CHRONIC BRONCHITIS**A FURTHER STUDY OF SIMPLE DIAGNOSTIC METHODS IN A WORKING POPULATION**

BY

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The syndrome of chronic bronchitis comprises three main types of abnormality (Fletcher, 1959). Firstly, there is simple chronic bronchitis in which there is hypersecretion of bronchial mucus, manifest as mucoid sputum. Secondly, there is chronic bronchitis with recurrent or persistent infection, manifest by recurrent chest illnesses and by purulent sputum. Thirdly, there is chronic bronchitis with airways obstruction which may cause impairment of ventilatory capacity and dyspnoea. In both clinical and epidemiological studies simple, valid, reproducible, and discriminatory diagnostic tests are required for estimates of the prevalence and severity of these abnormalities. Higgins *et al.* (1959), Elmes *et al.* (1959), Fletcher *et al.* (1959), and Olsen and Gilson (1960) have recently published accounts of surveys in which such techniques have been used. In this paper we describe a survey of respiratory symptoms (using a self-administered and an interview questionnaire), sputum volumes, and ventilatory capacity estimated by the Wright peak expiratory flow meter (Wright and McKerrrow, 1959). The results are compared with other surveys, in particular that of Fletcher *et al.* (1959) among postmen, in order to assess their validity.

Methods

The survey was carried out with the co-operation of the staff of the London Transport Executive Works at Chiswick and Acton. The works at Chiswick are concerned with the maintenance of London buses, and the neighbouring Acton works with the servicing of underground trains. The men employed there are engaged in heavy or light engineering work, and there is no special industrial hazard. The survey was confined to men aged 30 to 59. After preliminary discussions with the employers and the workmen's representatives a short questionnaire on cough, sputum, dyspnoea, and smoking habits (see Appendix A) was issued with their pay slips to all men aged 30 to 59 in February, 1959. The men were asked to complete the questionnaire and return it in a sealed envelope that was provided. The statistical department of London Transport Executive issued us with a list of all men in this population with works numbers ending in 0 or 1. This provided a one in five random sample consisting of 513 men.

The men in this sample were invited to attend for interview during March, 1959. At these interviews sitting height was recorded in centimetres and weight in pounds, and then a questionnaire (see Appendix B), similar to the previous one but with some additions, was completed by us. One of us (C. M. F.) had had considerable experience in the use of respiratory questionnaires, and had taken part in a survey of Post Office workers reported by Fletcher *et al.* (1959); the other (C. M. T.) studied tape-recordings of interviews obtained during

that survey. She then conducted six interviews with patients having some respiratory symptoms. These interviews were tape-recorded, and a few differences in technique of questioning were corrected. The subjects were allocated to the two interviewers in the order in which they arrived in the works surgery where the interviews were conducted. There was no special randomized allocation.

The ventilatory capacity was estimated by each observer, after completion of the questionnaire, using the Wright peak flow meter (Wright and McKerrrow, 1959). After demonstration of the technique by the observer, five readings were taken from each subject and the mean of the highest three readings was recorded for coding. For comparative purposes these figures were standardized to age 40 from the regression relationship with age calculated from the readings obtained from all the men who answered "no" to every question on symptoms and who produced no sputum. Finally, the men were asked to produce early-morning sputum specimens according to the technique described by Elmes *et al.* (1959). The total time taken to complete the questionnaire, to obtain peak flow recordings, and to issue the sputum bottle averaged 12 minutes. The answers to the written and interview questionnaires were coded, checked by both of us, and transferred to punch-cards for sorting.

Response and Observer Variation

The lapse rate on the written questionnaire issued to the whole population was approximately 25%. The verbal questionnaire was completed on 462 (91%) of the 513 men in the random sample. Measurements of peak expiratory flow were made on all but one of these men. Of those who failed to attend for interview, three were absent from work with bronchitis, one with pulmonary tuberculosis, and one with sciatica. The remainder had no recent record of sickness absence to account for their failure to attend. Of the 462 men who attended for interview, 47 (10%) did not complete the written questionnaire. Thus 98 of the 513 men failed to return the written questionnaire, so that the total lapse rate for this part of the survey was 19%.

Since we wish to compare our results with those of Fletcher *et al.* (1959), who studied postmen aged 40–59, we shall largely confine our attention to the 363 men aged 40–59 whom we interviewed. The mean age of these men interviewed by each observer was almost identical (Table I), but they differed in certain other respects. Observer A saw significantly more present smokers and fewer ex-smokers than observer B, and recorded a slightly but not quite significantly higher proportion of cough on rising, and very much more "wheeze on most days and nights." On the other hand, observer A recorded fewer chest illnesses. It is unlikely that the recorded differences in smoking habits were due to observer variation, for little observer differences in recording smoking habits were found by Fairbairn *et al.* (1959). It is probable that in this important respect the samples seen by the two observers were really different. The slightly higher proportion of cough recorded by observer A may be associated with the difference in smoking habits. The difference in number of men with wheezing may have been due to observer variation, for observer A illustrated wheezing by an audible demonstration in asking this question, while observer B did not do so. The mean value of peak expiratory flow rates obtained by the two observers did not differ significantly.

TABLE I.—Percentages of Men Aged 40–59 with Respiratory Symptoms Recorded by Two Observers at L.T.E.

Question	Observer A %	Observer B %
1 and 3 Chronic cough on rising ..	42.2	33.5
1, 2, and 3 " " all day ..	17.6	18.3
4 and 6 " phlegm on rising ..	37.2	32.9
4, 5, and 6 " " all day ..	17.1	18.3
7, Not 8–10 Dyspnoea, grade 2 ..	11.6	10.4
8, 9, or 10 " " 3 and over ..	10.1	6.1
11 and 14 Wheeze most days and nights ..	14.1*	6.7*
15 and 16 Chest affected by weather, with breathlessness ..	13.1	16.5
17, 18, and 19 Chest illness—only 1 in past 3 years ..	6.6	7.9
17, 18, and 20 Chest illness—2 or more in past 3 years ..	1.0*	6.7*
Smoking:		
Present smokers ..	79.3*	69.5*
Ex-smokers ..	12.6*	22.0*
Non-smokers ..	8.0	8.5
Present tobacco consumption:		
1–14 g. day ..	56.3	57.9
15–24 " ..	34.2	37.6
25 g. +/day ..	9.5	4.3
Morning sputum volume:		
Nil ..	42.8	48.2
Less than 2 ml. ..	18.6	17.1
2–6 ml. ..	18.6	17.1
More than 6 ml. ..	9.0	8.5
Bottle not returned ..	11.1	9.1
Mean age-standardized peak expiratory flow rate ..	550 l./min.	530 l./min.
Mean age ..	51.1 years	51.0 years
Number of men ..	199	164

* Differences significant at 5% level.

The lower prevalence of chest illnesses recorded by observer A requires discussion. For two reasons it did not appear to be due to observer error. Firstly, it was confined to the men at Acton. Both observers recorded the same percentage of chest illnesses at Chiswick, and there was no difference in the technique adopted at the two works. Unfortunately, it was not possible to check the observer's findings at Acton against records of absence from sickness, for these were not complete for the relevant period. At Chiswick a comparison of our findings and the official record of sickness absence showed a slight but equal bias towards overrecording by both observers.

We conclude that differences between the observers were due chiefly to sampling differences, except in the case of wheezing, and that, with reservation in respect of this symptom, it is legitimate to combine the records of the two observers. It must, however, be emphasized that because we did not use any formal method of randomizing the allocation of subjects to observers, we cannot be sure how far the differences between the two observers were due to differences in technique of questioning and of estimating peak expiratory flow. It is most desirable that in surveys employing more than one observer the allocation of subjects should be properly randomized.

Comparison of Results with Surveys at General Post Office and Elsewhere

Respiratory Symptoms, Chest Illnesses, and Sputum Volume

The prevalence of symptoms at L.T.E. may be compared with that found by Fletcher *et al.* (1959) in London postmen (G.P.O.), since the questionnaire used at L.T.E. was essentially an abbreviated version of that used at G.P.O. There were more men aged 50–59 than aged 40–49 at L.T.E., while there were equal numbers in both age-groups at G.P.O. The figures at L.T.E. have therefore been weighted to permit comparisons over the age range 40–59.

Except for cough on rising, which was more prevalent at G.P.O. and may be associated with the higher proportion of present smokers in this population, the incidence of cough, phlegm, and dyspnoea is similar in the two populations, and so is the distribution of sputum volumes (Table II).

The number of men who admitted to "weather affecting the chest and causing dyspnoea" was nearly twice as great at G.P.O. This may well reflect the exposure of postmen to the polluted air of the City of London on their rounds, in contrast to the L.T.E. workshops staff, who work indoors. There is an even greater contrast in the prevalence of chest illnesses causing loss of time from work. At first we considered that this difference might be because postmen are allowed up to 26 weeks' sick leave on full pay in any one year, whereas there is no such provision at the Chiswick and Acton works of L.T.E., and because of the more strenuous outdoor work of the postmen. Official sickness absence rates (Table III) support this explanation, for they show that, whereas the workshop staff at L.T.E. have fewer periods of sickness absence certified as due to bronchitis than postmen, the average duration of the spells of absence is greater, suggesting that these men do not stay off work so readily for minor chest illnesses.

Comparison of these results with those of other population surveys in which closely similar questionnaires have been used (Table IV) makes this explanation appear less likely. Although the figures at L.T.E. and G.P.O. (both working populations) are not strictly comparable

TABLE II.—Percentages of Men Aged 40–59 with Respiratory Symptoms at G.P.O. and L.T.E.

Question	G.P.O. %	L.T.E.† %
1 and 3 Chronic cough on rising ..	48.9*	37.5*
1, 2, and 3 " " all day ..	17.0	17.1
4 and 6 " phlegm on rising ..	38.0	35.0
4, 5, and 6 " " all day ..	16.5	16.4
7, not 8–10 Dyspnoea, grade 2 ..	14.0	11.0
8, 9, or 10 " " 3 and 4 ..	9.0	8.4
11 and 14 Wheeze most days and nights ..	15.0	10.0
15 and 16 Chest affected by weather, with breathlessness ..	24.0*	13.0*
17, 18, and 19 Chest illness—only 1 in past 3 years ..	20.0*	6.0*
17, 18, and 20 Chest illness—2 or more in past 3 years ..	19.0*	2.7*
Smoking:		
Present smokers ..	89.6*	75.0*
Ex-smokers ..	5.2*	16.8*
Non-smokers ..	5.2	8.2
Present tobacco consumption:		
1–14 g./day ..	59.4*	43.0*
15+ " ..	21.9*	32.0*
Morning sputum volume:		
Nil ..	38.0	46.2
Less than 2 ml. ..	20.3	17.8
2–6 ml. ..	16.7	17.1
More than 6 ml. ..	9.4	8.2
Bottle not returned ..	15.6	10.3
Mean age-standardized peak expiratory flow rate ..	527 l./min.	540 l./min.
No. of men ..	192	363

* Differences significant at 5% level. † Figures adjusted for comparison (see text).

TABLE III.—Sickness Absence Rates Due to Bronchitis at G.P.O. and L.T.E.

Population	Annual Attack Rate/1,000 at Age:			Average Duration of Spells (Days) at Age:		
	35–44	45–54	55–64	35–44	45–54	55–64
G.P.O. 1950–54 (Reid and Fairbairn, 1958) ..	64	101	129	11.2	14.9	18.7
L.T.E. 1949–52 (London Transport Executive, 1956) ..	14	42	70	20.7	23.3	25.6

TABLE IV.—Prevalence of Productive Cough and Chest Illnesses in Various Population Surveys

Population	Reference	Age	No. of Men	Percentage with:		
				" Usual " Cough and Phlegm	Bronchitic Chest Illnesses	
					Only 1	Two or More
Samples of general populations:						
1. Vale of Glamorgan (rural Wales) ..	Higgins (1957)	55-64	86	25.6	11.6	4.7
2. Annandale (rural Scotland)	Higgins and Cochran (1958)	55-64	87	19.5	13.8	4.6
3. Leigh (urban non-mining)	Higgins <i>et al.</i> (1956)	55-64	84	*	4.8	13.1
4. Staveley (urban, non-dusty)	Higgins <i>et al.</i> (1959)	55-64	81	32.1	8.6	12.3
5. { Rural men	C.G.P. (1961)	50-59	66	31.8	6.1	4.6
Men in small towns			145	31.7	10.3	6.2
Men in large towns			115	35.7	11.3	16.5
Samples of industrial populations:						
6. London postmen	Fletcher <i>et al.</i> (1959)	50-59	96	29.2	6.3	14.6
7. L.T.E. workshop staff	Present survey	50-59	226	*	6.6	4.0

* Comparable question not asked.

with those derived from sample surveys of the general population, the incidence of chest illness in London postmen with their favourable sick-pay scheme is similar to that found by Higgins and his colleagues in rather older urban men, but slightly lower than men of the same age in large towns surveyed by the College of General Practitioners (1961). The incidence of chest illnesses at L.T.E. is much lower than in any of the other urban surveys, and is similar to that found in rural areas by both Higgins and the College of General Practitioners, while the sick-pay arrangements are probably comparable to those experienced by the general population. The number of men who retired from L.T.E. because of chronic bronchitis during the five years preceding the survey was too small to influence the prevalence of chest illnesses.

It may be that these perplexing findings are due as much to difference in the recording of chest illnesses (for only illnesses which the subject stated were associated with an increase of phlegm are included in Table IV) as to real differences in prevalence. On the other hand, there was no evidence, either at G.P.O. (Fletcher *et al.*, 1959) or L.T.E. (see above), of any systematic error leading to under-recording of these illnesses. There appears, therefore, to have been an unusually low prevalence of recurrent chest illness among the men at L.T.E. But this low prevalence seems to extend to other employees of the L.T.E., for the rates of bronchitis sickness absence for workshop staff in the period 1949-52 were similar to those of all other groups of men employed by L.T.E. (Table V). It is possible that in recruitment to L.T.E. staff, fitter subjects have been given preference. Only prospective studies with contemporaneous recording of illnesses could establish the true incidence of recurrent bronchitis in these populations.

Chest illnesses and "chest colds" (question 21) were more frequent in men with the greater sputum volumes, there being, however, no difference in this respect

between those with no sputum and those with less than 2 ml. of sputum. This relationship was qualitatively similar to that found at G.P.O. (Fig. 1). It might appear that if "chest colds" causing no absence from work at L.T.E. would have caused absence at G.P.O. the difference between the two surveys would disappear. But question 21 was not asked at G.P.O. If it had been there would probably have been a number of chest colds not causing absence to be added here as at L.T.E.

Fig. 1.—Frequency of chest illnesses at G.P.O. (A) and L.T.E. (B) and of chest colds at L.T.E. in men aged 40-59, grouped according to morning sputum volume.

Elmes *et al.* (1959) found no relation between the volume and the purulence of sputum specimens, and we confirmed this in our study, although we received only three specimens that were really purulent. Subjects who produced mucopurulent sputum had no more frequent chest illnesses or chest colds, nor had they reduced peak expiratory flow rates, compared with those who had mucoid sputum.

Effect of Smoking

There were more light smokers and fewer ex-smokers at G.P.O. than at L.T.E. (Table II). The relationship between present smoking habits, cough, phlegm production, and chest illnesses was similar in the two surveys (Table VI and Fig. 2). The number of non-smokers is small in both surveys, and one of the ten non-smokers

TABLE V.—Annual Attack Rate Per 1,000 of Spells of Sickness Due to Bronchitis in L.T.E. Male Employees, 1949-52 (London Transport Executive, 1956)

Age	Occupational Group L.T.E.				
	Workshop Staff	Central Bus Drivers	Central Bus Conductors	Motormen and Guards	Clerical and Technical Staff
40-44	14	18	21	18	20
45-49	23	27	43	32	47
50-54	60	63	72	45	50
55-59	80	78	109	72	86

TABLE VI.—Symptoms, Sputum Volume, and Mean Peak Expiratory Flow in Relation to Smoking Habits in Men Aged 40–50 at G.P.O. and L.T.E.

Smoking Category	Survey Group	No. of Men in Group	Percentage with					Mean Peak Expiratory Flow Rate (l./min.)
			Cough All Day	Phlegm All Day	Dyspnoea Grade 3 or More	Chest Illness in Last 3 Years	More than 2 ml. Sputum	
Never smoked	G.P.O.	10	—	(10.0)	(10.0)	(20.0)	(10.0)	527
	L.T.E.	30	—	(7.0)	—	(4.3)	(8.7)	570
Smoker 1–14 g./day	G.P.O.	114	16.0	18.0	7.0	29.0	28.2	534
	L.T.E.	156	15.5	14.4	8.2	8.2	29.9	537
Smoker 15+ g./day	G.P.O.	52	25.0	19.0	13.5	44.5	44.4	513
	L.T.E.	116	27.3	20.9	8.6	10.7	36.9	528
Ex-smoker	G.P.O.	16	(18.7)	(18.7)	(6.0)	(25.0)	(18.7)	534
	L.T.E.	61	11.3	16.3	(6.7)	15.0	15.9	555
Total	G.P.O.	192	17.0	16.5	9.0	39.0	26.1	527
	L.T.E.	363	17.1	16.4	8.4	8.7	25.3	540

Percentages based on fewer than 5 men are in parentheses.

at the G.P.O. had bronchiectasis. The smokers are in nearly all respects worse off than the non-smokers and ex-smokers.

Lighter and heavier smokers differ in the proportion who have persistent cough and had at least one chest illness in the past three years. More of the heavier

FIG. 2.—Percentage of men aged 40–59 producing more than 2 ml. of sputum and admitting to cough and to phlegm throughout the day according to present tobacco consumption.

smokers produced over 2 ml. of morning sputum. The questions on persistent phlegm production appear to be less discriminatory than sputum specimens in respect of smoking habits.

Ventilatory Capacity

At G.P.O., half the readings were obtained by nurses who, on the average, recorded peak expiratory flow rates of 44 litres/minute less than doctors on repeat estima-

TABLE VII.—Relationship Between Sputum Volume Category and Mean Age-standardized Peak Expiratory Flow Rate in Men Aged 40–59 at G.P.O. and L.T.E.

Sputum Volume	Survey Group	Mean Peak Expiratory Flow Rate (l./min.)	No. of Men
Nil	G.P.O.	547	73
	L.T.E.	569	164
Less than 2 ml.	G.P.O.	566	39
	L.T.E.	534	65
2–6 ml.	G.P.O.	499	32
	L.T.E.	506	65
More than 6 ml.	G.P.O.	407	18
	L.T.E.	461	32
Bottle not returned	G.P.O.	536	30
	L.T.E.	565	37
Total	G.P.O.	528	192
	L.T.E.	540	363

tions on the same subjects (Fairbairn *et al.*, 1961). Since one of our observers took part in both surveys and there was no significant difference between the mean values observed by him and the other observer at L.T.E., we have added 22 litres/minute to all the G.P.O. figures to adjust for this systematic error. The measurements of peak expiratory flow for both the L.T.E. and G.P.O. surveys have been standardized to age 40 to facilitate comparisons.*

In Table VII and Fig. 3 the men have been classified according to their morning sputum volumes. In all but one sputum group the postmen have slightly lower peak expiratory flow rates, but none of the differences in comparison with corresponding groups at L.T.E. is significant. In both samples the mean peak expiratory flow rate declines with increasing sputum volume, the exception being that postmen with no sputum had slightly lower mean figures than those with less than 2 ml. of sputum. Elmes *et al.* (1959)

thought that some postmen with sputum had failed to expectorate, and are falsely included in the “no sputum” group.

In Fig. 4 it will be seen that measurements of peak flow below 300 l./min. (approximately equivalent to an F.E.V.₁ of 1.85 l.) were almost exclusively found in men who produced sputum and predominantly in those who produced more than 2 ml. On the other hand, a large proportion of men who produced sputum had normal peak flow rates. These findings are consistent with the relationship between sputum volume and forced expiratory volume in the postmen described by Fletcher (1959).

*The measurements of peak expiratory flow on the postmen were made with an early model of the peak flow meter which gave readings in arbitrary units. Readings were taken with this instrument and one used in the present survey from 19 male volunteers who had peak expiratory flow rates ranging from 100 to 800 l./min. A closer linear correlation was found between the readings on the two instruments, and from this relationship the readings on the postmen were converted into litres per minute.

FIG. 3.—Peak expiratory flow rates standardized to age 40 in men aged 40–59 grouped according to morning sputum volume.

At L.T.E. the smokers had lower values than the non-smokers or ex-smokers (Table VI). The low figure for non-smokers at G.P.O. is curious and presumably results from observer variation in the use of the peak flow meter

FIG. 4.—Percentage distribution of peak expiratory flow rates (Fairbairn *et al.*, 1961), since these men had a significantly higher indirect maximum breathing capacity than the smokers (Fletcher *et al.*, 1959).

Replies to Questions About Phlegm in Relation to Sputum Volume

Fletcher *et al.* (1959) suggested that simple bronchitis could be graded either according to answers to questions on phlegm production or on the volume of morning sputum in the winter. They found a highly significant correlation between the two methods of grading.

Table VIII compares our findings in the whole sample population aged 30–59 at L.T.E. with those given by Fletcher *et al.* (1959) in their Table II. The relationship in the two surveys is almost identical except that, compared with G.P.O., rather more men admitting to

TABLE VIII.—Relationship Between Answers to Questions and Winter Sputum Volumes in Two Male Populations. G.P.O. (Aged 40–59) and L.T.E. (Aged 30–59)

Answers to Questions	Survey Group	No. of Specimens	Winter Sputum Volumes %			
			Nil	< 2 ml.	2–6 ml.	> 6 ml.
No phlegm	G.P.O.	105	75	16	7	2
	L.T.E.	251	77	15	6	2
Phlegm part day	G.P.O.	74	27	39	23	11
	L.T.E.	89	21	24	44	11
Phlegm all day	G.P.O.	68	16	15	36	33
	L.T.E.	72	12	24	36	28

phlegm for part of the day at L.T.E. had sputum volumes between 2 and 6 ml. The close correspondence found in two independent surveys of men of different age composition and employing different observers increases the confidence that can be placed in either of these techniques as a simple independent means of estimating the same abnormality, presumably bronchial hypersecretion.

Comparison of Written and Verbal Questionnaires at L.T.E. (men aged 30–59)

In surveys of respiratory diseases little use has been made of questionnaires filled in by the subject unaided by an interviewer, though it has been shown (Brodman *et al.*, 1949) that this method can provide useful clinical information. When we compare the answers to questions about phlegm production given in our written

and verbal questionnaires (Table IX) we find that the correspondence is fairly close. 74% of the men fall into the same category by both techniques. The chief difference is that fewer men were classified as having phlegm for part of the day only, and more as having it throughout the day on the written questionnaire. When the answers to the questionnaire were related to sputum volumes the correspondence was similar for the written and for the verbal questionnaire. The correspondence between written and verbal questionnaires on cough was similar to that for phlegm. The agreement on questions concerning dyspnoea and smoking habits in the two questionnaires was also close (Tables X and XI). Among men who admitted to dyspnoea at the interview, however, there was a higher lapse rate (owing to incomplete replies) in the written questionnaire, which thus shows a slight, significant bias towards under-recording of this symptom

We might therefore conclude that in this sample of working-men the written questionnaire provided a method of surveying phlegm production and smoking habits that was as useful as a verbal questionnaire, were it not that

TABLE IX.—Relationship Between Answers to Verbal and Written Questions About Phlegm Production. L.T.E. Men Aged 30–59. Percentages in Parentheses

Answers to Verbal Questionnaires	Answers to Written Questionnaire			Total Written Questionnaires Returned Complete	Total Verbal Questionnaires Completed
	No Chronic Phlegm	Chronic Phlegm Part-day	Chronic Phlegm All Day		
No chronic phlegm	219	7	9	235 (61.4)	289 (62.7)
Chronic phlegm part-day	37	17	28	82 (21.4)	99 (21.4)
Chronic phlegm all day	14	5	47	66 (17.2)	74 (16)
Total	270 (70.6)	29 (7.6)	84 (22.8)	383 (100)	462 (100)

74% agree.

TABLE X.—Relationship Between Verbal and Written Questions About Dyspnoea. L.T.E. Men Aged 30–59. Percentages in Parentheses

Answers to Verbal Questionnaire	Answers to Written Questionnaire			Total Written Questionnaires Returned Complete	Total Verbal Questionnaires Completed
	Dyspnoea Grade 1	Dyspnoea Grade 2	Dyspnoea Grade 3		
Dyspnoea grade 1 (no symptoms)	306	18	6	330 (84.4)	345 (74.8)
Dyspnoea grade 2 (occasional breathlessness)	12	20	5	37 (9.5)	76 (16.4)
Dyspnoea grade 3 or more	2	6	16	24 (6.1)	41 (8.8)
Total	320 (82)	44 (11.2)	27 (6.8)	391 (100)	462 (100)

88% agree.

TABLE XI.—Relationship Between Verbal and Written Questions About Smoking Habits. L.T.E. Men Aged 30–59. Percentages in Parentheses

Answers to Verbal Questionnaire	Answers to Written Questionnaires			Total Questionnaires Returned Complete	Total Verbal Questionnaires Completed
	Smoker	Ex-smoker	Non-smoker		
Smoker	293	4	4	301 (72.6)	338 (73.2)
Ex-smoker	—	57	10	67 (16.1)	74 (16.0)
Non-smoker	—	—	47	47 (11.3)	50 (10.8)
Total	293 (70.7)	61 (14.7)	61 (14.7)	415 (100)	462 (100)

96% agree.

the written questionnaire carried an additional lapse rate of 10%, and the questions on phlegm production, in particular, were not completed by a further 30% of the men. The same written questionnaire, however, when issued to 780 Post Office clerical workers, carried a lapse rate of only 7%. The prevalence of symptoms elicited by the written questionnaire in these two populations was essentially similar, and the relationship of symptoms to sputum production at L.T.E. corresponded for both the written and verbal questionnaires. The contrasting lapse rates may be related to difference in occupation. A written questionnaire of this type should be more reliable in a population accustomed to clerical work.

Discussion

The correspondence between replies to questions about phlegm production and the volume of morning sputum found by Fletcher *et al.* (1959) has been confirmed in our survey (Table VIII). This suggests that replies to standard questions about phlegm by independent observers may be relatively free from bias. The technique of measurement of morning sputum volume has the advantage of greater objectivity. It also permits the separation of an extra category of subjects who produce larger volumes of sputum. These men have a greater incidence of chest illnesses (Fig. 1) and lower average ventilatory capacity (Table VII) than those who produce smaller volumes. Both the standard questions and the measurements of morning sputum volume may be as useful in clinical as in epidemiological studies.

A prevalence survey cannot reveal the reasons for these associations. We need to know whether bronchial hypersecretion, perhaps due to smoking, increased the attack rate of bronchial infection, or whether these infections caused persistent hypersecretion of mucus. We also need to know under what circumstances impaired ventilatory capacity develops in men with simple bronchitis. Prospective study might provide answers to these questions. The present survey was in fact designed to provide a basis for such a study, arrangements for which are now being made.

Our observations on the questionnaire which the men filled in themselves suggest that this technique may prove useful, particularly as a screening procedure. The high lapse rate might be overcome by interviewing those subjects who fail to return or complete this type of questionnaire. This simple technique might also permit studies of death rates from bronchitis and lung cancer in relation to symptoms as well as smoking habits in large populations.

The chief differences found between the employees of the General Post Office and London Transport Executive were that more of the former complained that the weather affected their chest (presumably because of their outdoor occupation), and there was a higher incidence of chest illness in the Post Office population. The simple explanation that the latter difference is due to differences in sick-pay schemes is not borne out by comparison with other population surveys. Questions about chest illnesses in recent years are at present the only means available, in prevalence surveys carried out on a single occasion, for estimating the frequency of recurrent infection in cases of chronic bronchitis. The results of surveys carried out in various parts of the United Kingdom shown in Table IV present a pattern of a uniform incidence of simple chronic bronchitis, but

an increased incidence of chronic bronchitis with recurrent infection in urban compared with rural areas. The inconsistency of our results with this general picture remains unexplained, and raises some doubts about the possible effects of variations due to both observers and subjects in recording chest illnesses that have caused absence from sickness over a period of three years.

We did not find that subjects with mucoid differed from those with mucopurulent sputum in any important respect. It does not at present appear that macroscopic inspection of the sputum has any value in epidemiological studies, though in clinical work the association between infection and purulence makes this a useful diagnostic procedure.

In our survey, the Wright peak flow meter proved a rapid and simple method of estimating ventilatory capacity, and we were able to show a significant depression in men with larger sputum volumes. However, Fairbairn *et al.* (1961) have shown that the peak flow meter is liable to observer variation and is less discriminatory between bronchitic and normal subjects than measurements of forced expiratory volume.

As in previous surveys reported by Higgins (1959), we have found smokers to have more frequent respiratory symptoms, more frequent chest illnesses, and depressed ventilatory capacity compared with non-smokers. The increased prevalence of symptoms and depression of mean ventilatory capacity of smokers compared with non-smokers which we observed is similar to that found by Higgins (1959) in five random samples of men aged 55–64 and by the College of General Practitioners (1961) in random samples of men and women aged 40–64. In all these surveys there has been a relatively small difference between heavier and lighter smokers.

There are various ways of interpreting these findings. It may be that the effect of smoking on the bronchial tree is due to some form of sensitivity and is independent of the quantity smoked after a threshold level has been passed. There are few people who smoke under 10 cigarettes a day, and we have not investigated this group of very light smokers separately. Alternatively, it may be that those whose bronchial tree is most severely affected by smoking tend to reduce the amount they smoke, so that the most susceptible subjects are found among the lighter smokers; the heavier smokers would then be in a residuum of relatively insensitive subjects. However this may be, there is little doubt that the symptoms and disabling consequences of chronic bronchitis are largely confined to cigarette smokers (Doll and Hill, 1956; Olsen and Gilson, 1960), and it is not unreasonable to conclude that cigarette smoking is one of the more important aetiological factors in chronic bronchitis in Great Britain.

Summary

A survey of respiratory symptoms, using a self-administered and an interview questionnaire, morning sputum volume, and ventilatory capacity estimated by the Wright peak expiratory flow meter, was carried out on a random sample of 513 men aged 30 to 59 at the London Transport Executive workshops.

Agreement between the answers on cough, phlegm, dyspnoea, and smoking habits in the two questionnaires was good, but the written questionnaire was not returned or was incompletely filled in by a quarter of the men. The lapse rate was only 7% in a group of Post Office

clerks. It appears that a self-administered questionnaire can provide useful information, especially in a population accustomed to clerical work.

Comparison of the results of the present survey with a previous survey of London postmen revealed a similar prevalence of respiratory symptoms in the two populations, but the London Transport employees had fewer chest illnesses than postmen or random samples of men in other urban areas. Possible explanations for this difference are discussed. The relationship between answers to questions about phlegm production and morning sputum volume was closely similar in the two populations, confirming the validity of these techniques in the diagnosis of simple chronic bronchitis.

In both populations, cough, phlegm production, chest illnesses, and impaired ventilatory capacity were more frequent in smokers than in non-smokers. Chest illnesses and impaired ventilatory capacity were more frequent with increasing sputum volume. Prospective study is needed to reveal the reasons for these important associations.

We thank the London Transport Executive authorities for permitting the investigation, and Mr. J. W. Wicks and Mr. G. S. Bingham and their staffs for all the trouble they took on our behalf. We are indebted to Dr. Leslie Norman, Dr. P. A. B. Raffle, and Dr. A. W. Gilks and his staff for help and encouragement, and to Mr. C. J. Cornwall for drawing our random sample and for information on sickness absence rates. We are grateful to the unions whose members are employed at the Chiswick and Acton works for their support, and to the men interviewed by us for their willing co-operation. The investigation was supported by a grant from the Medical Research Council.

APPENDIX A

Self-administered Questionnaire

CONFIDENTIAL

MEDICAL RESEARCH COUNCIL BRONCHITIS RESEARCH

Please help this research by answering the questions on this form. It is most important that **everyone** should do this. Even a few refusals may spoil the whole scheme. Only the doctors doing the research will see the information on this form.

Surname..... First name(s).....
Date of Birth : Day.....Month.....Year.....Grade.....Branch.....

PART I

Put **Yes** or **No** in the square after each question. (If in doubt put No.)
Put **O** in the square if the question doesn't apply to you.

1. Do you cough at all during the winter when you first get up. ... ☐
when you first smoke. ... ☐
when you first go out. ... ☐
2. Do you cough during the rest of the day in winter. ... ☐
3. Answer this if you have answered 'Yes' to question 1 or 2 :
Do you cough like this on most days for as much as 3 months each winter. ... ☐
4. Do you bring up any phlegm at all from your chest (not from your nose) during the winter when you first get up. ... ☐
when you first smoke. ... ☐
when you first go out. ... ☐
5. Do you bring up any phlegm during the rest of the day in winter. ☐
6. Answer this if you have answered 'Yes' to question 4 or 5 :
Do you bring up phlegm like this on most days for as much as 3 months each winter. ... ☐
7. Do you usually get short of breath if you hurry when walking on the level. ... ☐
8. Do you have to walk slower than other people on the level because of breathlessness. ... ☐

PART II

First decide whether you are a smoker, ex-smoker or non-smoker. Then fill in the squares in **only one** of the sections below.

A Smoker is anyone who regularly smokes as much as one cigarette a day or half an ounce of tobacco a week.

An Ex-smoker is anyone who has ever smoked as much as this for as long as one year, but who now smokes less than this.

A Non-smoker is anyone who has never smoked as much as this for as long as one year.

SMOKERS	EX-SMOKERS	NON-SMOKERS
I began smoking regularly when I was aged ☐	I began smoking regularly when I was aged ☐	Put 'X' in the square opposite the right answer.
At present I smoke about :	I last gave up smoking when I was aged ☐	
☐ Cigarettes a day.	Before I last gave up I was smoking :	I have never smoked at all ☐
☐ Ounces of tobacco a week in hand-rolled cigarettes.	☐ Cigarettes a day.	I have had an occasional smoke ☐
☐ Ounces of tobacco a week in pipe.	☐ Ounces of tobacco a week in hand-rolled cigarettes.	
☐ Cigars a week.	☐ Ounces of tobacco a week in pipe.	
	☐ Cigars a week.	

APPENDIX B

Verbal Questionnaire

Cough

1. Do you cough at all when you get up, or first thing in the morning ? Yes/No
2. Do you cough during the rest of the day ? Yes/No
- If yes to either:
3. Do you cough like this on most days for as much as three months every winter ? Yes/No

Phlegm

4. Do you bring up any phlegm at all from your chest (not from the back of your nose) when you get up, or first thing in the morning ? Yes/No
5. Do you bring up phlegm during the rest of the day ? Yes/No
- If yes to either:
6. Do you bring up phlegm like this on most days for as much as three months every winter ? Yes/No

Breathlessness

7. Are you troubled by shortness of breath ? Yes/No
8. Do you have to walk slower than people of your own age on the level because of breathlessness ? Yes/No
9. Do you ever have to stop for breath when walking at your own pace on the level ? Yes/No
10. Do you have to stop for breath after walking about 100 yds. (or after a few minutes) on the level ? Yes/No

Wheezing

11. Does your chest ever sound wheezy or whistling ? Yes/No
12. If yes: Is this: Only with colds ? Yes/No
- Occasionally—apart from colds ? Yes/No
14. Most days or nights ? Yes/No

Weather

15. Does the weather (such as fog or cold) affect your chest ? Yes/No
16. If yes—Does it make you (more) breathless ? Yes/No

Chest Illness

17. In the last three years have you had a chest illness which has kept you off work for as much as a week ? Yes/No
18. If yes—Did you bring up (more) phlegm than usual in any of these illnesses ? Yes/No
- During the past three years have you had
19. Only one such illness with increased phlegm ? Yes/No
20. More than one such illness ? Yes/No
21. Apart from this do you get such bouts of (increased) cough and phlegm lasting at least three weeks each winter ? Yes/No

Smoking

22. Do you smoke ? Yes/No
23. If no: Have you ever smoked as much as one cigarette a day for as long as a year ? Yes/No
24. At what age did you begin smoking regularly ?
25. At what age did you last give up smoking ?

	Now	Changes during past 10 years
Cigarettes per week ..		
Oz. tobacco/week (hand-rolled) ..		
Oz. tobacco/week (pipe) ..		
Cigars (number/week) ..		

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FREEZE-DRIED B.C.G. VACCINE FROM AN ISONIAZID-RESISTANT STRAIN

A LABORATORY INVESTIGATION

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The use of a B.C.G. vaccine made from an isoniazid-resistant strain for vaccinating tuberculosis contacts while they are receiving prophylactic treatment with isoniazid would have obvious advantages. Such a vaccine has been proposed by Canetti (1956). With the availability of more precise methods of preparing stable freeze-dried B.C.G. vaccine (Ungar *et al.*, 1956; Muggleton, 1960) a comparison of B.C.G. from isoniazid-resistant and isoniazid-sensitive strains has been undertaken. This paper describes the preparation of the freeze-dried vaccines and their properties as determined in the laboratory.

Experimental

Preparation of the Isoniazid-resistant B.C.G. Culture

The strain of B.C.G. used in our laboratories was derived from the Copenhagen substrain in 1954. It is maintained in freeze-dried master cultures, which are recovered, as required, on Löwenstein-Jensen egg medium. These cultures were used to inoculate tubes of Dubos's liquid medium; these, after nine days' incubation at 37° C., in turn provided inocula for a series of tubes of the same medium containing falling concentrations (double dilutions of 100 µg./ml., 50 µg./ml., 25 µg./ml., etc.) of isoniazid. After nine days' incubation at 37° C. the tubes were examined for growth of the B.C.G. The culture containing the highest concentration of isoniazid showing visible growth was used as inoculum for a further set of tubes, and the process was repeated until 14 transfers in isoniazid had been made.

The B.C.G. strain was originally sensitive to 0.05 µg. of isoniazid per ml. Resistance development took place

in slow steps up to 25 µg./ml.; at this point it appeared to stop, and further serial transfers failed to increase the resistance. Freeze-dried master cultures of the resistant substrain were then prepared.

At this point the substrain developed a tendency to grow poorly in Dubos's medium—a phenomenon that was later associated with its inability to produce catalase. Sauton's medium would not support its growth at all, although it grew freely on Löwenstein-Jensen egg medium, on glycerol/potato slopes, and on blood agar.

Tests for catalase on washed centrifuged cells from Dubos's cultures were negative, whereas the control parent isoniazid-sensitive strain gave a positive result.

Morphologically the resistant and sensitive cultures were identical in size, shape, and staining characteristics. The differentiation of living and dead cells from older cultures could be made with both cultures by the neotetrazolium reduction technique of Greenberg *et al.* (1958) or by the differential staining technique of Lack (1953).

The virulence of the resistant substrain to guinea-pigs was compared with that of the parent sensitive strain. A group of six 250-g. male albino guinea-pigs was used for each, and each animal received the equivalent of 5 mg. of moist weight of centrifuged organisms from a 9-day-old Dubos culture. The animals were observed for 10 weeks, during which they each gained more than 220 g. in weight. They were then killed; post-mortem examination did not show any progressive disease in any of the animals. Both the resistant substrain and its sensitive parent produced an abscess 5 mm. in diameter at the site of injection, with some enlargement of regional lymph nodes.

Preparation of Freeze-dried Vaccine

The isoniazid-resistant culture was used to prepare three batches of ampoules of freeze-dried vaccine by the method we have described previously (Ungar *et al.*, 1956). Since the resistant culture would not grow in the Sauton medium usually employed for preparing vaccine from the sensitive parent strain, two of the batches (192 and 331) were prepared from cells grown for 12 days in Dubos's medium. The cells were collected in the centrifuge, washed once in saline to free them from traces of serum albumin from the culture medium, and used to prepare the vaccine. The third batch (390) was grown in a modified medium, based on Sauton's formula, in which the glycerol was replaced by sodium glutamate, glutamine, and a purified casein hydrolysate. Two batches (258 and 389) of vaccine prepared from the parent isoniazid-sensitive strain were used for control purposes.

The residual moisture contents of the three resistant and two sensitive batches were measured by the vapour-pressure method (Beckett, 1954) and found to fall between 0.9 and 1.1% residual moisture.

Viability Counts

The viabilities of the batches were assessed by a modification of the technique of Miles *et al.* (1938) on Petri dishes, with an oleic acid-albumin medium containing 10% human blood. The colonies were counted under a stereobinocular microscope after 28 days' incubation at 37° C. Sometimes, and unpredictably, the isoniazid-resistant culture would grow poorly and give low counts in one set of tests, a phenomenon that seemed to be associated with the lack of catalase formation by the substrain.