REFERENCES

- Abrahams, D. G. (1950). *British Medical Journal*, 2, 1418.
 Banks, H. H., Seligman, A. M., and Fine, J. (1949). *J. clin. Invest.*, 28, 548.
 Bauer, G., Boström, H., Jorpes, E., and Kallner, S. (1950). *Acta med. scand.*, 136, 188.
 Cosgriff, S. W., Cross, R. J., and Habif, D. V. (1948). *Surg. Clin. N. Amer.*, 28, 324.
 Dale, H. H., and Laidlaw, P. P. (1911). *J. Path. Bact.*, 16, 351.
 Duff, I. F., Linman, J. W., and Birch, R. (1951). *Surg. Gynec. Obstet.*, 93, 343.
 Goodwin, J. F., and MacGregor, A. G. (1950). *Lancet*, 2, 667.
 Gubbay, E. R., and Pash, E. (1953). *Canad. med. Ass. J.*, 69, 105.
 Hauch, E. W., and Barker, N. W. (1951). *J. Lab. clin. Med.*, 38, 550.
 Loewe, L. (1947). *Amer. J. Med.*, 3, 447.
 McClean, D. (1942). *J. Path. Bact.*, 54, 284.
 Marks, J., Truscott, B. M., and Withycombe, J. F. R. (1954). *Lancet*, 2, 787.
 Meyer, K. (1947). *Physiol. Rev.*, 27, 335.
 Simon, N., and Narins, L. (1949). *Amer. J. Roentgenol.*, 61, 91.
 Tuchman, M. S., and Moolten, S. E. (1950). *Amer. J. med. Sci.*, 219, 147.
 Wynn, A., and Goodwin, J. F. (1952). *British Medical Journal*, 1, 893.

PULMONARY TUBERCULOSIS IN A RURAL AREA IN SOUTH SCOTLAND

THE ANNANDALE SURVEY*

BY

J. B. COCHRAN, M.B., B.Sc., F.R.F.P.S., M.R.C.P.

AND

CHRISTOPHER CLAYSON, M.D., F.R.C.P.Ed.
D.P.H.

WITH

W. BELL FLETCHER, F.S.S.

Organizing Secretary

(From Dumfries and Galloway Sanatorium, Lochmaben)

This paper describes a community x-ray survey in South Scotland designed primarily to measure the prevalence of pulmonary tuberculosis in a rural area. For convenience of administration and organization the survey area was defined by parish boundaries, with Lochmaben Sanatorium approximately at the centre. The sanatorium undertakes the routine tuberculosis service of the area, and this was of great advantage in organizing the survey and in obtaining an accurate overall measurement of prevalence, distinguishing between previously known and hitherto unknown cases.

The survey began with a private census on March 7, 1956, and the x-raying was completed by August 7, by which time 95.13% of the population of 8,658 had been x-rayed.

Methods

Survey Team.—The team comprised a medical director, organizing secretary, records officer, radiographer (untrained), and two home visitors—all full-time. In addition, the county medical officer of health seconded a tuberculosis health visitor for four afternoons a week. This health visitor worked voluntarily on many evenings, and a retired farmer also freely devoted a great deal of time to the survey. There were other part-time occasional workers. An overall estimate of the strength of the team in terms of full-time personnel would be seven or eight. The clinical aspects of the survey—including examination of recalls—were undertaken by the medical director with sanatorium nursing and x-ray staff.

Survey Area.—This measured 136 square miles (352 square kilometres) of mainly farm land in the valley of the River Annan, in Dumfriesshire. There are eight parishes

and two small burghs. One of the burghs (Lockerbie) is a small market town, while the other (Lochmaben) is a residential burgh with no industry. The area is predominantly agricultural. The only industry is a small cheese factory. About 12% of the working population are employed in factories and offices outside the survey area in or near the towns of Dumfries and Annan.

The population density for the whole area was about 11 per 100 acres (40 hectares). This figure varied widely, reaching almost 600 in the burghs and declining to 2 per 100 acres (40 hectares) in the remoter landward areas (General Registry Office, 1953).

Survey Population.—This was initially defined by private census. Any population may, of course, vary from day to day. The total area was roughly divided into sectors (30 in all), and the subjects were x-rayed from a central point in each sector. The defined population comprised all persons over the age of 5 years who were resident on the last day of the main x-ray session for each sector. A person was considered resident in the area if he or she normally slept there at least two nights a week. Although all sectors were revisited at least once throughout the survey, changes in population since the original visit were largely ignored. Children at boarding-school outside the area, H.M. Forces at home on leave, and resident sanatorium staff were excluded. Residents at two boarding-schools within the area were included. The population "at risk" was eventually found to be 8,658.

General Method of Work.—The success of the survey depended on a 90 to 100% response, and to this end reliance was placed on personal contact with the population. The team of four or five home visitors (including the medical director) undertook a preliminary private census, and later, during the x-raying, the same team carried out persistent door-to-door canvassing. The x-raying was done in halls or in a specially constructed van, using a mobile Schonander x-ray unit throughout.

Results

The defined and x-rayed populations, analysed for age and sex, are shown in Table I. In Fig. 1 the population responses to x-ray examination are shown for Annandale and the Vale

TABLE I.—Percentage of Defined Population X-rayed—Analysed by Age and Sex

Age Group (Years)	Males			Females			All Cases		
	No.	X-rayed		No.	X-rayed		No.	X-rayed	
		No.	%		No.	%		No.	%
5- ..	866	865	99.9	778	776	99.7	1,644	1,641	99.8
15- ..	570	561	98.4	593	586	98.8	1,163	1,147	98.6
25- ..	672	652	97.0	635	621	97.8	1,307	1,273	97.4
35- ..	624	595	95.4	614	601	97.9	1,238	1,195	96.6
45- ..	626	594	94.9	680	649	95.4	1,306	1,243	95.2
55- ..	407	375	92.1	530	478	90.2	937	854	91.1
65- ..	456	392	86.0	607	491	80.9	1,063	883	83.0
All ages	4,221	4,034	95.6	4,437	4,202	94.7	8,658	8,236	95.1

of Glamorgan (Cochrane, Miall, and Clarke, 1956), a similar 95% rural survey in South Wales. There is a striking similarity in the response of the two areas and a clear relationship with age. The only obvious disparity is in males aged 65 and over, which may be related to the inclusion of a small number of domiciliary x-ray examinations in the Welsh survey. Cochrane, Cox, and Jarman (1955) have drawn attention to the sharp drop in response around the age of 20 observed in Norway and the U.S.A. This decline is also present to a slight degree in the Welsh survey, but in Annandale there is a uniform relationship with age for both sexes. In Annandale 95.1% of the defined population over the age of 5 years submitted to x-ray examination. An attempt has been made to analyse the 5% lapse rate. Invalidism and infirmity accounted for one-fifth of the lapses—that is, 1% of the population were physically unfit to attend for x-ray examination. Of the remainder no clear-cut reason for declining x-ray examination was volunteered, but it is believed that fear was the major factor. One-tenth of all

*The survey was financed by a grant from the Royal Victoria Hospital Tuberculosis Trust, Edinburgh.

FIG. 1.—Population response in two rural x-ray surveys.

lapses actually admitted to fear of x-ray examination. A similar number, mainly in the younger age group, lapsed almost certainly because they were difficult to contact—for example, long-distance drivers.

The percentage x-rayed in the various parishes varied from 93.6 to 99.1 (Table II). A large number of factors may well have influenced the response in separate parishes—for example, proximity to the sanatorium, number and situation of x-raying points, density of population, amount of home visiting, etc. When the results are analysed, for the age group 5 to 44 years the percentage x-rayed is not only higher in all parishes but also more uniform. This suggests that the varying parish responses at all ages are to some extent affected by the proportion of elderly residents. That this is not the sole factor is evident when the actual percentage

TABLE II.—Percentage of Defined Population X-rayed in Various Parishes and Burghs

Parish or Burgh	Defined Population Over 5 Years			Defined Population 5-44 Years			
	(1)		(2)	(3)		(4)	
	Total	No.		Total	% of (1)	No.	% of (3)
Applegarth	656	650	99.1	460	70.1	458	99.6
Dryfesdale(excl. Lockerbie)	514	496	96.5	339	65.9	334	98.5
Lochmaben Burgh	1,080	1,041	96.4	656	60.7	645	98.3
" Parish	1,110	1,064	95.9	677	61.0	664	98.1
Hutton and Corrie	438	419	95.7	260	59.4	258	99.2
Dalton	528	505	95.6	376	71.2	370	98.4
Tundergarth	233	222	95.3	153	65.7	146	95.4
Hoddom	1,142	1,071	93.8	716	62.7	694	96.9
St. Mungo	454	425	93.6	292	64.3	287	98.3
Lockerbie Burgh	2,503	2,343	93.6	1,423	56.8	1,401	98.5
Whole area	8,658	8,236	95.1	5,352	60.6	5,257	98.2

TABLE III.—Prevalence of Tuberculosis in Annandale

	Age Group (Years)															
	5-14		15-24		25-34		35-44		45-54		55-64		65 Up		All Ages	
	O	N	O	N	O	N	O	N	O	N	O	N	O	N	O	N
Males:																
Infective	—	—	—	—	—	—	—	1	—	3	1	—	—	—	1	4
Active (excl. infective)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Quiescent	—	—	—	—	1	—	2	2	2	—	—	2	—	3	5	7
Total males (per 1,000)	—	—	—	—	1 (1.5)	—	5 (8.4)	—	6 (10.1)	—	5 (13.2)	—	4 (10.2)	—	21 (5.2)	—
Females:																
Infective	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—
Active (excl. infective)	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Quiescent	2	—	1	1	6	—	—	—	1	2	—	2	1	—	10	3
Total females (per 1,000)	3 (3.9)	—	4 (6.8)	—	6 (9.7)	—	—	—	3 (4.6)	—	2 (4.2)	—	1 (2.0)	—	19 (4.5)	—

O = Old cases previously known. N = New cases discovered.

of persons aged 5 to 44 years is compared with the overall response in each parish (Table II).

Twelve new cases of active pulmonary tuberculosis were found in the survey. These people attended for x-ray examination without persuasion; thus there was no relation between the finding of tuberculosis and the order in which people came to be x-rayed. Again this is in agreement with the Vale of Glamorgan survey (Cochrane *et al.*, 1956).

Pulmonary Tuberculosis

The prevalence of pulmonary tuberculosis in the survey area is summarized in Table III, which shows the number of previously known and newly discovered cases within the various age groups. The prevalence, including arrested disease, is shown diagrammatically in Fig. 2. The overall

FIG. 2.—Prevalence of post-primary tuberculosis in Annandale. (Note: The width of each column represents the number in each age group.)

amount of clinically significant (active and quiescent) disease was low—4.9 per 1,000 (5.2 per 1,000 for males and 4.5 per 1,000 for females). Prior to the survey the corresponding figures were 2.2 (males 1.7 and females 2.6). The rate for new cases was therefore twice as high for males as for females.

As regards infective tuberculosis, four of the seven new active male cases had positive sputa, and these men were aged between 44 and 47 years. No new infective disease was found in the female population.

Other interesting findings which emerge from the survey are: of 1,642 schoolchildren x-rayed, only one (aged 6 years) had active primary tuberculosis; only one new case of active tuberculosis (not infective) was found in the population over 60 years of age; only one case of active tuberculosis was found in the female population aged 15 to 44 years.

Comparison of Results in Annandale and the Vale of Glamorgan

The Annandale and the Vale of Glamorgan (Cochrane *et al.*, 1956) surveys are unique in that 95% of truly rural populations have been x-rayed. The outstanding finding is the low level of clinically significant pulmonary tuberculosis in each area. The actual rates of infective disease were 0.7 per 1,000 in Annandale and 1.1 per 1,000 in the Vale. The yield of previously unknown infective tuberculosis was 0.5 per 1,000 in Annandale and 0.9 per 1,000 in the Vale. In both surveys the male prevalence of infective and active tuberculosis is predominantly in middle or later life, while in females the prevalence is mainly in the 15 to 44 age group. From attack-rate studies (Springett, 1951; Cochrane *et al.*, 1955; Long and Jablon, 1956) it is likely that in middle-aged males there is occurring a breakdown of disease contracted in young adult life.

As regards infective tuberculosis, the ratio of male to female prevalence is approximately 2:1 in the Vale and 6:1 in Annandale. The Vale Survey was carried out in 1955, and the Annandale Survey in 1956. The corresponding ratio in the first Rhondda Survey (Cochrane *et al.*, 1952), done in 1950-1, is 0.8:1. Therefore the ratio of male to female cases of infective tuberculosis increases from Rhondda to Vale to Annandale. We suggest that this may, in fact, be the tendency as the tuberculosis epidemic recedes.

Discussion

The principles and techniques of community chest x-ray surveys have been established in this country by the work of Cochrane and his colleagues in South Wales (Cochrane *et al.*, 1952, 1955, 1956). The highly successful surveys achieved by Cochrane and by the Welsh Mass Radiography Service (Welsh R.H.B., 1952-4) have not been repeated anywhere else in the United Kingdom. Cochrane *et al.* (1956) attribute success to three factors: (1) the taking of an accurate census, (2) persistent home visiting of non-attenders, and (3) suiting the objectives to the size of the team. The Annandale Survey was based on these three principles. The overall result of a 95.13% survey compares favourably with the Welsh work and serves to underline the techniques developed there. It is evident that the successful Welsh work is related to technique and not to any special quality of the population.

There seems little doubt that the complete community chest x-ray survey is the most certain method of detecting and thereby eradicating the residual tuberculosis infection in any area. So long as chest x-ray examination remains voluntary it is important to try to find out what special techniques can be employed to encourage the population to come forward for it. It is quite obvious that a short visit from an M.M.R. unit with some newspaper propaganda will attract only a very small percentage of any population. At the other extreme there is the community survey undertaken by a specially trained unit, with its private census, extensive propaganda, and persistent home visiting. In Annandale, certainly a widely scattered rural area, it nevertheless took five months to x-ray 8,200 people. This was accomplished by a staff of approximately seven to eight personnel, who had to work very hard indeed for long hours. There is no doubt that the eventual result is related largely to the effort expended. Whether the mass radiography service, as at present constituted, could achieve community surveys along these lines is a matter which has yet to be proved. This has been accomplished in Wales (1952-4), although in relatively small populations. Large urban surveys in this country have so far not achieved anything approaching a 90% result (Marshall, 1954; Birmingham R.H.B., 1954; City and Royal Burgh of Edinburgh, 1954). It has yet to be shown whether or not the Welsh techniques could be successfully applied to an urban area.

From our experience in Annandale we would stress the importance of the following factors in any mass radiography campaign: (a) personal contact with the population by responsible and tactful home visitors, especially during the

x-raying period; (b) the active co-operation and participation of the general practitioners concerned during the campaign—many reluctant people, and especially the elderly, will act on the advice of their general practitioner; and (c) prompt notification by letter of normal as well as recall cases.

In Annandale the infective cases were admitted to the sanatorium, and with chemotherapy underwent rapid sputum conversion. Therefore, 95% of the survey population are, for the time being, free of infective pulmonary tuberculosis. It is tempting to draw an analogy with the control of bovine tuberculosis, as the survey was carried out in an "attested" county, and to press for the human problem to be tackled with the same enthusiasm and wholeheartedness as has been applied to the disease in cattle.

Summary

The prevalence of pulmonary tuberculosis in a rural area in South Scotland has been measured. The population was defined by private census and comprised 8,658 persons over the age of 5 years, of whom 95.13% were persuaded to have a chest x-ray examination.

The overall prevalence of clinically significant tuberculosis was low—4.9 per 1,000. The yield of previously unknown infective tuberculosis was also low—0.5 per 1,000. Of 10 cases of active pulmonary tuberculosis discovered in the survey, 7 were middle-aged or elderly males, of whom 4 were infective.

As a result of the survey 95% of the defined population are, for the time being, free of infective pulmonary tuberculosis.

There is evidence that as the tuberculosis epidemic recedes the ratio of active disease as between males and females is increasing.

Techniques believed to be important in persuading people to be x-rayed are discussed.

Details of procedure (publicity, census, home visiting, radiography, and records) are available and can be obtained on application to J. B. C.

We are deeply indebted to the Royal Victoria Hospital Tuberculosis Trust, who bore the cost of the survey. We are most grateful to Dr. A. L. Cochrane, of the Medical Research Council's Pneumoconiosis Unit, for his guidance and encouragement throughout; and to Dr. W. E. Miall, of the same unit, for his criticisms. The staff of the Survey Unit maintained their enthusiasm throughout long hours of very arduous work, and to Miss B. Kearney, Miss E. Bell, Miss A. D. Henderson, and Mr. R. Tait we express our sincere thanks. A survey of this type inevitably involves many people, and it would be impossible to mention individually all those who helped. We would, however, especially like to thank Dr. S. K. Drainer, medical officer of health for Dumfries County, Mrs. J. Berry, tuberculosis health visitor, Mr. J. Brownlee and Mr. J. Wallace, of Dumfries and Galloway Hospital Board, and Mr. A. Marshall, of Lockerbie. To the general practitioners, officials of the local authorities, rural institutes, farmers' associations, and Church guilds, and to other public-spirited people in the area we are deeply grateful. The Western Regional Hospital Board kindly arranged the secondment of one of us (J. B. C.) for the period of the survey. The Oxford Regional Hospital Board gave assistance in mechanical tabulation. And, lastly, we would pay tribute to the people of Annandale, without whose co-operation this report could not have been written.

REFERENCES

- Birmingham Regional Hospital Board (1954). Stoke-on-Trent Mass Radiography Unit Report.
- City and Royal Burgh of Edinburgh (1954). Annual Report on Health Education and Prevention of Home Accidents.
- Cochrane, A. L., Cox, J. G., and Jarman, T. F. (1952). *British Medical Journal*, 2, 843.
- (1955). *Ibid.*, 1, 371.
- Miall, W. E., and Clarke, W. G. (1956). *Tubercle (Lond.)*, 37, 417.
- General Registry Office, Edinburgh (1953). Census 1951, Scotland. County Report, Dumfries. H.M.S.O., Edinburgh.
- Long, E., and Jablon, S. (1956). *Tuberculosis in the Army of the U.S. in World War II*. Veterans Administration, Washington.
- Marshall, F. N. (1954). Intensive Mass Radiography of the City of Salford. Manchester Regional Hospital Board.
- Springett, V. H. (1951). *British Medical Journal*, 2, 144.
- Welsh Regional Hospital Board (1952-4). Mass Radiography Service Report 1952-54.