PULMONARY TUBERCULOSIS IN NORTHERN IRELAND

AN EXAMINATION OF THE STATISTICAL DATA FOR 1948-54

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INTRODUCTION

In countries where mortality statistics are reasonably complete but where morbidity statistics are not, there is a danger that variations in death rates will be accepted too readily as indicative of similar variations in sickness rates. The errors of such acceptance are obviously small for diseases which are usually fatal, and the greatest difficulties arise in deducing secular trends of morbidity from mortality data of diseases with decreasing fatality rates. Northern Ireland is such a country and respiratory tuberculosis is such a disease. This particular combination of disease and country is probably studied more easily than others because in Northern Ireland all the tuberculosis services, for the whole population of about 1·4 million, are controlled by a single authority, the Northern Ireland Tuberculosis Authority. The purpose of this paper is to examine the existing morbidity and mortality data in an attempt to assess their value as measures of the success of the fight against respiratory tuberculosis.

The crude death rate attributed to respiratory tuberculosis in Northern Ireland fell from 128 to 14 deaths per 100,000 of the population between 1922 and 1954. During the first 24 years the rate was reduced by 50 per cent., and during the last 8 by more than 75 per cent. A full appreciation of this trend cannot be made without reference to the age and sex distribution of the mortality, because the changes have not been uniform in every age and sex group; indeed in some, notably men aged 55 years and over, the rates have increased (Cheeseman, 1952).

It is more difficult to obtain comparable morbidity rates. Mortality rates are of little value as an indirect measure of the trend of morbidity because they are influenced not only by the volume of disease but also by increasing success in the treatment of infected persons. For the community as a whole,

few morbidity data are available prior to the establishment of the Northern Ireland Tuberculosis Authority in 1946. To put their notification records into proper perspective, the impact of the Authority's work on the tuberculosis problem must be appreciated. The Authority was instituted with a unique responsibility, for the whole country, "of securing, in co-operation with sanitary and other local authorities, the prevention and more effective treatment of tuberculosis and kindred diseases" (Northern Ireland Tuberculosis Authority, 1948).

The resources inherited in 1946 were meagre; they consisted of some 500 beds in five hospitals, three chest clinics with x-ray facilities, a static mass miniature radiography unit, and some forty poorly equipped dispensary premises. The development of these resources and the new facilities provided since 1947 have been described elsewhere (*Brit. med. J.*, 1954; Elder, 1953), and the present situation may here be summarized briefly. About 970 beds are now available in the Authority's hospitals and 700 in other hospitals. There are 28 chest clinics, all but six being attached to hospitals with full diagnostic facilities. Two mobile mass radiography units have supplemented the existing static unit and a B.C.G. vaccination programme is in operation. The service is medically staffed on an area basis with a consultant and two or more chest physicians, or assistant chest physicians, in each area.

Notifications of respiratory tuberculosis under the Authority's scheme are available by age, sex, and "state of disease" classification for each year since 1948. In 1952, it was decided to exclude patients with active primary tuberculosis from the published notifications (Kelly, 1955), but the relevant details of such patients from 1952 onwards have been made available to me (Harvey, 1955), and in this report such patients are included in all references to notifications. The Authority uses the classification

suggested for England and Wales by the Ministry of Health (1947):

- Group 1. Cases with slight constitutional disturbances.
- Group 2. All cases which cannot be placed in Groups 1 and 3.
- Group 3. Cases with profound systematic disturbance or constitutional deterioration, and with marked impairment of function, either local or general.

In addition all notifications are further subdivided as follows:

- Class A. Cases in which tubercle bacilli have never been discovered in any exudate, excrement, discharge, or tissue.
- Class B. Cases in which tubercle bacilli have been found at any time in any exudate, excrement, discharge, or tissue.

The annual notifications and their distribution by age and sex from 1948 to 1954 are shown in Table I. The downward trend for the five consecutive years in the absolute numbers from 2,499 to 1,614 occurred in spite of the increasing intensity of the ascertainment procedures. Relatively, the largest decrease occurred in the period 1948-50, and since then the decrease has been relatively small.

Although a population census was held in 1951, sufficiently accurate estimates are not available for non-census years to permit a critical examination, by age and sex groups, of the 7-year trend. If it is assumed that, over this short period, the age and sex distribution of the population did not materially

change, then there is some evidence for males, but not for females, of a change in the age distribution of notified disease. Even over this short period, the proportion of male cases notified in the age group 20-29 years has fallen, while that in the age group 50 and over has increased. Moreover, even these crude figures show that male and female notifications had very different age distributions, to which later reference is made, throughout the whole period.

PRESENT AGE AND SEX DISTRIBUTION

Age and sex specific mortality and morbidity curves for respiratory tuberculosis have been prepared by using data for the 1951 population and the deaths and notifications in the three years 1950-52.

The first part of Table II (opposite) shows the mortality rates; these are plotted in Fig. 1 (opposite) with the corresponding rates for England and Wales. For convenience, the rates for the oldest age group, 75 years and over, are plotted at 75 years. In considering the curves for Northern Ireland, too much attention should not be paid to small irregularities for two reasons:

- (i) in some age groups the numbers of deaths were small;
- (ii) there is evidence that the ages given at death registration, particularly in 1950 and 1951, were frequently only approximate.

TABLE I
PERCENTAGE AGE DISTRIBUTION OF NOTIFICATIONS OF RESPIRATORY TUBERCULOSIS FOR EACH SEX
(NORTHERN IRELAND, 1948-54)

Sex	Age Group (yrs)	Year						
		1948	1949	1950	1951	1952	1953	1954
Male	0-9	6.8	12.1	12.2	11.1	12.9	12.1	11.0
	10-19	15.1	14.9	15.2	16.5	17.8	18.8	17.0
	20-29	29.5	25.0	23.0	22.9	20.7	21.4	19.0
	30-39	14.7	14.2	14.9	13.1	14.0	13.3	13.3
	40-49	17.1	14.6	13.5	14.0	11.8	11.4	15.7
	50-59	9.8	10.4	12.2	12.4	12.9	11.7	11.2
	60 and over	7.1	8.7	8.9	9.9	9.8	10.6	12.8
	Not known	—	—	—	0.1	—	0.7	0.1
Total		100 (1,259)	100 (1,103)	100 (908)	100 (909)	100 (898)	100 (884)	100 (860)
Female	0-9	4.8	11.4	11.5	10.2	11.9	12.7	11.0
	10-19	24.9	24.3	23.1	23.5	25.7	27.0	24.5
	20-29	36.0	32.0	31.5	35.3	31.3	31.5	31.3
	30-39	16.6	14.2	15.5	15.2	13.1	14.6	16.0
	40-49	9.7	8.8	8.6	7.5	7.8	5.5	7.8
	50-59	4.8	5.3	4.9	4.3	5.2	3.7	3.6
	60 and over	3.3	4.0	4.9	3.9	4.8	4.7	5.4
	Not known	—	0.1	0.1	0.1	0.2	0.4	0.3
Total		100 (1,240)	100 (1,074)	100 (922)	100 (864)	100 (872)	100 (788)	100 (754)
Total		(2,499)	(2,177)	(1,830)	(1,773)	(1,770)	(1,672)	(1,614)

Figures in brackets show numbers of notifications.

TABLE II
AVERAGE ANNUAL DEATH AND NOTIFICATION RATES
PER 100,000 OF POPULATION FROM RESPIRATORY
TUBERCULOSIS BY AGE AND SEX
(NORTHERN IRELAND, 1950-52)

Age Group (yrs)	Death Rates		Notification Rates	
	Male	Female	Male	Female
0-4	2	2	78	77
5-9	—	1	82	75
10-14	1	2	82	98
15-19	7	18	185	301
20-24	29	45	233	321
25-29	44	61	182	236
30-34	54	48	149	168
35-39	52	32	132	105
40-44	53	37	142	88
45-49	72	18	148	72
50-54	100	34	180	67
55-59	80	30	167	46
60-64	109	34	158	58
65-69	74	41	78	31
70-74	69	35		
75 and over	30	20		
Total	39	27	136	126

Maximum male mortality in Northern Ireland occurred at about the age of 60 years, some 5 years younger than the peak rate in England and Wales. In sharp contrast, the female mortality was greatest at about age 30, as in England and Wales. In

passing, it should be noted that, except among old men, the Northern Ireland rates consistently exceeded those of England and Wales. The secondary peak in the female mortality curve at about age 68 in Northern Ireland is of interest as it is not a feature of the curve for England and Wales.

Similar examination of the Northern Ireland notification rates (last part of Table II and Fig. 2, overleaf) reveals a bimodal male curve; the maximum rate occurred at about age 22 and another high rate (some 50 per 100,000 less than the maximum) at about age 53. The female notification rates however rose to the early maximum at the same age as the males, but thereafter fell continuously. The level of the early maximum rate was higher in females than in males, by some 80 per 100,000. (It should be noted that in Figs 2 and 3 the rates for age 65 and over have been plotted at age 72½).

Using the notifications in Birmingham for 1951, Lowe (1954) first drew attention to the bimodal character of the age distribution of respiratory tuberculosis notifications among males in England and Wales, although Stocks (1950), from the limited data then available, thought that some such sex difference was likely at later ages. Lowe was able to

FIG. 1.—Respiratory tuberculosis mortality, average annual rates, 1950-52.

FIG. 2.—Respiratory tuberculosis notification rates, Northern Ireland, average annual rates, 1950–52.

demonstrate that, when notifications were classified by state of disease, female rates in each of the three groups reached a maximum at age 20–24. However, for males, the Group 1 rates had only one peak and this was at age 15–19; the Group 2 rates had two peaks at ages 20–24 and 45–49; and the Group 3 rates had only one peak at age 50–54. Although not commented upon (this aspect of the disease was not the main purpose of his work), his rates for females with Group 3 disease, and to a lesser extent with Group 2, increased slightly at the older ages.

The Northern Ireland notification rates, after similar classification, give curves with characteristics like those of Birmingham (Table III and Fig. 3, opposite). For females there is one well-defined peak for each group in the young adult ages, at 15–19 years for Group 1 and 20–24 for Groups 2 and 3. For males there is one peak for Group 1 at age 15–19, two for Group 2 at 20–24 and 50–54, and one for Group 3 at 60–64. In the Group 3 rates for males there was also a very slightly raised rate in the age group 20–24 compared with rates in adjacent age groups, but Fig. 3 shows that this results in only a slight disturbance to the upward trend in these young adult ages. As

with the Birmingham data, there was a slight increase in the age specific rates for Group 3 disease among females after age 59. It must be noted that of the 5,373 notifications on which these Tables are based, 65 were not classified by state of disease and have been excluded from Table III. Their inclusion

TABLE III
AVERAGE ANNUAL NOTIFICATION RATES PER 100,000 OF
POPULATION BY AGE, SEX, AND SEVERITY
CLASSIFICATION (NORTHERN IRELAND, 1950–52)

Sex		Male			Female		
Group		1	2	3	1	2	3
Age Group (yrs)	0–4	66	2	10	62	3	11
	5–9	72	5	6	67	5	4
	10–14	71	7	4	77	15	5
	15–19	110	51	24	161	103	36
	20–24	102	98	34	156	118	43
	25–29	69	93	21	92	111	32
	30–34	53	69	26	72	71	24
	35–39	40	67	26	36	47	21
	40–44	29	77	36	24	43	20
	45–49	30	81	34	19	36	15
	50–54	25	95	56	16	35	16
	55–59	15	95	53	9	27	9
	60–64	12	72	68	8	27	21
	65 and over	7	35	28	1	10	14
Total		55	53	26	60	45	19

FIG. 3.—Classified respiratory tuberculosis notification rates, Northern Ireland, 1950-52.

in the appropriate age groups, even if they were all of the same classification, would make so little difference to the notification rates that none of the foregoing observations would be materially altered.

Table IV sets out the notification rates for the full classification. With so much subdivision, many

of the resulting rates were small, but it would appear that the male differences and female similarities in the ages of peak rates between Groups 1, 2, and 3 were features of both Class A and Class B notifications. In view of the small numbers in Class B, and of the fact that Class A is, in effect, a residual group,

TABLE IV
AVERAGE ANNUAL NOTIFICATION RATES PER 100,000 OF POPULATION BY AGE, SEX, AND SEVERITY AND SPUTUM CLASSIFICATION (NORTHERN IRELAND, 1950-52)

Sex		Male						Female					
Class		A			B			A			B		
Group		1	2	3	1	2	3	1	2	3	1	2	3
Age Group (yrs)	0-4	64	2	6	2	—	4	62	2	7	—	1	4
	5-9	71	5	4	1	—	2	66	4	1	1	1	3
	10-14	69	5	2	2	2	2	72	11	3	5	4	2
	15-19	99	29	12	11	22	12	141	60	16	21	43	21
	20-24	84	47	10	18	51	23	130	68	17	27	50	26
	25-29	49	49	6	20	43	15	76	61	7	16	50	25
	30-34	45	34	7	8	35	19	58	35	8	14	36	16
	35-39	26	29	8	14	38	18	29	24	7	7	23	14
	40-44	21	31	9	9	46	26	20	17	4	4	26	17
	45-49	19	36	9	11	45	25	17	22	8	2	13	7
	50-54	18	53	14	7	43	43	12	14	5	4	21	11
	55-59	12	41	8	3	53	45	9	17	5	—	10	4
	60-64	8	40	20	4	33	48	7	14	11	1	12	10
65 and over		6	16	9	1	19	19	—	5	6	1	4	8
Total ..		47	26	8	8	27	18	53	25	7	8	20	12

the homogeneity of which is dependent upon the thoroughness of the search for the bacillus being uniform for all patients, no attempt has been made to pursue this aspect of the data.

In effect these results show that there is very little advanced (Group 3) disease in the notifications of young men and very little early disease (Group 1) in the notifications of the older men. In the young adult age groups, when each stage of disease is most notified among females, the latter consistently have a higher rate than males, but even so, relatively few of all female notifications at these ages refer to advanced disease.

DISCUSSION

Crude mortality rates and crude notification rates, without, at least, subdivision by age and sex, are clearly unreliable indices on which to base the policy of a tuberculosis service, or to assess its efficiency. The increasing mortality among men aged 55 and over, and the preponderance of severe disease among them, are both hidden by the decreasing mortality rates and numbers of notifications at all ages combined. Even with age and sex specific rates available, their interpretation is not easy. The ultimate criterion of the success of a tuberculosis service is the reduction of the frequency of occurrence of the disease in the community to negligible proportions. It seems unlikely that much more will be learnt about this frequency from the study of death rates alone, since successful treatment of the disease is continually becoming more possible.

However, tuberculin surveys, mass x-ray surveys, and proper use of notification data can all contribute to measuring the volume of disease. So far, the use of tuberculin surveys in Northern Ireland has been restricted to a single sample survey of Belfast schoolchildren (Sherrard, 1952) but within the last year a scheme has been started for the testing of 5-year-olds in Belfast schools, whom it is hoped to retest in a longitudinal study for some years to come (Calwell, 1956). The activities of the mass radiography service are discussed later, but no surveys on a communal basis have yet been undertaken in which an exhaustive effort has been made to examine every member of a locality. Thus for the time being the notification rates must remain as the only available measure of the disease frequency in Northern Ireland.

The efficiency of the notification rates as a measure of the true frequency of the disease depends in turn on the efficiency of the diagnostic activity in the

community. Theoretically, the latter can only be considered as wholly efficient if the diagnostic procedure invariably detects the disease in a person who has it and if all members of the community are examined. Thus, if mass radiography is accepted as an efficient diagnostic tool, then it must be applied to all members of the community to achieve this theoretical ideal. The importance of this complete "screening" has been stressed by many workers; for example, Bradbury (1948) reported the results of five mass x-ray surveys in Lancashire and concluded that the variation in the amount of tuberculosis detected was almost directly proportional to the proportion of the population in the surveyed areas agreeing to be x-rayed. He estimated that even with a 70 per cent. response only about 50 per cent. of the tuberculosis would be discovered.

In Northern Ireland diagnostic activity is essentially in the control of the chest clinics and the mass radiography units. In 1954, there were 67,962 attendances at the former, but only 16,089 of these were made by persons seen for the first time and of these about 40 per cent. were contacts of known tuberculosis patients. In the same year, 96,219 x-ray examinations were carried out by the mass x-ray units. So that in that year the proportion of the total population which had a chest x-ray was, even at a most generous estimate, very small and certainly less than 15 per cent. It might be argued that if a different 15 per cent. were x-rayed each year then complete coverage would be achieved relatively soon. From the above it is clear that such "rotation" could only be achieved by the mass x-ray units, but, in fact, the present policy is such that it is probable that a large proportion of the persons x-rayed in any one year are x-rayed annually.

Unfortunately data are not available about the numbers x-rayed for the first time. In 1954, apart from 9,266 persons referred by general practitioners of Belfast (Barr and Ritchie, 1955), and 3,544 persons x-rayed as part of an experiment in East Belfast (Ritchie, Calwell and Barr, 1955), the bulk of examinees were seen either as "individual volunteers" or as members of "organized groups". The former are persons attending open sessions held in various areas, and the latter attend under special arrangements made between the director of the service and employers or heads of institutions. The numbers in these groups are not available for 1954, but in the preceding year, of the total attending the static unit, 10 per cent. were individual volunteers and 90 per cent. were members of organized groups, while for the mobile unit the corresponding proportions were 30 per cent. and 70 per cent.

Clearly the mass radiography service is the most effective method in the search for new cases, but Table V shows that in 1954 only about 7 per cent. of the total population were examined. Moreover, because the larger part of the units' work, particularly in Belfast, is concentrated on organized groups, many of which are seen annually, in any one year only a very small proportion of the population, which must be less than 7 per cent. at present, are mass x-rayed for the first time. Thus, probably, the vast majority of the population have never attended a mass radiography unit. Table V shows that the mass x-ray activities have up to the present, been more intense in the young adult age groups than in others, so that such diagnostic activity in the older age groups must be negligible. These are the age groups in which, for men, there is a preponderance of advanced disease, a fact confirmed by the Rhondda Valley survey, of over 90 per cent. of the adult population, in which the maximum age and sex rate of infectious disease was found in males aged 50 and over (Cochrane, Cox, and Jarman, 1952).

TABLE V
MASS RADIOGRAPHY IN NORTHERN IRELAND
IN 1950 AND 1954

Sex	Age Group (yrs)	Year			
		1950		1954	
		Number x-rayed	Percentage of Northern Ireland Population x-rayed	Number x-rayed	Percentage of Northern Ireland Population x-rayed
Male	Under 15	7,687	4.0	8,503	4.4
	15-24	9,584	9.2	14,651	14.1
	25-34	4,402	4.8	10,702	11.6
	35-44	3,903	4.4	7,850	8.9
	45-59	3,132	3.0	7,068	6.8
	60 and over	508	0.6	1,528	1.8
	Total	29,216	4.4	50,302	7.5
Fe-male	Under 15	7,041	3.8	7,745	4.2
	15-24	10,313	9.8	18,502	17.6
	25-34	3,969	4.0	8,681	8.8
	35-44	2,201	2.3	5,363	5.7
	45-59	1,391	1.2	4,562	3.9
	60 and over	195	0.2	1,064	1.0
	Total	25,110	3.6	45,917	6.5

In the past it has been the policy to direct the mass x-ray service mainly at the young adolescent group, because this was the section of the community in which it was originally anticipated there would be most tuberculosis (Ritchie, 1952). To pursue this policy the net was cast to organized groups, largely arranged with industrial undertakings, to catch the annual recruitment of school leavers. Fig. 2, however, suggests that for males the frequency with which new cases are now found in the population is nearly as high in the old adults as it is in the young ones, and

it would appear reasonable to think in terms of shifting the emphasis from the younger to the older age groups, particularly as in the older men the disease is likely to be more severe (Fig. 3).

It is unquestionably desirable, from the point of view of the individual young adult, that diagnostic procedures should be readily available to him, since if tuberculosis is discovered it will most probably be in its early stages and will be amenable to treatment. In turn, the community will also benefit in years to come in that the young tuberculosis patient discovered now and brought under observation should not become, some 30 years later, a source of infection to a future generation. At the same time, however, the present reservoir of infection in the older male age groups continues to spread the disease among young people. In this context the report on respiratory tuberculosis among old men by Wilkins (1956) is of some significance, in that of a small series of 35 men aged 65 and over who subsequently developed active diseases as many as sixteen showed no prominent chest symptoms.

Some authorities (*e.g.* Cox, Cochrane, and Crofton 1956), impressed by South Australian experience since 1951 (Woodruff, 1956), have suggested compulsory x-ray examination of people living in areas of high incidence and of persons whose work is such that one open case among them endangers others. Some (*Medical Officer*, 1956) feel that compulsion would not be generally acceptable, and have suggested that general practitioners might well be the best people to persuade their older patients to avail themselves of the facilities of the mass x-ray services and that health visitors and welfare workers whose activities bring them into the homes of the community could also be similarly persuasive.

Such arguments are based largely on the poor response rates to mass x-ray in England and Wales and apply equally in Northern Ireland. Of the suggested methods of increasing the diagnostic activity, compulsion is so far practised only in one instance, the annual x-ray of all undergraduate students at the Queen's University of Belfast (Johnston, 1956). Of the other methods, it should be noted that 90 per cent. of the school teachers in Northern Ireland have agreed to an annual x-ray examination and that all new entrants to the profession in grant-aided schools have their chests x-rayed at the initial medical examination. Finally in Belfast the scheme by which general practitioners can refer patients direct to the static x-ray unit already mentioned has been in force since 1952. All this goes only a small way towards the complete "screening" of the population necessary before the apparently favourable rates at

all ages combined can be regarded with complacency. Much more diagnostic activity is required, coupled with closer attention to the older men in the community.

SUMMARY

The age of maximum mortality from respiratory tuberculosis in Northern Ireland in 1950-52 was approximately 60 years for men and 30 years for women. In this respect the mortality resembled that for England and Wales, although the level of the rates was generally higher in Northern Ireland.

The age distribution of the Northern Ireland notification rates in 1950-52 was bimodal for men and unimodal for women. The major peak in the male distribution occurred at about age 22 and the minor peak at age about 53. The maximum female rate occurred at about the same age as the major male peak.

Classification of the notification rates by stage of disease shows that the young adult male peak in the rates was largely due to the detection of early rather than advanced disease, while the peak at the older age was largely due to advanced disease. Although all stages of disease contributed to the young adult female maximum, early disease was preponderant; there was some evidence of a secondary peak in the age morbidity curve for advanced disease in the older age groups for females.

Although, while the tuberculosis services have been developing, the total number of notifications has decreased from year to year since 1948, the "age, sex, and stage of disease" interactions and possibly incomplete ascertainment make the interpretation of this trend impossible in terms of the true incidence of the disease.

Relatively fewer old than young adult people have been examined by routine mass radiography, and it is probable that relative to the true incidence less advanced disease than early disease is detected by this means. Although this is possibly balanced by more effective ascertainment of advanced disease by other methods, no evidence is available to assess such a balance. In a given year less than 10 per

cent. of the population are examined by mass radiography policy.

In view of these conclusions, it is suggested that the time has come for a review of the mass radiography policy.

An appreciation of the present situation is required to see whether the technical resources available, in addition to the continued detection of early cases, can also help in the eradication of sources of infection by more active work amongst the older members of the community. In any case, the present poor response to mass x-ray, must be overcome and to this end many people, both in and out of the tuberculosis services, have a part to play.

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REFERENCES

- Barr, A., and Ritchie, J. (1955). *Tubercle (Lond.)*, 36, 228.
 Bradbury, F. C. S. (1948). *Lancet*, 2, 293.
Brit. med. J. (1954). 1, 509.
 Calwell, H. G. (1956). Personal communication.
 Cheeseman, E. A. (1952). *Ulster med. J.*, 21, 15.
 Cochrane, A. L., Cox, J. G., and Jarman, T. F. (1952). *Brit. med. J.*, 2, 843.
 Cox, G. L., Cochrane, A. L., and Crofton, J. (1956). *Med. Offr.*, 95, 140.
 Elder, A. T. (1953). *British Journal of Preventive and Social Medicine*, 7, 105.
 Harvey, W. (1955). Personal communication.
 Johnston, W. (1956). "Seventh Annual Report of the Medical Officer, Academic Year 1954-55." Student Health Committee, The Queen's University of Belfast.
 Kelly, W. R. (1955). Personal communication.
 Lowe, C. R. (1954). *British Journal of Preventive and Social Medicine*, 8, 91.
Med. Offr. (1956). 95, 193.
 Ministry of Health (1947). "Tuberculosis," Memo 37/T (revised), Circular 83/47.
 Northern Ireland Tuberculosis Authority (1948). Second Annual Report (year ended Dec. 31, 1947). Belfast: N.I.T.A.
 Ritchie, J. (1952). "Work of the Mass Radiography Service," in Sixth Annual Report of the N.I.T.A. for year ending 31 Dec., 1951, p. 7. N.I.T.A., Belfast.
 Ritchie, J., Calwell, H. G., and Barr, A. (1955). *Tubercle (Lond.)*, 36, 301.
 Sherrard, S. E. (1952). *Ulster med. J.*, 21, 25.
 Stocks, P. (1950). *Practitioner*, 165, 212.
 Wilkins, E. G. (1956). *Brit. med. J.*, 1, 883.
 Woodruff, P. S. (1956). Quoted by Cox, Cochrane, and Crofton (1956).