AN EXPERIMENT IN MASS RADIOGRAPHY*

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From March to July, 1957, a chest x-ray survey was carried out in the burgh of Dumfries, in South Scotland, designed primarily as a controlled experiment to measure the influence of a preliminary census and of home-visiting on the population response to mass radiography. A further aim was to compare the prevalence of pulmonary tuberculosis in the burgh and in a near-by rural area surveyed by the same team in 1956 (Cochran *et al.*, 1957).

Methods

Burgh Surveyed.—Dumfries (estimated population mid-1957, 26,683) is a market town on the River Nith, in South-West Scotland, and is surrounded by rich

FIG. 1.—Nine municipal wards in the burgh divided into three sectors.

farmland. At the turn of the century the main occupations were farming and tweed manufacture. During this century light industry has developed in the area. Within the town there is a factory for milk canning. A rubber factory and a large chemical works are located just outside the burgh boundary. Tweed manufacture has largely been replaced by hosiery and knitwear.

A mass radiography unit visited the large factories in 1951 and 1956, and also held two or three public sessions in the town in the latter year.

Plan of Experiment.—The town has nine municipal wards, which were divided into two groups of five and four wards approximately equal in population (Fig. 1).

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

A private preliminary census was carried out in the group of five wards, of which two were intensively home-visited when x-raying began. The division of these five wards was planned to maintain a numerical and economic balance of the census population. Special attention was paid to the location of the wards, to the relative proportion of private and council houses, and to the amount of business property in each section. After the x-ray campaign was over a census of the group of four wards was carried out in the same way as that followed in the group of five wards before the campaign opened. Apart from the private census and home-visiting in the selected wards, the whole area was subjected to the same propaganda—for example, lectures, showing of a short film in the local cinema, distribution of leaflets and posters, newspaper announcements, loud-speaker van, etc. No prizes were offered.

There were therefore three distinct groups of population: *Sector A*—census, plus home-visiting, plus general propaganda (wards 2 and 8). *Sector B*—census, plus general propaganda (wards 1, 3, and 5). *Sector C*—general propaganda (wards 4, 6, 7, and 9); the census in these wards was carried out when the campaign was over.

At no stage in the survey was it made known that the burgh wards were being treated differently. Our experience during the campaign confirmed that the public regarded the survey as a simple comprehensive effort to x-ray the entire population of the burgh aged 15 years and over.

General Methods.—Details of the general methods followed, from the beginning of the census in mid-February to the conclusion of the three-months x-raying early in July, are set out in an appendix (available from J. B. C.).

Results

Details of Response

The population of the burgh—that is, those aged 15 years and over residing at home during the private census—was found to be 20,269. Of these 14,136 were x-rayed, giving an overall response of 69.7% (Table I). The figures for three groups of population were: *Sector A*—population 4,679; 87.6% x-rayed; *Sector B*—population 5,176; 64.5% x-rayed; *Sector C*—population 10,414; 64.3% x-rayed.

The percentage age and sex distributions of the whole burgh and of the three sectors are shown in Fig. 2. Sectors A and B had a similar distribution, but Sector C contained a younger population.

The influence of home-visiting and census-taking on x-ray response, analysed by age groups, is shown in Fig. 3. In all sectors there was the expected fall in response as age increased. The advantage of home-visiting was seen at all ages. Overall, a further 20% of the population attended the unit from the home-visited Sector A, and in the older age groups the improvement in response was about 30 to 40%. Although the overall response of Sectors B and C differed only by 0.2%, analysis by age groups showed a better response by Sector B at all ages over 35 years (Fig. 3). However, this difference is only statistically

significant for females aged 55 to 64 years. The overall similarity of response in Sectors B and C is explained by the younger population in Sector C (Fig. 2).

Previous Chest Radiography

Information was obtained from the whole x-rayed population regarding previous chest x-ray examination (Table II). In 40% of the males and more than 50% of the females the chest had not been previously x-rayed. Even in the age group 15 to 24 years 4 out of 10 persons were x-rayed by the unit for the first time. The chest x-ray examination of the general population during the preceding 18 months had largely

been done by the M.M.R. in those of working age, with the exception of males under 30; among this group it was found that chest x-ray examinations in connexion with recruitment or discharge from H.M. Forces formed by far the greatest number.

Other Data on Population Response

The population in Sector A, comprising 4,679 persons, which was intensively home-visited, was used to obtain further data on population response to mass radiography and reasons for not attending.

Response and Type of House.—An analysis of the percentage of persons x-rayed according to type of residence is shown in Fig. 4. The houses have been divided into three groups—council houses, villas, and all other houses. Overall, council-house tenants showed a slightly more favourable response than the tenants of other property (91.2% compared with 86.7% x-rayed). However, at ages 65 and over there was no difference in response between the council house and villa populations.

FIG. 2.—Percentage age-and-sex distribution of populations in whole burgh and in the three sectors.

FIG. 3.—X-ray response in the three sectors of the burgh.

FIG. 4.—X-ray response according to type of residence.

TABLE I.—Numbers in Each Age Group and Percentage X-rayed

Age Group	Males						Females						Both Sexes		
	Sector A		Sector B		Sector C		Sector A		Sector B		Sector C		% X-rayed in Sector:		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	A	B	C
15-24	336	96.4	303	75.6	1,102	72.3	338	95.9	430	81.4	1,027	77.8	96.1	79.0	75.0
25-34	470	94.7	454	71.4	951	71.2	500	94.8	476	72.5	1,015	72.9	94.7	71.9	72.1
35-44	331	90.6	383	70.8	994	70.1	395	91.9	440	72.7	1,060	71.2	91.3	71.8	70.7
45-54	334	88.7	425	64.5	941	60.4	450	89.6	522	70.5	978	67.1	89.2	67.8	63.8
55-64	275	77.8	349	58.7	550	54.7	454	83.5	505	60.2	702	54.3	81.3	59.6	54.5
65-74	161	75.2	205	49.3	288	37.5	339	74.9	357	48.7	462	34.4	75.0	48.9	35.6
75+	79	77.2	92	40.2	114	21.9	173	58.4	180	21.7	180	18.3	64.3	27.9	19.7
Not stated	2		21		24		2		34		26				
All ages	2,028	88.7	2,232	64.6	4,964	63.9	2,651	86.8	2,944	64.5	5,450	64.6	87.6	64.5	64.3

TABLE II.—Previous Chest X-ray Examination in Relation to Sex and Broad Age Groups

Previous Chest X-ray Examination	15 to 24		25 to 54		55 and Over		All Ages	
	M %	F %	M %	F %	M %	F %	M %	F %
None	42.4	40.6	34.0	50.9	55.0	74.2	39.6	54.4
Within 18 months	22.6	31.8	27.4	17.5	17.4	8.9	24.5	18.2
18 months to 3 years	12.2	8.4	8.8	8.0	7.3	3.5	9.2	7.0
More than 3 years	21.0	16.4	27.9	21.3	17.6	11.2	24.7	18.0
No information, doubtful	1.8	2.8	1.9	2.3	2.7	2.2	2.0	2.4
No. of persons	1,350	1,473	3,888	4,424	1,176	1,825	6,414	7,722

Influence of the General Practitioner.—All the general practitioners in the town had been approached to help make the campaign a success, and in the home-visited wards the name of the practitioner was obtained from each person, whether x-rayed or not. An analysis of the response in the seven practices (Table III) showed no striking differences. For all

TABLE III.—X-ray Response in Relation to General Practitioner (Sector A)

Practice	Age 15 to 64		Age 65 and Over		All Patients % X-rayed
	% of Patients	% X-rayed	% of Patients	% X-rayed	
A ..	30.0	90.1	34.8	70.3	86.5
B ..	22.5	90.1	22.0	73.5	87.5
C ..	18.4	92.6	18.1	70.1	89.0
D ..	13.7	91.8	11.8	77.5	89.8
E ..	3.5	93.5	2.9	63.6	89.4
F ..	5.2	89.7	5.4	70.7	86.5
G ..	2.1	90.4	2.1	87.5	89.9
Others ..	4.6	87.5	2.9	35.7	83.8
Total ..	100.0	90.7	100.0	71.5	87.6

persons up to 64 years the lowest response from any practice was 89.7% and the highest 93.5%. At ages 65 years and over, in the practices with at least 50% of these patients, the variation in response was from 70.1 to 77.5%.

Reasons for Non-Attendance.—All those who were not x-rayed from Sector A of the burgh were visited by the medical director, who attempted to assess the reasons for non-attendance (Table IV). Approximately

TABLE IV.—Reasons for Non-attendance Analysed in Broad Age Groups (Sector A)

Reason	Age 15-64		Age 65 and Over		All Ages %
	No.	%	No.	%	
Physically unfit ..	15	4.1	41	19.1	9.7
Health reasons, although fit for x-ray ..	32	8.9	57	26.5	15.4
Recently x-rayed, but not within past 6 months ..	74	20.5	6	2.8	13.9
Not specified ..	240	66.5	111	51.6	61.0
	361	100.0	215	100.0	100.0

10% of those not x-rayed were physically unfit to come to the x-ray unit. A further 15% were assessed to have legitimate health reasons for non-attendance, although they were not, in fact, physically unfit to come. About 15% had had a recent chest x-ray examination, but not within the acceptable limit of six months from the start of the survey. The remaining 60% had no obvious reason for refusing. Over the age of 65 years the proportion of those physically unfit to attend was three times greater in women than in men.

TABLE V.—Active Tuberculosis Discovered in Each Age Group of X-rayed Population

	15-24	25-34	35-44	45-54	55-64	65-74	75+	All Ages*
Males:								
No. x-rayed ..	1,350	1,446	1,286	1,157	720	330	123	6,414
.. infective ..	1	1	1	5	1	—	—	9
Other active ..	—	—	1	1	—	—	—	2
Total ..	1	1	2	6	1	—	—	11
(per 1,000)	(0.7)	(0.7)	(1.5)	(5.2)	(1.4)	—	—	(1.7)
Females:								
No. x-rayed ..	1,473	1,559	1,438	1,427	1,064	587	173	7,722
.. infective ..	2	2	1	—	2	—	—	6
Other active ..	1	2	—	—	—	—	—	4
Total ..	3	4	1	—	2	—	—	10
(per 1,000)	(2.0)	(2.6)	(0.7)	—	(1.9)	—	—	(1.3)

* Including those whose age was not stated

Pulmonary Tuberculosis

Twenty-one cases of active tuberculosis (1.5 per thousand x-rayed) were discovered in the burgh, and 15 of them had tubercle bacilli in the sputum. The age/sex distribution of the active cases is shown in Table V and Fig. 5.

Eight of the 10 female patients with active disease were under 45, while 7 of the 11 male patients with active disease were over 45.

An accurate measurement of prevalence of tuberculosis (cases discovered plus those already known) could only be made for Sector

FIG. 5.—Active tuberculosis per thousand x-rayed discovered in the burgh

A. A comparison with Annandale (Cochran *et al.*, 1957) shows similar low rates for active and infective disease, but a higher rate for quiescent and arrested disease in Dumfries (Table VI).

In Table VII the rates for active tuberculosis are shown separately for the three sectors of the burgh population. The same rate (1.5 per thousand x-rayed) was found in Sector A (87.6% survey) as in the remainder of the burgh (64.4% survey).

TABLE VI.—Comparison of Prevalence of Tuberculosis in the Burgh (Sector A) and in a Near-by Rural Area (Annandale)

Pulmonary Tuberculosis	Dumfries Burgh (Sector A) (Pop. 4,098)		Annandale (Pop. 6,595)	
	No.	Per 1,000	No.	Per 1,000
Infective ..	5	1.2	6	0.9
Active (incl. infective) ..	9	2.2	12	1.8
Quiescent ..	24	5.9	25	3.8
Arrested ..	101	24.6	110	16.7

TABLE VII.—X-ray Response in the Three Sectors of the Burgh in Relation to Yield of Active Tuberculosis

Sector	% X-rayed	Active Cases Found	
		No.	Per 1,000 X-rayed
A ..	87.6	6	1.5
B ..	64.5	4	1.2
C ..	64.3	11	1.6

TABLE VIII.—Age/Sex and Sector Distribution of Cases of Active Pulmonary Tuberculosis Discovered in Burgh in Year After End of Survey

Sector	15-24	25-34	35-44	45-54	55-64	65-74	75+	All Ages
A { M ..	—	—	—	—	—	—	—	—
{ F ..	—	—	—	—	—	—	—	—
B { M ..	—	—	—	2	—	1	1	4
{ F ..	1	—	—	—	—	—	—	1
C { M ..	—	2	1	1	—	—	1	4
{ F ..	—	—	—	—	—	2	—	3

In the year after the completion of the survey (August, 1957, to July, 1958) 12 additional cases of active pulmonary tuberculosis were notified in the burgh. Nine of these patients were not x-rayed during the survey. The age/sex and sector distributions of the 12 patients are shown in Table VIII. Five of the patients were over 65 years of age, and none was from Sector A.

Discussion

Mass miniature radiography has greatly developed in this country during the past 10 years. It has become established as an important method of case-finding and as a powerful weapon in the eradication of pulmonary tuberculous infection. There is, however, no general policy in its use, and, mainly owing to shortage of the expensive equipment required, the service has been largely confined to industrial areas and large burghs, concentrating on organized groups of the working population. The community survey, in which a total population is accurately defined by census and actively encouraged to be x-rayed, has been developed for purposes of epidemiological research by Cochrane *et al.* (1952, 1955, 1956) in South Wales. The Welsh principles and techniques have been successfully applied to a rural area in South Scotland (Cochran *et al.*, 1957). The community survey is a time-consuming and expensive undertaking in which the size of the object must be related to the resources available. Probably it can be justified only as a research method to study the various factors involved in population response to mass radiography and to give accurate epidemiological data on tuberculosis and other diseases.

A complete community survey of Dumfries burgh was outside the resources of the unit, and therefore the survey was designed as a controlled experiment on various aspects of population response, as has been described. While the work was being planned an all-Scotland mass radiography campaign was devised by the Department of Health, beginning in the spring of 1957 with the mammoth and highly successful community survey of the City of Glasgow. An extensive publicity campaign, including the attraction of substantial prizes, door-to-door canvassing by 15,000 voluntary workers and the use of 37 x-ray units from all parts of the British Isles (J. E. Geddes, 1957, personal communication) all combined to give a 76% survey on a scale which could not become a routine procedure. This has been followed by similar surveys in other large Scottish cities. The publicity associated with this Scottish campaign had without doubt a beneficial effect on the response in Dumfries, but, as has been stated, this survey was conducted for research purposes rather than as a method of case-finding.

It has been shown that persistent home-visiting will increase the response to mass radiography by about 20% up to the middle-age groups, and thereafter by about 30 to 40%. There is suggestive evidence that the personal contact of a preliminary census also has a beneficial effect on the response of the elderly. The amount by which door-to-door canvassing will increase the percentage x-rayed depends, of course, on the extent of the other publicity methods used. Our experience is that a good survey response can be obtained by intensive home-visiting with little or no additional publicity. On the other hand, there seems no doubt that large urban surveys with their emphasis on case-finding receive a great fillip from extensive publicity campaigns with large prizes. It is not known, however, to what degree publicity can raise the response, but we believe that without door-to-door canvassing by enthusiastic workers a survey is unlikely to exceed the 60 to 70% level. It must be emphasized that large errors can occur in assessing the response unless the population "at risk" is accurately defined and care taken to exclude from the analysis the

inevitable large numbers of persons x-rayed from outside the surveyed area. For example, in Dumfries, where great emphasis was placed on accurate definition of the burgh population, one in five of all persons x-rayed was from outside the burgh.

A special study was made of the lapses in the home-visited wards to try to determine the reason why people will not attend for x-ray examination despite considerable pressure and the provision of ample opportunity. When the sick and infirm and those who have had a recent chest x-ray examination done elsewhere are excluded, it is found that about 60% of those who lapsed can advance no obvious reason for declining. Although based only on a rapid subjective assessment, we have no doubt that fear of disease (tuberculosis, lung cancer) and its socio-economic consequences is the predominant factor in non-attendance.

A National Health Service M.M.R. unit had visited the town on two occasions prior to the survey, in 1951 and 1956. These visits were largely concentrated on the large factories, with only a few public sessions in the town. It is surprising to find that of the population x-rayed in the present survey 39.6% of males and 54.4% of females had never before had a chest x-ray examination. It is disconcerting to find that about 40% of the young adult population (15-24 years) had had no prior chest x-ray examination. These figures show the need for more mass radiography facilities in the smaller towns. Analysis of the method of previous chest x-ray examination shows that National Service chest radiography accounts for the bulk of previous x-ray examinations in young adult males. With the reduction in National Service recruitment, the x-raying of young men may well decline unless other mass radiography facilities are made available.

The impression gained by the home-visitors that the occupants of villas were more reluctant to attend for x-ray examination than council-house tenants held good only up to the age of 65 years, and was only a 3% advantage. After 65 years the difference in response was negligible.

Experience in the Annandale Survey had emphasized the great value of the enthusiastic general practitioner in encouraging persons on his list to co-operate. An analysis of the response in the home-visited sector of Dumfries showed a close uniformity of attendance in the various practices, and no conclusions can be drawn. The intensive home-visiting done by the medical director in this sector may have eliminated a possible general-practitioner factor in influencing the response.

The low rate of active tuberculosis discovered in the town (1.5 per thousand x-rayed) was the same as that found in the rural survey in Annandale in the preceding year. The age/sex distribution of these active cases was similar to the pattern found in other surveys and in day-to-day clinical experience. The disease is predominantly attacking women aged 20 to 40 and men aged 40 to 60.

A comparison of prevalence rates in the home-visited sector of Dumfries and in Annandale showed that there was little difference in infective and active disease between the town and the rural area. The higher attack rate in the past among town dwellers is reflected in their greater incidence of quiescent and arrested lesions.

It has been claimed that the yield (rate per thousand x-rayed) for active disease increases as the percentage

x-rayed rises (Bradbury, 1948). This did not occur in Dumfries. The same rate (1.5 per thousand x-rayed) was found in the home-visited sector (87.6% survey) as in the remainder of the town (64.4% survey).

We attach considerable importance to the follow-up study of the burgh with respect to pulmonary tuberculosis arising in the year following the survey. There were 12 new notifications. Three of these patients had been x-rayed in the survey; on re-reading the films only one of the three was regarded as having been "missed." The remaining two patients, aged 51 and 72 years, were, we believe, correctly passed as free from tuberculosis and yet within the year had developed active and infective lesions. This has occurred in a relatively small survey, and stresses the danger in clinical practice of excluding the possibility of active tuberculosis because of a recent clear M.M.R. film, even in a person over 50 years of age.

Among the 12 new notifications in the year after the survey there were nine patients who were not x-rayed during the campaign. None of these patients was from the home-visited sector of the burgh, where the survey reached the 86% level; this shows the value of a high x-ray coverage. Five of the nine patients were over 65 years of age, whereas in the survey no active disease was found above that age. X-ray response falls as age increases, and special efforts are necessary to get the co-operation of the elderly. It does appear from the survey that the residue of tuberculous infection is occurring in the areas and at the ages where the response was least satisfactory.

Summary

A controlled experiment in mass radiography has been carried out in a Scottish burgh (population 26,600). By dividing the town into three sectors and applying different techniques, the influence of home-visiting and census-taking on population response has been measured. Home-visiting increased the response by 20% up to the middle-age groups, and thereafter by about 30 to 40%. There was evidence that the personal contact of a census also increased the response of the elderly.

Other factors which might influence x-ray response have been examined.

A special study of those not x-rayed indicated that fear of disease was the predominant factor in non-attendance.

Measurement of the amount of previous chest radiography in the burgh showed the need for more facilities for mass radiography.

The low rate of active tuberculosis discovered in the town (1.5 per thousand x-rayed) and its age and sex pattern were similar to that found the previous year in a near-by rural area.

A follow-up study of active tuberculosis arising in the year after the survey has shown the value of high x-ray coverage and the danger in clinical practice of excluding tuberculosis because of a recent clear mass radiography film.

Many people are involved in a survey of this type, and it would be difficult to mention them all individually. We are indebted to the Provost and civic officials of the burgh, particularly the medical officer of health, Dr. E. Mills, for the many facilities placed at our disposal. The Western Regional Hospital Board again generously arranged for the

secondment of one of us (J.B.C.); Mr. J. Brownlee and Mr. J. Wallace, of the local hospital board, relieved the unit of all accountancy work, and Dr. J. G. McWhirter, consultant radiologist to the board, kindly arranged for his staff and department to be available for re-calls for large films.

All the voluntary organizations co-operated in publicizing the campaign; the local Round Table also provided transport, whilst the Girl Guides came to our aid in the distribution of several thousand leaflets. The publicity accorded to the survey by the local press was invaluable, whilst the help given us by the local cinema in the preparation and subsequent showing of a short film is gratefully acknowledged.

The staff of the survey unit spared no efforts to make the scheme successful, and maintained their enthusiasm throughout; particularly would we place on record the work of Miss B. Kearney and Miss E. Bell, the two members of the team who had taken part in the previous survey, for their untiring work under all conditions; we also thank the Oxford Regional Hospital Board for help in mechanical tabulation of records.

Finally, we thank the Royal Victoria Hospital Tuberculosis Trust, who so generously provided the funds to enable the survey to be carried out.

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PUERPERAL CARDIOMYOPATHY

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Congestive heart failure associated with idiopathic myocardial degeneration in the last trimester of pregnancy and in the puerperium was first mentioned by Virchow in 1870, but was not recorded in detail until 1937, when Gouley *et al.* published reports of fatal and surviving patients. To date, 102 cases have been reported from the United States and Canada, but only three are recorded in British literature (Brigden, 1957). No mention of this disease is made in such standard textbooks as those of White (1951), Paul Wood (1956), Friedberg (1956), or Levine (1958). It is hoped that this communication will encourage recognition of further cases, and that detailed study of these cases might reveal the aetiological factors concerned in the production of the myocardial degeneration.

Case History

A housewife aged 35 was admitted to hospital on October 12, 1957, in the 32nd week of a twin pregnancy, complaining of dyspnoea. She had had two previous normal deliveries in 1946 and 1950 after uncomplicated pregnancies. No past medical history was of importance. Clinical examination showed no evidence of oedema, the pulse rate varied between 80 and 100 a minute, the blood pressure was 120/80, while urine analysis showed no albuminuria. After one week's bed rest she was discharged home, and remained well for the next two weeks, when palpitations and ankle-swelling were noticed and the return of dyspnoea necessitated her readmission on November 26. Examination on