TUBERCULOSIS IN INDUSTRY*

BY

FREDERICK HEAF, M.D., F.R.C.P.

Tuberculosis is a disease full of uncertainties. Our inability to determine accurately the degree of disablement, the possibility of infection in those who have apparently recovered, and the uncertain prognosis of any case cause endless problems to those studying its relation to industry. To the employer, responsible for the welfare of his staff, who has to measure efficiency in terms of costings and production, infection and reduced working capacity are two features of the disease that cause him to look upon the employment of the tuberculous with anxiety. On the other hand there is a natural desire to assist such disabled persons to obtain suitable work with a living wage: we do not wish to penalize anybody because he has tuberculosis.

Much harm can be caused by exaggerating the infectivity of the disease and the relationship to tuberculosis of the fumes and dusts of certain industries. An occupation itself rarely causes tuberculosis, though it may be a predisposing factor; but before we can come to any conclusion we must refer to the present knowledge of the pathogenesis of tuberculosis.

Pathogenesis of Tuberculosis

The majority of persons over the age of 30 have received and recovered from their primary contact with the tubercle bacillus; but the age when the primary infection is received is rising. This is seen from the recent work on skin-testing certain classes (Table I).

TABLE I.—Percentage of Negative Skin Reactors

Authority	Class	No.	Ages	Percentage Negative
Daniels (1944) ..	Nurses	3,764	All	19.2
Lees (1943) ..	Nurses	73,000	School	20.4
Lees ..	Students		15-19	78.2
Anderson (1943) ..	Nurses		20-24	76.4
			25-29	51.2
			30-34	30.2
Profit Survey (1944) ..	Naval boys		15-16	17.2
	London boys		15-16	40.0
	Nurses (voluntary hospital)		16-30	12.0
	Nurses (municipal hospital)		16-30	11.5
	Medical students		{ Male	17.8
			{ Female	16.3
				11.2

The healed primary complex, consisting of the focus at the site of infection and the lymphatic gland into which it drains, appears to confer a certain degree of immunity but at the same time may harbour virulent organisms which, if resistance is lowered, may cause reactivation of the lesion and, eventually, lesions of the reinfection type in other parts of the lung. Whether an exogenous reinfection causes an endogenous exacerbation or is itself the cause of the lesion does not concern us; but in all those occupations in which there is no reason to suppose that the individual is exposed to recurrent infection the chief cause of the development of a secondary lesion is lowered resistance. Where resistance is maintained at a high level by adequate nourishment, rest, and good environment, as in sanatoria or village settlements, constant contact

with highly infectious cases fails to produce active tuberculosis in the large majority of the staff.

Incidence and Mortality

Not only is primary contact with the bacillus occurring later, but the age group showing the highest incidence of tuberculosis is also rising, particularly in males. In Figs. 1 and 2 the distribution of fatal cases according to age groups is shown for the years 1937-9 and 1940-1 for the county of Middlesex, for males and females (E. Lewis-Faning, 1943). The increase in the higher age groups for males is clearly indicated.

Furthermore, when we work out (Parliamentary report, 1943) the percentage increase or decrease of the 1942 tuberculosis figures compared with those of 1938 for the various age groups the increase in all ages over 10 becomes apparent (Fig. 3).

FIG. 1.—Pulmonary tuberculosis. Males. Distribution of fatal cases according to age groups. (*British Medical Journal*, 1943, 2, 684.)

FIG. 2.—Pulmonary tuberculosis. Females. Distribution of fatal cases according to age groups. (*British Medical Journal*, 1943, 2, 684.)

This means that active tuberculosis is being found more often than before in the more experienced worker. Most of those lesions in the 35-45 age group are probably due to endogenous reinfection resulting from lowered resistance. In women the maximum incidence is earlier and other factors influence the problem. We know very little of the effect that endocrine disturbances have on the development of tuberculosis, and it may be that the unstable state of adolescent girls is related to the rapid rise of the incidence curve between the ages of 15 and 25. But this will not explain the distinct rise in incidence and mortality in the 20-30 age group during the war years 1940-2. The problem we have to solve is how far industry is responsible for the changes in the incidence of tuberculosis in the various age groups.

The rate of discovery of cases has increased, so the rise in incidence is not a true rise in the rate of development of the disease. Some consider

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that the increase in case-finding, mainly by radiography, accounts for 50% of the rise. For the remaining 50% we must look elsewhere. Diet, overwork, anxiety, overcrowding, and poor ventilation are probably the chief predisposing causes.

Influence of Industrial Conditions

Although normally only eight hours of the day are spent in work, it is important that working conditions should be satisfactory, and I am not going to expatiate on the necessity for adequate ventilation, good lighting, and sufficient nourishment during working hours. Absence of these will cause a lowered resistance, which may lead to reactivation of an old focus or to a new focus from recurrent infection from a probably unknown carrier. In workers previously uninfected a progressive primary lesion may develop from the initial infection, or the reinfection may follow so quickly upon the primary that a secondary lesion develops before the primary has had time to heal or acquired immunity to develop. Where working conditions are poor there is often an abnormal amount of dust.

FIG. 3.—Percentage increase or decrease of notifications of tuberculosis in age groups in 1942 compared with 1938.

and although it is difficult to demonstrate tubercle bacilli in dust even when collected from rooms occupied by open infectious cases, the incidence of phthisis is usually higher in dusty occupations than in others. Some dusts bear a special relationship to the development of tuberculosis; these dangerous trades are well known, and skiagraphic examination of all entrants is essential, as well as an annual survey of all employees.

It is not easy to estimate the danger of dust to health. The so-called harmless dusts may indirectly spread tuberculosis by causing chronic catarrh in an individual with an undiscovered active lesion. Some time ago I made an investigation of a group of offices where a number of cases of pulmonary tuberculosis had occurred. Sickness due to catarrhal influenzal colds was highest in those offices in which methods of removing dust were most inadequate, and although I could not trace any direct relationship between the incidence of tuberculosis and the degree of dustiness in the offices, the standard of general health in the cleaner offices was certainly higher than in the dusty ones. If the general health was better, then so was the resistance to disease, and there would be less likelihood of tuberculosis developing.

Certain dusts have a direct bearing on the incidence of tuberculosis. For instance, among the grinders of Sheffield the death-rate from respiratory tuberculosis in 1938 was reported in Parliament (1938) to be four times the rate for all persons over 15 in Sheffield. Further evidence comes from the figures of the Silicosis Medical Board (Sutherland, 1940) for the period 1932-9. Of 1,397 deaths due to silicosis, active tuberculosis was present in 797 cases. Numerous reports have shown that

dormant tuberculosis lesions may become active when a simple silicosis has developed. As for the infectivity of dusts in general, complete proof is not usually possible, but Cruickshank (1940), Mitman (1945), and W. F. Wells in America have shown that droplet infection is important in the spread of disease. Coughing and sneezing are particularly mentioned as expelling infected droplets into the air. Dust, by increasing catarrh, may make coughing and sneezing more frequent and so favour the spread of infection.

The importance of working conditions is seen when we consider how the mortality of tuberculosis varies in different occupations (Tables II and III).

TABLE II.—Deaths Registered 1930-2 per 100 Calculated Standard Deaths at Ages 20-65

Occupation, Males	All Causes	Resp. Tuberculosis
<i>Non-dusty Occupations</i>		
Stevedores	121	239
Barmen	149	212
Costermongers	140	200
Dockers	137	186
Waiters	134	176
Messengers	125	160
Hotel keepers	155	148
General labourers	127	146
Printers	89	128
Brewers	121	120
Compositors	92	116
Bargemen	121	110
Typists	77	105
<i>Dusty Occupations</i>		
Grinders	240	757
Sand blasters	304	750
Sandstone masons	180	396
Textile warehousemen	234	364
Metal grinders	137	275
Filers	154	260
Kiln and oven men	157	227
Barbers	122	162
Chimney sweeps	136	150
French polishers	110	148
Coal heavers	113	141
Cobblers	98	131
Horse drivers	126	124
Metal moulders	112	112
Plasterers	112	110
Sawyers	92	108
Bakers	78	71

TABLE III.—Deaths Registered 1931-2 per 100 Calculated Standard Deaths

Occupation, Single Women	All Causes		Resp. Tuberculosis	
	20-65	35-65	20-65	35-65
Nuns	110	110	194	256
Tailoresses	95	96	113	136
Charwomen	126	132	94	126
Dressmakers	108	110	124	119
Waitresses	109	111	124	119
Laundry workers	105	103	151	107
Domestics	106	115	84	103
Weavers	103	118	79	86
Typists	68	69	78	84
Sick nurses	78	74	82	81

Light work under bad conditions can be more harmful than heavy work under good conditions, as is seen by comparing the figures for farm labourers, stone quarriers, smiths, and steel forgers with those of hairdressers, barmen, costermongers, and waiters. Heavy work and poor economic conditions are a serious combination—e.g., dockers. With regard to irritating fumes, there is evidence that the inflammatory reaction of the lung to chemical irritants favours the development of tuberculosis. An exception is fumes containing silica. This is supported by the American figures (1919) of 70,552 soldiers gassed in the 1914-18 war, of whom only 173 cases subsequently developed tuberculosis—2.45 per 1,000. The general rate for U.S. soldiers was 3.50 in 1918 and 4.30 in 1919.

Figs. 4, 5, and 6 (compiled from Registrar-General's Returns, 1931-2) show the percentage mortality from tuberculosis of all occupied males in certain industries in relation to various age groups. The mortality is generally higher in the dusty trades, the peak of the curve falling in the 50-55 age group in these and in the 40-45 age group in the non-dusty and heavy occupations. When similar figures are plotted for the Registrar-General's social class divisions (Fig. 7), in all the occupied classes the peak of mortality falls in the 40-45 age group for

males. It would seem that one factor which shifts the tuberculosis mortality to higher age groups is working in a dusty occupation, and that in such work there is a greater risk of dying from tuberculosis over the age of 45 than in the non-dusty occupations.

FIG. 4.—Non-dusty occupations. Males. 1931-2.

FIG. 5.—Dusty occupations. Males. 1931-2.

Mass Radiography

With primary infection tending to occur in the higher ages the need for discovering active cases becomes increasingly important, and with the development of miniature radiography, better termed fluorography, many unsuspected active cases have been found. In mass radiography surveys the number of cases found positive by smear examination of sputum is approximately 3.5 per 1,000 examined. These need sanatorium treatment, and the quicker they get it the better. The 8 per 1,000 with lesions of

clinical significance cause difficulty, and will continue to do so until we have a more accurate method of assessing the degree of activity. At present it is by trial and error that we determine a man's capacity for work, and the allocation of a person with a stationary minimal lesion to modified work, change of occu-

FIG. 6.—Heavy industries. 1931-2.

pation, or continuance in his present employment is largely a matter of guesswork.

Curious situations may develop as a result of mass radiography. When the person in whom an active and possibly infectious lesion is discovered refuses to accept advice, the authorities are in a difficult position: the information, being confidential, must not be divulged to the managers of the firm

FIG. 7.—Social classes. Males. 1931-2.

concerned. Occasionally an error of judgment may have been made by the medical staff of the mass radiography unit, and as a result of an abnormal film being pronounced normal the management may retain the man at work, with a considerable occupational risk. Should that worker develop the disease the management might claim justification for their action because of the normal report.

The position of the industrial medical officer is somewhat anomalous: he may be informed of the number of individuals

in the works in whom abnormalities have been discovered but must not be given the names of the persons who have tuberculous lesions. A much closer link between the tuberculosis dispensary, the local labour office, and the welfare unit of the firm is required; and a workers' health and welfare committee should be formed where these matters can be discussed without prejudice. In this way suitable employment for a disabled tuberculous person might be arranged in the works without raising criticism. The importance of strengthening the links between the D.R.O., the tuberculosis officer, and the local labour office of the Ministry of Labour is recognized in the Ministry of Health Circular Letter 52/46, May 15, 1946, which states that in future the T.O. must inform the L.O. of every tuberculous person under his care who in his opinion is fit for a measure of employment and needs and desires assistance in finding it, and any patient who may not be fit for employment but nevertheless wishes to have advice about employment prospects, registration, and the facilities of the Disabled Persons Employment Act (1944). The T.O. must also furnish, at the request of the D.R.O., medical reports on Form D.P.1(X), and provide facilities for him to visit patients at the dispensary and advise him as to the nature and conditions of work suitable for the particular patient concerned. This is not easy, and much research is needed into the problem of employing the disabled.

There are other situations in mass radiography surveys causing some apprehension—e.g., searching for tubercle bacilli in symptomless cases showing minimal pulmonary shadows. Laryngeal swabs and gastric lavage are producing a high percentage of positive results in these otherwise apparently healthy people. Webster (1943), in his examination of 1,630 cases, discovered by mass radiography among Australian military forces 364 positive cases of whom 189 said they were perfectly well and symptomless after exhaustive investigation. Are we to regard them as active, infectious cases with respect to their employment and need for treatment? Our laboratories must be above suspicion, as serious errors can occur from unsound methods or technique. Personally I think we should take every precaution to prevent the spread of infection and to arrest the disease, for we have a good chance of curing these cases; and that a compromise between employment and treatment while activity exists should be avoided. In the past too much time and skill have been wasted on the impossible task of restoring the advanced case to health when consideration of the morbid anatomy would have caused us to direct our energies to efficient treatment of early cases. Mass radiography is increasing our opportunities to effect permanent cures, and we must not default by relying on the apparently healthy condition of the individual, making a wrong assessment of his capacity for work because we can offer him a light job.

Mass radiography can be of great value in discovering any person with clinically significant shadows in the chest skiagram and eliminating him from occupations in which the risk of developing tuberculosis is high. As mass radiography of the whole population is impracticable, it is best applied to serial examination of those sections of the community in which the tuberculosis risk is highest. Pre-employment radiographic examinations throw a serious responsibility upon employers in hazardous industries, for if tuberculosis subsequently develops in an individual it can be more conclusively attributed to conditions of employment.

Rehabilitation

Great advances are being made in the rehabilitation of the tuberculous by granting financial assistance. Memorandum 266T. of the Ministry of Health provides for financial assistance to pulmonary cases likely to return to work. It is insufficient for his needs, but the principle is right. It is a wartime emergency measure and will probably be abolished when the National Insurance Bill is passed. The industrial section of this Bill is of particular interest as regards tuberculosis. Part iv, clause 54, 2a, states:

"A disease or injury may be prescribed (for the purposes of this part of the Act) in relation to any insured persons, if the Minister is satisfied that (a) it ought to be treated, having regard to its causes and incidence and any other relevant considerations, as a risk of their occupations and not as a risk common to all persons,

and (b) it is such that, in the absence of special circumstances, the attribution of particular cases to the nature of the employment can be established or presumed with reasonable certainty."

Perhaps the Minister will schedule tuberculosis as an industrial disease, but this is doubtful, and it is probable that every claim will be taken on its merits. As the injury benefit is 19s. per week more than the sickness benefit there will be more claims that tuberculosis shall be considered as an injury. There has already been one ruling in court that a tuberculous lesion is an injury in the meaning of the Act. Our incomplete knowledge of the pathogenesis of tuberculosis will increasingly emphasize the need for a national tuberculosis research body supported by Government funds to investigate tuberculosis problems—particularly the development of the disease and assessing the activity of the lesion. The best solution for the tuberculous would be to enhance the privileges under Memorandum 266T. in favour of all those suffering from tuberculosis and thereby eliminate the need for proving that the disease is due to the nature of the employment.

Disabled Persons Employment Act

The Disabled Persons Employment Act, 1944, is another measure which provides means whereby the tuberculous may be rehabilitated. The full benefits of this Act have not yet been appreciated, as some time must elapse before the machinery for its working is complete, but the Minister of Labour has powers to establish a full rehabilitation scheme. One drawback to the smooth working of the Act is the reluctance of tuberculous persons to put their names on the Disabled Persons Register. The disabled person hides as much as possible his having suffered from the disease for fear of being penalized.

The general opinion of employers is against the inclusion of tuberculous persons in normal industry. Bashford and Scott (1936), after examining the histories of 3,755 cases of pulmonary tuberculosis occurring in a Post Office staff of 185,000 men and 55,000 women, concluded that of those who incur tuberculosis not more than 50% return to work even after prolonged treatment; and that of those who returned to industry there was a further wastage of about 48% from recurrent pulmonary tuberculosis or other forms of ill-health by the end of ten years. The heaviest wastage occurred in the first six years. There was a further wastage of 14% of those who survived the first ten years.

The time has come to treat this problem realistically. Two most important principles are that the employment of the tuberculous in industry must not disturb the relationship between management and labour by introducing special privileges and conditions for a selected few employees, and that the tuberculous person may be employed at work which requires a low energy output, but while he works he must complete his duties, and not expect that he can slack because he is tuberculous.

Employable patients who have received the maximum benefit from treatment are in two groups: (1) sputum-positive; (2) sputum-negative. (1) These are infectious, have an active focus in the lungs, and are particularly liable to relapse if subjected to strain or anxiety. Only exceptionally should they be re-employed in normal industry. They need special workshops and close medical supervision. These can be provided under the Disabled Persons Employment Act. They present a formidable problem. A subsidy is needed to cover their reduced capacity for work, and workshops in the form of industrial clinics where sheltered conditions can be provided. (2) These can be subdivided into three classes: (a) fit to resume on full time their occupation or trade; (b) fit to resume work on part time; (c) cannot resume their occupation or trade but could be employed at other work if properly trained. The first class does not present any difficulty. The second can sometimes be accommodated by large firms, but difficulties over wages and privileges are too great for the small firm. So-called light work often means dead-end jobs with poor pay. Unless there is a prospect of return to full work within twelve to eighteen months it is better for them to be retrained in work within their capacity and skill. It is highly important that the energy output required is within the man's capacity. The research of Orr and Leitch (1938) on the calories expended per hour (Table IV) in carrying out certain tasks should

form a standard by which we can gauge the suitability of any occupation for a particular individual. However, we still seek an easy means of determining the limit of energy output for tuberculous patients beyond which it is unsafe to go. When this is known it will not be difficult to suggest suitable occupations for most patients when sanatorium treatment is completed.

TABLE IV.—*Calorie Requirements of Man (Orr and Leitch)*

Occupation	Calories per Hour
Sewing	10-20
Writing	10-20
Sweeping	110
Stone mason	380
Sawing wood	420
Tailoring	50
Typewriting	55
Bookbinding	65
Stonemaking	90
Painter	160
Smith (heavy)	350
Coal-mining	320
Walking	150-240
Charwomen	81-157
Lecturing	73
Seamstress	6
Dusting	110
Carpentry	155

Those who cannot be re-employed in their previous occupation will have to be given other work, though to maintain the original standard of living is often difficult. Retraining usually means either temporarily or permanently lower wages for the person over thirty. The peak of the tuberculosis-incidence curve in males is shifting to the higher age groups, so this problem is likely to increase. The situation calls for the establishing of centres for the tuberculous similar to Egham, with close connexion with special workshops where continued employment may be obtained for those unable to find suitable posts in normal industry. Considerable advance in the principles underlying the employment of the tuberculous has been made by the Ministry of Labour's agreeing that such persons need not be given outdoor work. Most outdoor jobs are heavy and often poorly paid. It is very satisfactory that this should be recognized and that sedentary work should be arranged.

Russia has successfully linked sanatorium treatment with the prophylactic workshop attached to the main works, which provides modified employment for patients still under treatment at a dispensary or a night sanatorium. Adequate nourishment and rest are ensured, but remuneration is on a lower scale than that of the healthy worker. The scheme is worthy of close study and might be adopted with slight modification here.

Conclusions

To summarize the relationship of industry to tuberculosis: occupation rarely causes tuberculosis, but conditions of labour can predispose to it. These conditions, particularly the elimination of dust, which appears to be more harmful with regard to tuberculosis in the higher age groups, should receive continued attention, and also that all workers should obtain adequate nourishment during work hours. Tuberculous persons entering hazardous employment should be examined periodically by miniature radiography. A fundamental principle is the exclusion of infectious persons from normal industry, except where the other workers can be protected and suitable employment provided for the disabled person. Pre-employment radiography imposes a liability on the employer when engaging proved healthy persons in a hazardous industry. The return of the tuberculous person to normal industry must be through a properly organized rehabilitation scheme, which should be closely associated with industries that can provide suitable employment for recovered persons. Recent legislation has made this possible, but the co-operation of industry as a whole is needed to ensure success.

A national tuberculosis research organization would investigate methods for assessing the disability of those who are recovering or have recovered from the disease. The Government has accepted its share of the liability; it is now our responsibility to take advantage of the privileges provided and develop this section of industrial medicine. Special workshops or industrial clinics are required for those who cannot take their place in normal industry; indoor work within the disabled

person's capacity is more suitable than outdoor, which is usually heavy and poorly paid.

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THE INTERNAL COMBUSTION ENGINE AND THE SPREAD OF DISEASE

• BY

G. M. FINDLAY, C.B.E., M.D., D.Sc., M.R.C.P.

Late Consulting Physician, West African Command

From the dawn of history infectious diseases, together with other specialized merchandise, have spread along the trade routes of the world, whatever the mode and speed of transport. To-day it is the speed of travel both on land and in the air which adds danger to the spread of disease from endemic to non-endemic areas. Fifty years ago, when the first European missionaries went to Uganda, it took them between three and four months to walk from Mombasa; to-day the same journey can be made by air in from three to four hours. Flights of twenty-four hours for a journey from West Africa to India or of sixteen hours from England to West Africa are becoming commonplace. With jet-propelled planes the flying times will be even shorter; speeds of 500 to 600 m.p.h. (800-960 km.p.h.) for passenger planes are predicted in the near future. But it is not only in the air that the barriers to rapid intercourse have fallen. A generation ago few Africans dared to wander far from their tribal lands: if they did, it was at the risk of death, or at the best enslavement. Mountains once formed an insuperable barrier. In the old days, for instance, the Nyakyusa in East Africa feared to cross the 8,000-ft. (2,438-m.) range which blocks their valley to the north, since they were liable to die from cold. Disease was also a barrier, for the same tribe did not often visit the adjoining Kinga, who live on the Livingstone Mountain, not only because of the cold but because they were afraid of catching tick fever, which was endemic among the Kinga (Wilson and Wilson, 1945). One small tribe in the Nuba Mountains, in south-eastern Kordofan, are said to have introduced tsetse flies in order that the Baggara, or Cattle Arabs, should give them a wide berth. Evans-Pritchard (1940) relates that the Galla and Amhara of the Ethiopian highlands refuse to descend to the plains for any length of time for fear of malaria. Immediately before the war, and still more during the war, motor roads have been built throughout the Tropics in ever-increasing numbers. Shakespeare's prophecy that "the vasty wilds of wide Arabia are as thoroughfares now" is no less true of Africa and Asia, and the local inhabitants have readily taken advantage of those roads and of the motors which pass along them. There is evidence that in the past few years in Africa yellow fever, cerebrospinal fever, relapsing fever, trypanosomiasis, intestinal bilharziasis, and gonorrhoea have all been spread by those who have used the roads in their search for work or trade.

The possibility that infectious diseases and their insect vectors might take advantage of the rapid means of transport now available was translated into fact when in 1930 Shannon discovered *Anopheles gambiae* in the city of Natal, Brazil; it had apparently arrived from tropical Africa, where it is the most important malarial vector, not by air but by one of the fast torpedo-boats employed in connexion with the French transatlantic air service.

In 1933 the first International Sanitary Convention for Aerial Navigation was drawn up; but in many ways it was unworkable, and in 1944 some of its provisions were modified in the light of more recent knowledge. During the war the possibility that infectious diseases or their insect vectors might be carried from endemic to non-endemic areas was met in the more dangerous areas of Africa by the formation of inter-Allied mosquito control boards, the membership of the boards being