of the surveys in 1950/51 and 1953 is shown in Figs. 9 and 12. (It should be noted that these diagrams are based on our 1953 readings of the films. At the time of the second survey, we were particularly interested in the attack rate of P.M.F. and thus read A shadows at a level definitely below our standard A shadow film.) Even in this case, it is difficult to interpret all the details. The difference in prevalence in the younger age groups, if correct, appears important but it must be remembered that, first, the difference might be an artefact due to film technique or readers' bias. We do not think that this is the explanation but it is difficult to exclude. Secondly, if it is a true finding there are several possible explanations. Some of this group were radiographed on one occasion and not on another, some left the area, and a few died. Such factors could in certain circumstances produce a difference in prevalence which had nothing to do with a change in the attack rate of the disease. We do not, however, think that this is the explanation in this case. We believe that the simplest explanation of the findings is that there has been a true fall in the attack rate of simple pneumoconiosis and P.M.F. in relation to age. This fall, as far as simple pneumoconiosis is concerned, is probably partly due to the later age at which mining entrants reach the coal face today and partly to a reduction in the dust concentrations in the collieries. The fall in prevalence of P.M.F. is probably partly due to the lower prevalence of simple pneumoconiosis and partly to the reduced tuberculous infectivity in the area (Cochrane and Miall, 1956).

Relationship between Prevalence and Other Characteristics of the Population.—Many of the more important relationships have been adequately summarized elsewhere, *e.g.*, with pulmonary disability (Gilson and Hugh-Jones, 1955; Gilson and Carpenter, in the press), with expectation of life (Carpenter and Cochrane, 1956), with pulmonary tuberculosis (Cochrane, 1954b; Cochrane *et al.*, 1955), with anthropometry (Oldham, 1953; Cochrane and Miall, in the press). We are here concerned with some other relationships which have not previously been discussed.

Relationship with E.S.R. Measurements.—The ease with which the E.S.R. can be carried out in practice and the simple numerical form in which it can be expressed made it inevitable that it would be carried out on large numbers of miners. Moreover, Stewart (1948) regards the E.S.R. as a good index of progression. In a sense, this has been unfortunate as too little is known about the distribution of E.S.R. values in normal populations for this to be of much value. What are needed are the E.S.R.s of those members of a large defined population who have passed some clinical test for normality. The results published by Bruusgaard (1950) and Dahlberg (1948) approach this more closely than others, but still fall short.

During the last 15 years there have been several references in the literature to the relationship between the erythrocyte sedimentation rate and industrial pulmonary disease. Sen (1937) recorded that the sedimentation rate was accelerated in a

number of cases of coalworkers' pneumoconiosis which he examined in South Wales but he gave no actual figures. Craw (1937) performed sedimentation tests on a group of haematite miners and found that acceleration of the E.S.R. only occurred when gross shadowing was seen on the radiograph. He obtained normal readings from 14 men with silico-siderosis of simple nodular type. Heimann (1946) pointed out that an abnormal E.S.R. could be found in cases of simple silicosis as well as in cases with coalescent shadowing, although he did not attempt to draw any conclusions from this observation. Caplan (1947), on the other hand, stated that in miners with " uncomplicated pneumoconiosis " from the Kolar Goldfields, the E.S.R. was normal and only occasionally raised in tuberculo-pneumoconiosis. Tortori-Donati (1947), who examined 103 Belgian coal-miners, found slight acceleration of the E.S.R. in association with radiological reticulation, nodulation, and nodulation with coalescence. He suggested that the sedimentation rate increased when progressive lesions were present, and that this increase was evidence in favour of the theory that coalescent shadows were caused by infection. He attributed the abnormal E.S.R.s in the early stages of the disease to bronchial catarrh.

In Germany, Schmidt (1949) found some correlation between radiological category and sedimentation rate. His population consisted of 2,000 miners applying for pensions and no steps were taken to exclude those suffering from other diseases. He was also using the original I, II, and III classification of *silikose* which would include some early P.M.F. In France, Nadiras, Batique, and Michot (1948) also came to the same conclusion. They studied 850 miners, the majority of whom were seen in the course of routine examinations. They found an increasing percentage of abnormal sedimentation rates corresponding to increasing abnormality in the radiograph. The differences between *reticulation*, *micro-nodulaire*, and *nodulaire*, which correspond to simple pneumoconiosis, are small, and it seems possible that the differences could be accounted for by the different age distribution, for which Nadiras *et al.* make no allowance. Their results for *formes confluentes* and *formes pseudo-tumorales*, which correspond to P.M.F., are similar to ours. On the other hand, Saita (1945) found the E.S.R.s of early and nodular silicosis to be normal.

Our own material consists of the results of sedimentation rates carried out on miners and ex-miners in five different populations. For those studied in Population B by one of us (M.H.C.W.) the Wintrobe technique was used. For all the others the technique was that of Westergren. Population A consists of miners and ex-miners who were in the Unit's ward at Llandough. Population B consists of volunteers from amongst miners working at Colliery C. No particular care was taken to exclude those suffering from diseases other than pneumoconiosis likely to affect the sedimentation rate. Population C consists of working miners selected at random from the defined underground population of Colliery C (two and a half years after the previous investigation) to fill an age-radiological category " square ". Great care was taken to exclude all diseases other than pneumoconiosis which might affect the sedimentation rate. Population D consists of a group of volunteers from amongst the miners and ex-miners living in the Rhondda Fach, with A and early B shadows who were examined before a therapeutic trial. Some, but not all, of those suffering from other diseases, have been excluded. Population E is that used by Gilson and Hugh-Jones for their large-scale physiological experiment (Gilson and Hugh-Jones, 1955). For details of the method of selection, the reader is referred to their report. Briefly, it represented an attempt to obtain a sample of all miners and ex-miners weighted by age and radiological status. The majority of other diseases were excluded but the criteria were not so strict as in Population C.

The results are given in Tables 4, 5, and 6. They all suggest that a man with P.M.F. will probably have a higher E.S.R. than one of the same age with a radiograph normal as regards dust or one with simple pneumoconiosis. They also illustrate what varied results can be obtained according to the population examined and the type of selection.

TABLE 4
NUMBER OF MINERS AND EX-MINERS IN VARIOUS AGE-RADIOLOGICAL GROUPS IN FIVE POPULATIONS

		Radiological Categories				
Population	Age Group	0	1–2	3	A	B.C.D.
A	± 35	2	4	9	4	9
	± 45	1	4	9	4	23
	± 55	1	9	4	4	13
B	± 35	6	13	7	–	—
	± 45	3	8	3	2	–
	± 55	3	11	3	2	–
C	± 35	8	8	8	3	–
	± 45	8	8	7	7	–
	± 55	8	8	8	5	–
		A			B	
D	± 35	30			11	
	± 45	42			31	
	± 55	8			5	
		Normals—Never a Miner	0	1-2	3	C	D
E	± 35	10	8	8	8	8	6
	± 45	10	7	8	8	8	7
	± 55	10	6	8	8	7	8

TABLE 5

AVERAGE AGE AND SCATTER IN VARIOUS AGE-RADIOLOGICAL GROUPS IN THE FIVE POPULATIONS

Population	Age Group	0	1-2	3	A	B.C.D.
A	± 35	36·0 (35–37)	35·5 (34–37)	35·2 (33–39)	34·2 (31–39)	36·9 (35–39)
	± 45	47·0	47·25 (46–49)	42·5 (40–47)	43·25 (40–47)	44·7 (41–49)
	± 55	55·0	52·7 (51–63)	56·5 (54–60)	59·0 (51–62)	55·4 (50–59)
B	± 35	35·7 (29–39)	33·9 (30–38)	32·6 (30–34)		
	± 45	42·3 (40–47)	44·9 (41–48)	44·3 (40–49)	42·0	
	± 55	52·0 (50–53)	53·0 (50–57)	51·3 (50–53)	53·5 (50–57)	
C	± 35	34·5 (31–37)	34·6 (33–38)	34·25 (31–37)	35·0 (31–38)	—
	± 45	45·25 (43–47)	45·0 (43–47)	45·9 (43–47)	45·4 (42–49)	—
	± 55	52·6 (51–57)	54·5 (53–58)	55·5 (54–59)	56·0 (53–60)	—

Population	Age Group	A	B
D	± 35	35·9 (30–39)	34·9 (30–39)
	± 45	44·9 (40–49)	44·4 (40–49)
	± 55	50·25 (50–51)	50·04 (50–51)

Population	Age Group	Normals—Never a Miner	0	1–2	3	C	D
E	± 35	35 (33–37)	35·5 (34–38)	35·4 (34–37)	35·6 (32–39)	36·1 (34–38)	35·8 (31–39)
	± 45	43·7 (41–47)	45·1 (41–49)	44·6 (41–46)	45·0 (42–48)	44·0 (41–47)	45·4 (43–47)
	± 55	54·3 (52–58)	54·0 (50–56)	54·2 (53–55)	54·9 (53–59)	55·1 (51–57)	55·0 (51–60)

TABLE 6

AVERAGE E.S.R. AND SCATTER IN VARIOUS AGE-RADIOLOGICAL GROUPS IN THE FIVE POPULATIONS

		Radiological Categories				
Population	Age Group	0	1–2	3	A	B.C.D.
A	± 35	4·5 (1–8)	5·5 (3–10)	4·9 (1–14)	27·0 (3–90)	28·1 (8–63)
	± 45	5·0 —	13·5 (10–22)	13·0 (2–35)	11·25 (4–19)	31·5 (4–90)
	± 55	5·0 —	18·3 (5–37)	12·25 (4–23)	11·25 (4–29)	27·8 (3–92)
B	± 35	4·2 (2–6)	7·3 (1–18)	7·4 (2–13)	—	
	± 45	5·0 (1–12)	14·1 (2–48)	8·3 (8–9)	16·5 (15–18)	
	± 55	5·3 (3–9)	11·7 (4–25)	7·3 (3–10)	18·0 (8–28)	
C	± 35	6·75 (2–11)	4·1 (2–6)	4·4 (2–8)	7·75 (5–13)	
	± 45	6·0 (2–11)	5·25 (3–8)	4·4 (2–7)	8·9 (6–13)	
	± 55	4·9 (3–7)	5·9 (3–15)	7·0 (2–18)	12·6 (2–25)	

Population	Age Group	A	B
D	± 35	9·7 (1–41)	9·1 (3–25)
	± 45	8·6 (1–33)	11·3 (3–42)
	± 55	17·1 (2–94)	8·2 (4–13)

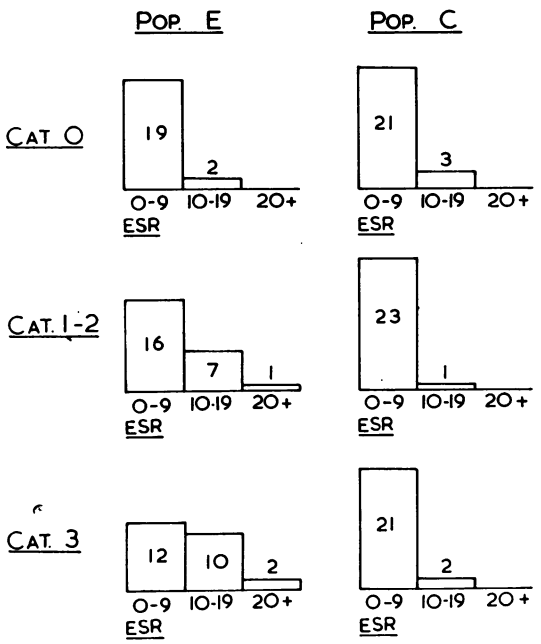
Population	Age Group	Normals—Never a Miner	0	1-2	3	C	D
E	± 35	4·1 (2–5)	5·7 (1–12)	6·7 (1–12)	5·4 (2–10)	23·4 (2–63)	26·7 (14–62)
	± 45	4·9 (2–7)	3·4 (1–7)	9·7 (5–22)	8·1 (2–21)	27·9 (6–70)	24·3 (10–45)
	± 55	9·4 (3–18)	5·7 (2–15)	6·7 (3–11)	13·9 (4–23)	15·4 (3–33)	37·0 (14–100)

The only approach to such an untidy mass of material is to ask certain specific questions and see if clear-cut answers can be deduced.

(1) Is there any relationship between the finding of tubercle bacilli in the sputum of pneumoconiotics and a high E.S.R. ? There has been considerable discussion in the literature as to the relationship between silico-tuberculosis and the sedimentation rate (Schmidt, 1949; Nadiras *et al.*, 1948; Saita, 1945). The problem seems of rather limited importance. The diagnosis of silico-tuberculosis on radiographs alone is subject to such large inter- and intra-observer error as to be of little value. The only useful definition of silico-tuberculosis is that of a " case of P.M.F. with a positive sputum " and it is therefore only necessary to do a sputum examination in addition to the radiograph. Nadiras *et al.* (1948) have pointed out that such cases do, in fact, on the average, have a higher sedimentation rate than other cases of P.M.F., but the sedimentation rate cannot replace the sputum examination. It might be used to select cases of P.M.F. for sputum examination but it is our experience that this is better done on the basis of cavitation in the radiograph, and recent history of loss of weight.

(2) What, if any, is the relationship between E.S.R. and radiological category ? There is general agreement that cases of P.M.F. have, on the average, higher E.S.R.s than cases of simple pneumoconiosis.

FIG. 13.—Comparison between E.S.R. and radiological status in two populations.



Interest is chiefly centred on the relationship between E.S.R.s and the categories of simple pneumoconiosis, and from two points of view: (*a*) If there were a regular and significant increase in average E.S.R. with radiological category there would be some additional support for the validity of our radiological classification. (*b*) If, on the other hand, all cases of simple pneumoconiosis had normal E.S.R.s, there would be additional support for the theory that it is simply dust retention with minimal fibrosis without any infectious element, as others have suggested, and would indirectly give support for the "two-disease" hypothesis.

To investigate such a point accurately one would require a random sample stratified for age and radiological status from a large well-defined population of miners and ex-miners from whom all those with abnormalities likely to raise the E.S.R. other than pneumoconiosis have been excluded. Such material does not, of course, exist and one can only hazard guesses as to what it might be like from the approximations to it that are available.

There are only two populations from our five that need be considered. Population C is close to the ideal except that it is confined to working miners. Population E includes ex-miners but is not so satisfactory as regards sampling, definition of population, or exclusion of other diseases. The two are compared in Fig. 13. (The age groups have been combined as the age distribution is similar, see Table 4.) The results from Population E would unfortunately support one theory and that of C the other, and there is no method of deciding whether the rising E.S.R. is due to the inclusion of the ex-miners or the faulty sampling, or the inclusion of cases with other diseases likely to raise the E.S.R.

We might possibly suggest that the prevalence of upper respiratory infections is associated with simple pneumoconiosis and that only the most heroic methods of exclusion can get rid of this association, and furthermore, that the theoretical and practical interest is so slight that it does not justify the hard work involved.

Relationship with Gamma Globulin Measurements.—Estimates of gamma globulin in Kunkel tests were made by Dr. Kayser of the Welsh National School of Medicine on the majority of populations A and C. The results are shown in Table 7. It will be seen that on the average the values are higher for P.M.F. but the wide scatter discouraged us from further investigations on these lines.

Relationship with Social Disability.—The social consequences of pneumoconiosis were reviewed by Hugh-Jones and Fletcher (1951). They pointed out how serious the problem of unemployment was for the ex-miner with pneumoconiosis, owing to his disability on the one hand and his suspension from his trade on the other. The problem was re-investigated in greater detail during the first Rhondda Fach survey. Fig 14 shows an analysis based on the

TABLE 7

AVERAGE VALUE AND SCATTER OF GAMMA GLOBULIN IN THE VARIOUS AGE-RADIOLOGICAL GROUPS IN THE TWO POPULATIONS

Population	Age Group	Radiological Categories				
		0	1–2	3	A	B.C.D.
A	± 35	7·3 (7·1–7·5)	5·4 (3·5–6·7)	5·1 (1·6–9·1)	11·6 (5·7–20·7)	10·4 (3·8–18·2)
	± 45	2·4 —	5·8 (1·9–12·9)	8·3 (3·7–14·0)	7·2 (4·1–9·0)	9·4 (4·0–18·7)
	± 55	4·1 —	7·2 (4·0–12·7)	7·4 (2·4–10·2)	5·8 (3·5–9·8)	7·1 (3·1–11·0)
C	± 35	5·0 (2·8–8·6)	5·0 (2·6–7·5)	5·5 (2·7–9·5)	4·8 (4·5–5·4)	
	± 45	5·7 (3·3–14·0)	4·2 (2·6–6·9)	3·8 (2·0–6·3)	4·9 (2·9–6·5)	
	± 55	5·4 (3·2–9·2)	5·6 (2·2–8·0)	5·0 (2·6–9·6)	6·8 (3·9–9·1)	

FIG. 14

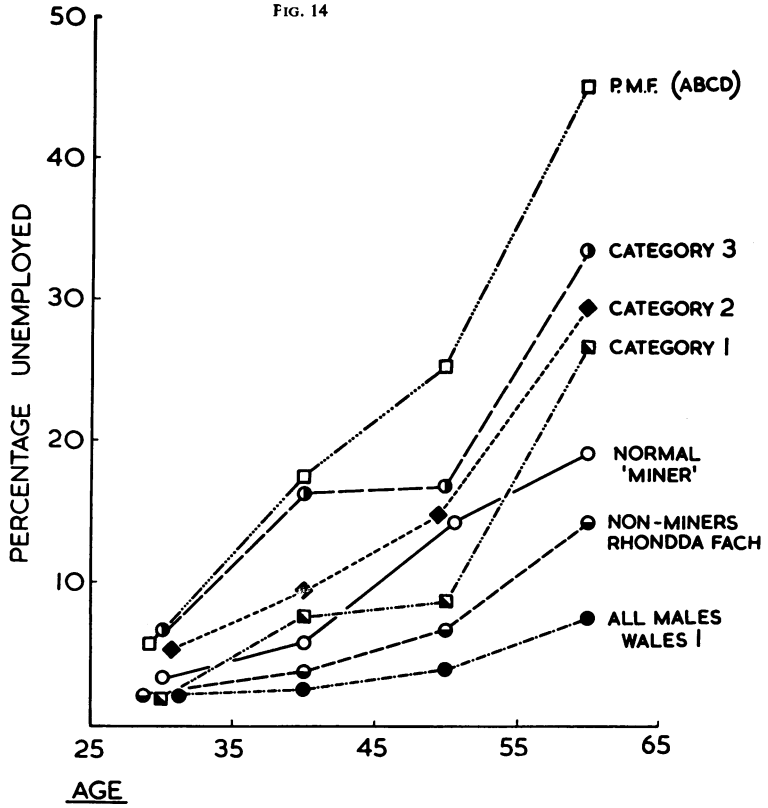
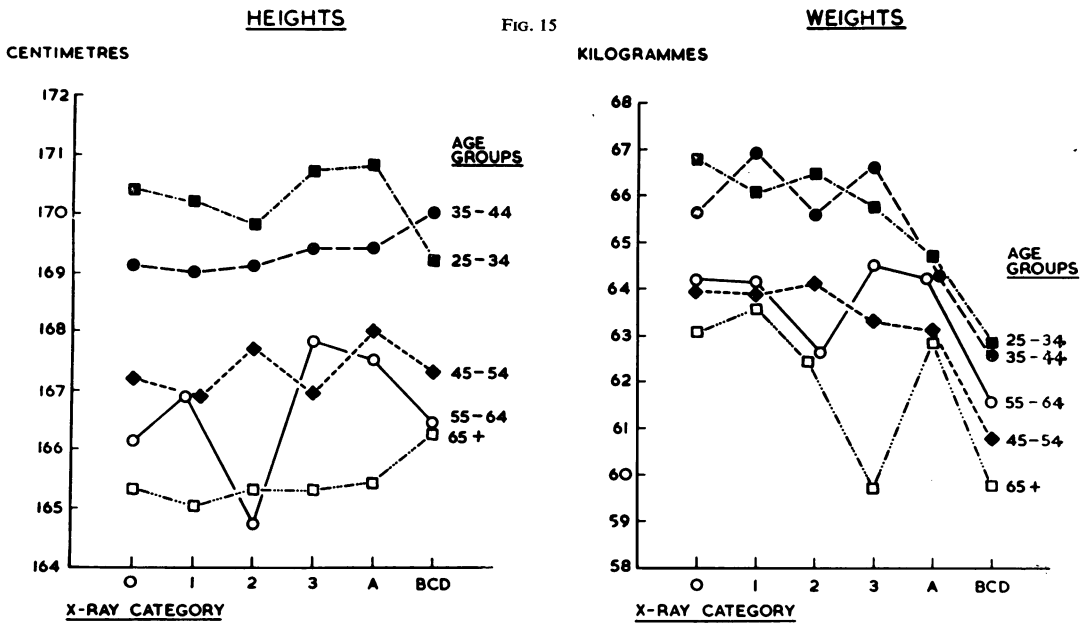


Fig. 14.—Miners, ex-miners, and non-miners by age, radiological category, and unemployment,

FIG. 15.—The average heights and weights of miners and ex-miners in the Rhondda Fach analysed by age and radiological category.

FIG. 15



industrial histories of the miners and ex-miners interviewed and radiographed during the scheme. It shows that there is a very definite empirical relationship between radiological category and percentage unemployment if due allowance is made for age. It is, however, uncertain whether the radiological category is connected with unemployment through " disability " or " suspension ", or both.

Relationship with Height and Weight.—Fig. 15 shows the relationship between age-radiological category and height amongst the miners and ex-miners in the Rhondda Fach. The usual decline with age is seen in all radiological groups. There is no significant difference between the different radiological groups. Gilson and Hugh-Jones (1955) found that stem height and radiological status were related, the higher radiological groups having lower average stem heights, but we are unable to confirm this in our data for heights. Fig. 15 also shows the relationship between age, radiological category, and weight on the same population. It demonstrates that the more advanced stages of complicated pneumoconiosis cause a very definite loss of weight.

Conclusions

All the evidence we have assembled suggests that the radiological prevalence of pneumoconiosis, in comparison with other abnormalities, is high—although probably not higher than in comparable areas in other countries. It must, however, be remembered that the prevalence has been measured in purely radiological terms. Before considering this as giving information about the size of the problem one must consider the relationships established between radiological category and other biological characteristics.

We are now in a position to say that simple pneumoconiosis is unassociated with loss of weight or serious loss of expectation of life; probably unassociated with a raised E.S.R., and associated with only slight pulmonary disability. It is, however, probably associated, as far as categories 2 and 3 are concerned, with an increased liability to develop P.M.F. In the absence of P.M.F., the high prevalence of simple pneumoconiosis would not represent a serious problem.

All the evidence, on the other hand, suggests that P.M.F. is a serious, chronic, slowly progressive disease, associated on the average with loss of weight, raised E.S.R., pulmonary disability, an increased tendency to develop a positive sputum, and a shortened expectation of life. It is therefore only correct to pay more attention to the prevalence of P.M.F. than to that of simple pneumoconiosis.

It is, however, a sad fact that the prevalence of P.M.F. is far too high. It can be looked at from three different points of view. It is in the first place an awful warning as to what happens when industrial processes continue for many years without adequate medical control. Secondly, it is a challenge to preventive medicine. The measures suggested to prevent this disease are better discussed with the factors influencing the attack rate of P.M.F., but in summary it can be said here that the possible approaches might include some of the following:

(1) The reduction of dust concentration in the mines to such a level that only a small percentage of miners exposed to this concentration throughout their working lives would be likely to develop sufficient simple pneumoconiosis to be at risk as regards the development of P.M.F.

(2) A system of routine radiography which would remove miners from further dust exposure likely to cause progression of simple pneumoconiosis after category 1 is reached. This would have the additional advantage of controlling tuberculosis in the collieries.

(3) The reduction of tuberculous infectivity in mining areas (Cochrane *et al.*, 1955).

Another point of view is the " tuberculosis " one. Many of us have hopes of eliminating tuberculosis from this country in the near future. There are many obstacles in the way, but one of them will be the number of cases of P.M.F. in some mining areas, combined with their tendency to develop positive sputum. This will call for constant vigilance by the chest clinics in the mining areas.

Summary

In radiological surveys of coal-miners the Pneumoconiosis Research Unit has used a classification consisting of three categories of simple pneumoconiosis and four of progressive massive fibrosis (P.M.F.). It has proved to be a reliable index of dust exposure and to give some indication of pathological change. Progressive massive fibrosis is a sinuously disabling disease which may shorten life, while simple pneumoconiosis causes slight disability.

The underground populations of 12 British collieries had prevalences of radiological abnormality ranging from 60% to 20%. At eight of these collieries (in Wales) the surface populations had prevalences ranging from approximately 40% to 20%. There is some indication that the prevalences of pneumoconiosis among surface and underground workers in four Rhondda Fach collieries were similar to prevalences in French collieries. Among Belgian coal-miners there was a relatively high

percentage of simple pneumoconiosis with a low prevalence of P.M.F.

A comparison of the prevalence of pneumoconiosis among the younger miners and ex-miners radiographed in the Rhondda Fach in 1950-51 and 1953 suggests that there has been a true fall in the attack rate of simple pneumoconiosis and P.M.F. While patients with P.M.F. have on the average higher enythrocyte sedimentation rates (E.S.R.) than those with simple pneumoconiosis, there is no reliable evidence that there is a regular and significant increase in the average E.S.R. with radiological category in the simple form of the disease.

The more advanced stages of P.M.F. are shown to be associated with a definite loss of weight.

There is a definite relationship between radiological category and percentage unemployment, but it is uncertain whether this is due to physical disability or the operation of compensation Acts, or both.

Since P.M.F. only develops upon advanced simple pneumoconiosis it could be prevented by reducing dust concentrations which are responsible for producing advanced simple pneumoconiosis. Its attack upon men who already have simple pneumoconiosis could be prevented by routine radiography and by reducing tuberculous infectivity in mining areas.

In work of this nature it is impossible to acknowledge personally all the assistance that has been given. It is, however, a pleasure to acknowledge the great help we have had from the officials of the National Coal Board and members of the National Union of Mineworkers in all the areas concerned, the Ministry of Fuel and Power, the Ministry of Pensions and National Insurance, the people of the Rhondda Fach, the staff of the Pneumoconiosis Research Unit, and all those who were at various times members of the epidemiological and radiographic teams.

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