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Some Aspects of a Tuberculosis Prevalence Survey in a South Indian District *

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As a preliminary to a number of pilot projects intended to assess the efficiency of various tuberculosis control measures, a sample prevalence survey was undertaken in the Tumkur District of Mysore State, South India. Such surveys would be greatly simplified if correlations could be established between the infection rates, as determinated by a positive tuberculin reaction, and the prevalence rates for radiologically active and bacteriologically confirmed disease. The paper discusses various indices of infection and radiological disease. Prevalence rates for these indices are presented and their degree of correlation with each other and with the prevalence of bacteriologically confirmed disease is determined. The value of the various indices is discussed in the light of these results. Although the correlations do not justify a clear-cut selection of the best possible indices, they provide a useful basis for further work. The survey also revealed certain interesting variations in prevalence that suggest the desirability of stratification in sampling when making surveys in future.

Tumkur District in Mysore State, South India, was selected for running a number of pilot programmes to judge the relative efficiency of certain operations for tuberculosis case-finding and treatment in the rural and semi-urban areas. The importance to developing countries of finding and assessing cheaper methods cannot be too strongly stressed. A sample survey was carried out from August 1960 to February 1961 to provide data for the planning and assessment of these programmes.

The objective was to establish prevalence rates for tuberculous infection, radiological evidence of lung disease suggestive of tuberculosis (hereinafter referred to as "radiologically active disease"), and bacteriologically confirmed disease for different age- and sex-groups. Special stress is laid in this paper on certain specific problems relating to tuberculin distributions. X-ray shadows and their interpretation in relation to "radiologically active disease" are discussed in detail.

Tuberculosis sample surveys of the type described are costly, time-consuming and not easy to execute, especially in the developing countries. Furthermore, interpretation of the data collected is by no means simple or straightforward. In this paper, correlations between the infection rates on the one hand and radiologically active and bacteriologically confirmed disease rates on the other have been worked out in an attempt to improve the methodology of interpretation of the data collected and provide a basis for further work.

MATERIAL AND METHODS

Tumkur District consists of 2392 villages, 10 smaller towns and the district headquarters town of Tumkur. The census figures for 1951 and 1961 (the latter obtained subsequently to the survey) are as follows:

	1951 census	*1961 census*
District	1 151 694	1 366 722
Rural areas (2392 villages)	1 045 797	1 227 392
The 10 towns	69 812	91 893
Tumkur town	36 085	47 437

The district headquarters town, Tumkur, was excluded from the survey. Random samples from

* A full report of the survey has been published in the *Indian Journal of Tuberculosis*, 1963, **10**, 85.

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the remaining towns and villages were worked out separately.

From the inhabited villages as given in the 1951 Census Handbook, a simple random sample of 63 villages was selected. One village which had a population of 9 in 1951 was found to be depopulated and was excluded from the survey. From the 10 towns, a simple random sample of 4 towns was first selected, and from each of these one block was selected for inclusion in the survey. Thus, there were 66 units in all, and these constitute the study population.

In each of the 62 villages, every house was numbered. A map of the village showing the number and location of each house was prepared. A census of the total population of the village was taken by house-to-house visits. A similar procedure was adopted in each of the four town blocks. For each individual in the 66 units a card was prepared on which the relevant data were entered. All persons normally resident in the village (permanent residents), whether present at the time of registration or temporarily absent, as well as visitors temporarily present in the village, were included in the census and registered.

All the available individuals in the registered population were given a Mantoux test with 1 TU of RT 23 tuberculin in 0.1 ml of diluent containing 0.005% of Tween 80. The test was made on the middle volar surface of the left forearm. Presence or absence of a previous BCG scar, definite or doubtful was recorded. Three to four days after the test, the longitudinal diameter of induration of the tuberculin test was measured and recorded in millimetres.[1] At the time of measurement, the reader had no knowledge of the presence or absence of a previous BCG scar in the examinee.

At the time of the tuberculin test, all persons aged 10 years or above were offered a single 70-mm photofluorogram. Owing to the availability of light, compact mobile X-ray units, no village had to be excluded as inaccessible, in spite of poor roads.

The X-ray films were read by two readers independently. Any X-ray picture found abnormal was categorized according to a classification based mainly on the one used in the National Tuberculosis Sample Survey (Appendix 1). For each picture read as abnormal, including those with non-tubercular pathology, and for each technically inadequate picture where the X-ray examination could not be repeated, a "spot" specimen of sputum of the individual concerned was collected at the time of reading the tuberculin test. Sputum examination was also performed on persons who could not be X-rayed owing to physical disability or for other reasons. All sputum samples were brought to the National Tuberculosis Institute, cooled in the containers by immersion in ice (no cooling during winter months), and stored in a refrigerator before being sent to the Union Mission Tuberculosis Sanatorium, Arogyavaram, for a direct smear and culture examination.[1]

Staff requirements

The survey was carried out by two teams, each with its own complement of census takers, testers, readers, laboratory and X-ray technicians, mobile X-ray unit, transport and other staff and working in different areas. Before starting the survey each member of the team had at least six months' training in survey techniques under field conditions.

Coverage

In the 66 groups, a total of 34 746 persons were registered, 17 652 males and 17 094 females (Table 1). The results presented in this paper refer only to the *de facto* population in the sample groups. The age distribution by sex of the *de facto* population is given in Table 2.

The coverages of the *de facto* population obtained in respect of the various stages of the survey are given in Table 3. Coverages vary from 92 % to 95 % of those eligible for the different procedures.

RESULTS OF TUBERCULIN TESTS

Tuberculin reactions

Distributions of tuberculin reactions by millimetre size in eleven age-groups among those without previous BCG scars are given separately for males and females in Tables 4 and 5. The frequency of bigger reactions, as also of intermediate reactions, increases in each succeeding age-group. Histograms for tuberculin reactions in different age-groups for the two sexes among those without evidence of previous vaccination are shown in Fig. 1. In none of the 5-year age-groups in this figure does the distribution show a clear line of demarcation be-

[1] The longitudinal diameter of induration was measured because of the considerably greater support provided by the length of the volar aspect of the forearm to the transparent scale which, when held by one hand, shakes much less than when similarly held along the breadth of the forearm.

[1] The National Tuberculosis Institute Laboratory did not start functioning until some time after the survey.

TABLE 1
SEX DISTRIBUTION OF THE REGISTERED POPULATION BY VARIOUS CATEGORIES

	Males	Females	Total
Permanent residents	15 684	14 694	30 378
Temporarily present (TP)	599	990	1 589
Total *de facto* population	16 283	15 684	31 967
Temporarily absent (TA)	1 369	1 410	2 779
Total registered population	17 652	17 094	34 746

TABLE 2
AGE AND SEX DISTRIBUTION OF THE *DE FACTO* [a] POPULATION

Age	*De facto* population		Distribution per 1000 persons	
	Male	Female	Male	Female
0-9	4 584	4 643	143	145
10-19	3 562	3 140	111	98
20-29	2 512	2 924	79	92
30-39	2 071	1 831	65	57
40-49	1 463	1 348	46	42
50-59	1 123	1 039	35	33
60+	959	756	30	24
Total	16 274	15 681	—	—

[a] Excludes 12 persons who could not be contacted.

TABLE 3
COVERAGES FOR VARIOUS EXAMINATIONS

	Number of persons	% of *de facto* population	% of persons eligible
De facto population	31 967	100.0	—
Tested	30 431	95.2	95.2
Read	28 994	90.7	95.3
Eligible for X-ray	22 740	71.1	—
X-rayed	21 021	65.8	92.4
Eligible for sputum examination	2 441	7.6	—
Sputum examined	2 333	7.3	95.6

tween what may be called " positive " and " negative " reactors. In Fig. 2 distributions of reactions for each of the age-groups 0-9 and 0-14 are shown. The distributions in Fig. 1 and 2 are of the type known as " bimodal ", with one mode near 0 mm and the other between 22 and 24 mm. Again, for the age-groups 0-9 and 0-14, the line of separation of the two modes could be anywhere between 8 and 16 mm. Thus these histograms do not give a clear or definite line of separation between positive and negative reactors. This difficulty of drawing any clear line of demarcation between positive and negative reactions in some communities is well recognized.

Definition of a positive reaction

In an attempt to define a positive reaction, the following hypothesis was formulated. It was assumed that in a series of observations infection rates and case rates are closely correlated, and that the correlation is closest when the empirically chosen criterion of a " positive " tuberculin test corresponds to the " true " or " best " line of demarcation between infected and non-infected.

To examine this hypothesis, correlation coefficients were calculated for the 62 village groups between " infection rates " (taking various criteria of a " positive " tuberculin test) and the radiological and bacteriological case rates. Further, so that non-specific allergy, waning of allergy, or some similar factor should not reduce the magnitude of these correlations (this is particularly likely when infection rates in the older age-groups are included), coefficients of correlation were calculated separately between infection rates in each of the four age-groups 0-4, 0-9, 0-14 and all ages, taking various criteria of " positivity ", and the radiological and bacteriologically confirmed case rates as found in age-groups 10 years and above. These coefficients of correlation in respect of infection rates for all ages for the 62 villages are shown in Fig. 3. Infection in the younger age-groups could be expected to be a better index of the present or recent pool of infection in the community. But the infection rates in the lower age-groups did not give a higher coefficient of correlation with the radiological and bacteriological case rates. The coefficients of correlation were highest for all ages treated as one group. The coefficients of correlation were not significantly different for different criteria of a " positive " tuberculin reaction and, therefore, did not seem to be very helpful in defining a line of demarcation

TABLE 4

DISTRIBUTION OF MALES WITHOUT PREVIOUS BCG SCARS BY SIZE OF TUBERCULIN INDURATION AND AGE-GROUP *

Size of tuberculin induration (mm)	No. of males without previous BCG scars in age-group:											Totals for all age-groups
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50 +	
0	1 394	718	324	124	108	99	72	69	58	74	267	3 307
1	313	158	63	14	8	5	4	2	3	6	2	578
2	235	278	166	55	32	27	20	8	13	7	24	865
3	90	151	114	60	36	29	21	19	11	9	31	571
4	30	90	92	42	51	32	27	11	9	13	26	423
5	4	38	43	39	29	29	11	7	11	12	32	255
6	12	42	54	41	41	52	24	23	13	12	41	355
7	5	27	48	43	38	48	44	23	16	21	57	370
8	4	14	35	35	34	41	23	25	19	16	50	296
9	2	3	18	30	38	33	27	19	4	24	49	247
10	3	5	14	27	33	31	27	28	11	15	47	241
11	2	3	18	25	30	36	34	32	20	19	67	286
12	2	11	15	23	40	47	44	41	22	30	88	363
13	1	8	16	19	28	40	42	39	17	27	64	301
14	2	9	17	24	33	47	42	35	22	27	82	340
15	1	7	15	16	43	63	55	35	33	40	72	380
16	3	11	24	19	37	70	57	57	34	39	99	450
17	6	7	13	22	39	53	57	56	35	35	91	414
18	5	12	29	25	46	46	43	49	45	48	78	426
19	5	13	18	29	35	37	35	32	26	27	47	304
20	6	21	19	26	34	36	39	31	23	25	59	319
21	5	11	34	27	37	36	41	34	23	33	80	361
22	5	29	34	20	22	23	28	24	23	22	63	293
23	5	15	30	18	23	17	14	25	8	18	39	212
24	4	22	31	10	14	23	24	23	20	14	39	224
25	—	13	18	16	8	11	12	12	11	12	25	138
26	2	17	17	9	9	9	7	11	9	5	46	141
27	1	8	18	13	7	2	5	8	6	3	16	87
28	1	7	15	5	1	5	5	3	7	—	15	64
29	1	3	5	7	3	5	1	2	2	2	12	43
30 +	—	3	14	—	2	5	5	5	3	4	17	58
TOTALS	2 149	1 754	1 371	863	939	1 037	890	788	557	639	1 725	12 712

* Excluding 16 persons for whom there was no record of the presence or absence of a BCG scar.

TABLE 5

DISTRIBUTION OF FEMALES WITHOUT PREVIOUS BCG SCARS BY SIZE OF TUBERCULIN INDURATION AND AGE-GROUP *

Size of tuberculin induration (mm)	No. of females without previous BCG scars in age-groups:											Totals for all age-groups
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50 +	
0	1 413	799	354	184	221	210	155	114	92	113	377	4 032
1	284	190	64	35	33	13	14	7	4	8	13	665
2	244	304	179	87	113	78	41	28	20	27	52	1 173
3	83	161	135	83	95	82	41	40	31	22	42	815
4	29	79	94	68	76	75	39	32	28	16	40	576
5	6	35	56	53	52	52	25	16	19	15	29	358
6	5	31	60	41	66	52	30	29	24	20	45	403
7	6	28	45	33	46	39	34	34	18	12	56	351
8	1	11	26	22	40	33	24	21	16	14	37	245
9	2	5	24	9	32	35	20	21	11	13	31	203
10	4	9	11	8	21	25	18	14	12	15	31	168
11	—	5	8	11	22	23	13	20	15	15	40	172
12	1	9	11	20	29	21	30	12	17	16	43	209
13	—	4	16	13	19	25	15	14	18	12	35	171
14	4	12	11	4	17	22	23	14	14	18	44	183
15	—	8	9	14	25	27	16	25	15	12	45	196
16	6	17	11	14	41	49	31	21	29	18	46	283
17	8	13	14	19	26	39	28	22	20	24	54	267
18	5	19	15	16	29	36	32	27	18	26	51	274
19	4	15	15	17	26	28	27	25	18	10	45	230
20	3	19	21	16	35	23	19	26	10	22	34	228
21	5	14	36	21	40	34	34	33	35	18	56	326
22	3	21	36	29	42	42	30	22	26	14	54	319
23	4	21	30	21	32	32	29	24	27	32	58	310
24	2	17	37	18	35	38	31	23	21	24	40	286
25	2	13	28	12	30	32	25	16	16	10	35	219
26	2	14	23	22	27	21	14	22	16	14	35	210
27	—	11	22	8	12	17	13	11	3	9	15	121
28	—	7	11	8	11	10	7	14	12	9	26	115
29	2	7	11	6	4	10	8	2	5	6	13	74
30 +	—	12	21	6	10	22	17	14	14	10	42	168
TOTALS	2 128	1 910	1 434	918	1 307	1 245	883	743	624	594	1 564	13 350

* Excluding 16 persons for whom there was no record of the presence or absence of a BCG scar.

FIG. 1

HISTOGRAMS SHOWING THE DISTRIBUTION OF TUBERCULIN REACTIONS BY AGE AND SEX AMONG PERSONS WITHOUT PREVIOUS BCG SCARS

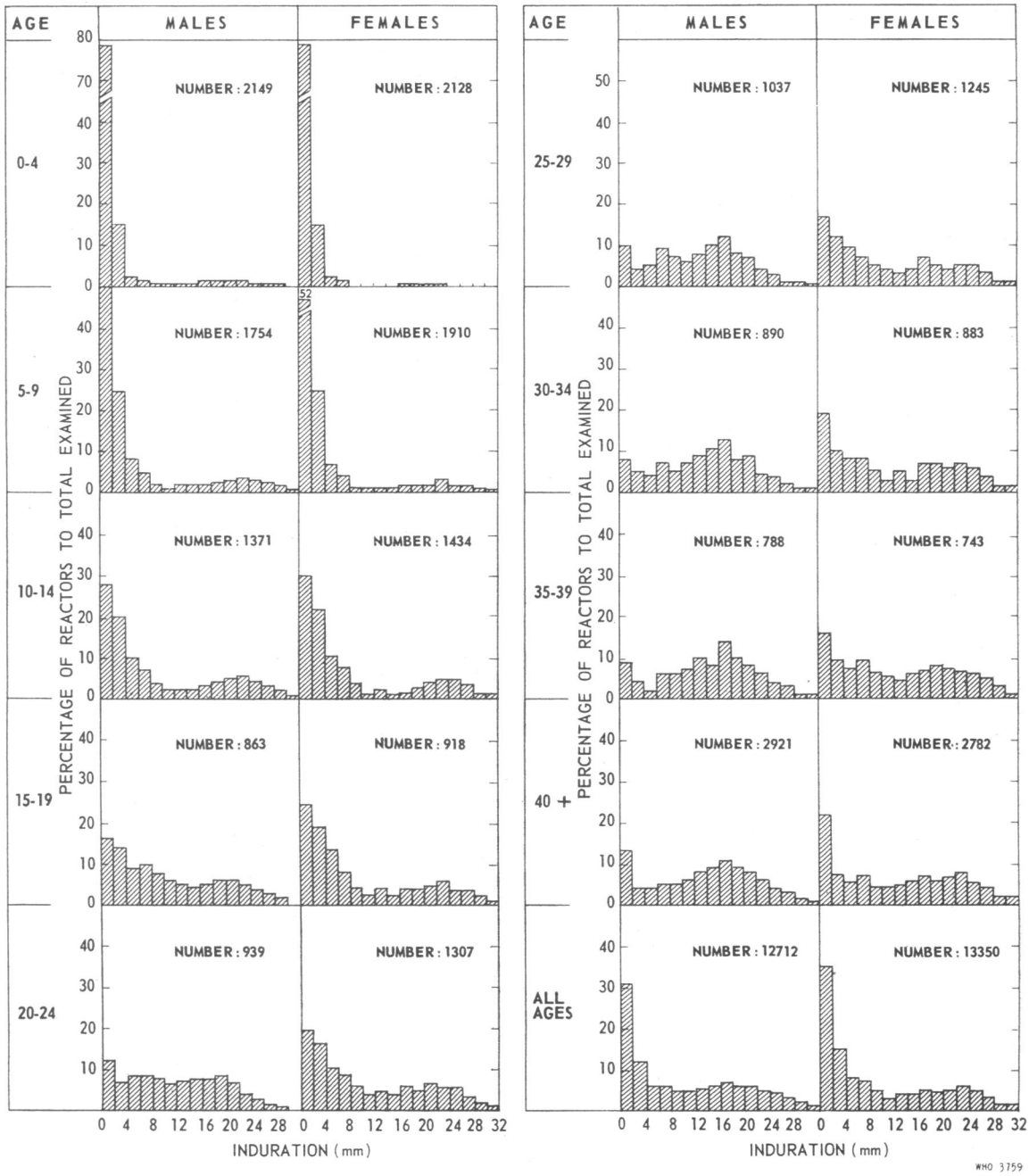
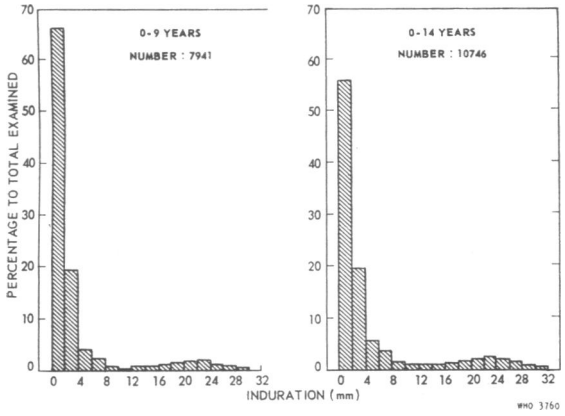


FIG. 2

DISTRIBUTION OF PERSONS WITH NO BCG SCAR ACCORDING TO THE SIZE OF THE TUBERCULIN REACTIONS



between positive and negative reactions. However, for calculating infection rates in the community on the basis of the histograms, an induration of 10 mm has been chosen, somewhat arbitrarily it must be admitted, as the reasonable minimum for a positive reaction.

Infection rates

On the basis of this definition of a positive reaction, Table 6 shows the percentage of persons infected in specified age-groups for each sex. The percentage of infected persons rises with age, reaching a maximum at about 40 years. Thereafter this percentage remains rather steady. For age-groups 10-19 years and above, infection rates are consistently higher among males, the difference being most marked between 20 and 60 years of age, with the peak at 30-39 years.

TABLE 6

SEX- AND AGE-SPECIFIC PREVALENCE OF INFECTION

Age-group	No. of persons infected [a]					
	Males		Females		Total	
	No.	%	No.	%	Total	%
0-4	60	2.8	55	2.6	115	2.7
5-9	235	13.4	267	14.0	502	13.7
10-19	794	35.5	700	29.8	1 494	32.6
20-29	1 166	59.0	1 109	43.5	2 275	50.2
30-39	1 199	71.5	861	53.0	2 060	62.3
40-49	845	70.7	695	57.1	1 540	63.8
50-59	671	71.0	493	54.5	1 164	62.9
60+	475	60.9	349	53.0	824	57.3
Overall	5 445	42.8	4 529	33.9	9 974	38.3

[a] Positive tuberculin reactors with an induration of ≥ 10 mm.

FIG. 3

COEFFICIENTS OF CORRELATION BETWEEN PREVALENCE OF INFECTION AND PREVALENCE OF (A) RADIOLOGICAL DISEASE AND (B) BACTERIOLOGICAL CASES PLOTTED AGAINST SIZE OF INDURATION TAKEN AS CRITERION OF INFECTION IN VILLAGE POPULATIONS

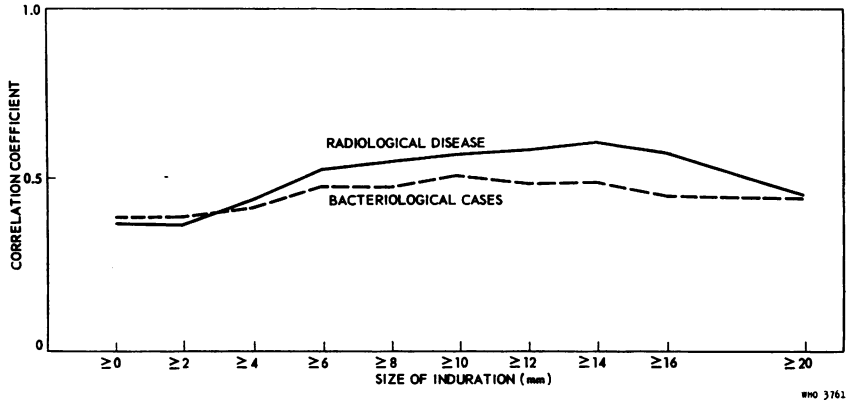


TABLE 7
SEX-SPECIFIC PREVALENCE OF INFECTION IN RURAL AND SEMI-URBAN GROUPS

	Males		Females		Totals		
	Tested and read	Reactors [a]	Tested and read	Reactors [a]	Tested and read	Reactors [a]	Prevalence (%)
Rural	11 942	5 074	12 521	4 196	24 463	9 270	37.9
Semi-urban	773	371	830	333	1 603	704	43.9
Totals	12 715	5 445	13 351	4 529	26 066	9 974	38.3

[a] Induration of ⩾ 10 mm.

Table 7 gives the number and percentage of infected persons in the 62 villages and the four town blocks. The number of persons test-read in the four town blocks is only 1603, which may not be adequate for drawing a definite conclusion. For this reason the four town blocks have been excluded from some of the tables.

The distribution of the 62 villages by prevalence of infection is given in Table 8. In one of the rural groups, the *de facto* population was 5. Of these, four were tested and one found positive. In 37 of the remaining 61 villages, the percentage of positive reactors varied from 25 to 39.

Complications of tuberculin reactions

Oedema, necrosis, vesicles or bullae were recorded, if present, for each tuberculin reaction that was read. Sometimes more than one complication was present. The distribution of these complications in 4 age-groups in the two sexes is given in Table 9. The frequency of bullous reactions, including the few vesicular reactions, is not high. Complications are more frequent in females in all age-groups except 0-4. No instance of necrosis was recorded.

Sex distribution of size of reaction

Age-specific curves taking indurations of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20 and 24 mm as the minimum levels for " positive " reactions were drawn for the two sexes. It was seen that although the percentage of reactors at all levels below 14 mm was greater among males than among females, the percentage of reactors at levels 20 mm and above was higher among females for all age-groups above 15 years. This is illustrated in Fig. 4 by age-specific curves for reactors with indurations equal to or larger than 6, 14, and 20 mm for the two sexes separately. The percentage of reactors at the 18-mm level was more or less equal in the two sexes (Fig. 5). This greater frequency of the larger tuberculin reactions in the female has also been noticed in another study (unpublished) carried out by the National Tuberculosis Institute in 1960. The significance of this phenomenon is not clear. An observation to the same effect has been

TABLE 8
DISTRIBUTION OF THE VILLAGES BY PREVALENCE OF INFECTION

Infection rate (%)	No. of villages with a *de facto* population [a] of:				Total no. of villages
	<250	250-499	500-749	750+	
0-4	1	—	—	—	1
5-9	—	—	—	—	—
10-14	—	—	—	—	—
15-19	—	1	—	—	1
20-24	2	2	1	1	6
25-29	7	4	3	2	16
30-34	3	5	3	1	12
35-39	3	3	3	—	9
40-44	3	1	1	1	6
45-49	—	3	—	3	6
50-54	1	—	—	1	2
55-59	—	—	—	1	1
60-64	1	—	—	1	2
Totals	21	19	11	11	62

[a] Total registered population less those temporarily absent.

TABLE 9

DISTRIBUTION OF COMPLICATIONS OF TUBERCULIN TEST WITH 1 TU OF RT 23 BY AGE AND SEX

Age-group	Males					Females					Overall rate per 1000
	Oedema only	Bulla only	Both	Totals	Rate per 1000	Oedema only	Bulla only	Both	Totals	Rate per 1000	
0-4	15	2	9	26	12.1	9	3	11	23	10.8	11.5
5-9	65	2	12	79	45.0	86	3	29	118	61.8	53.8
10-19	181	5	20	206	92.2	206	4	27	237	100.8	96.6
20+	242	13	22	277	42.1	394	15	69	478	68.7	55.8
Overall	503	22	63	588	46.3	695	25	136	856	64.1	55.4

reported by the WHO Tuberculosis Research Office (1955) in its study of the 5 TU versus the 10 TU tuberculin test. The report states: " Sex, on the other hand, made a consistent difference throughout: ' positive ' reactions among women were definitely more varied in size, and were slightly larger on the average, than those in males ". This observation appears to be in line with the earlier finding that the incidence of complications of tuberculin reactions is higher in females, although the total number of reactors among them is lower (see above).

Tuberculin reactions among radiologically active and sputum-positive cases

Fig. 6 shows the distribution of tuberculin reactions among radiologically active and bacteriologically confirmed cases. There were in all 392 persons with radiologically active disease and tuberculin

FIG. 4

PERCENTAGE OF PERSONS EXAMINED IN EACH AGE-GROUP GIVING TUBERCULIN REACTIONS OF $\geq$ 6 mm, $\geq$ 14 mm AND $\geq$ 20 mm

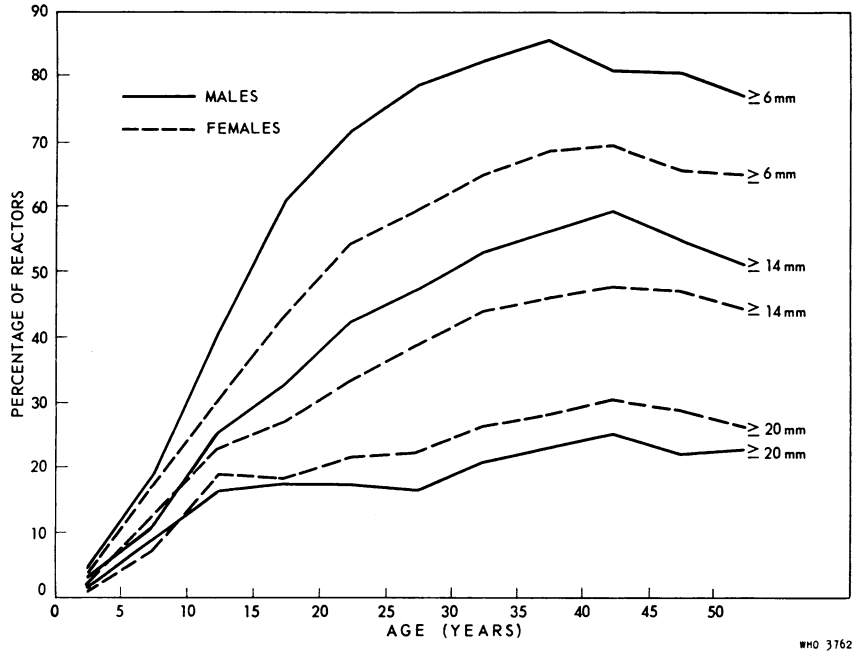
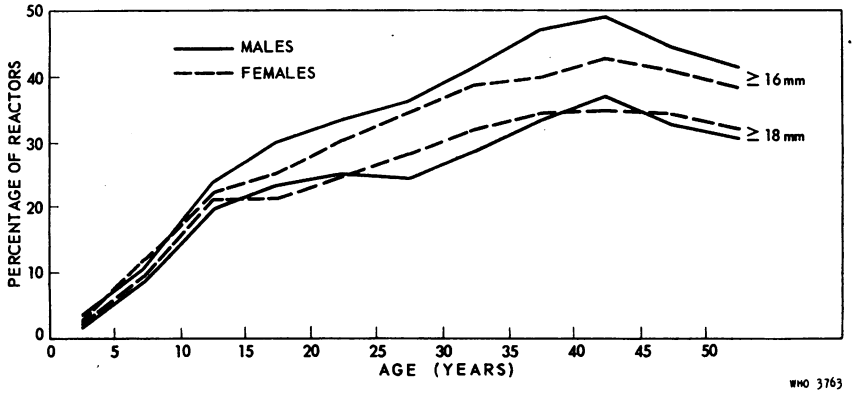


FIG. 5
PERCENTAGE OF PERSONS EXAMINED IN EACH AGE-GROUP GIVING TUBERCULIN REACTIONS OF ⩾ 16 mm AND ⩾ 18 mm



tests had been performed and read on 379. Of these 291 or 77% were positive tuberculin reactors. There were 86 bacteriologically confirmed cases in all; a tuberculin test had been performed and read on 85 of these and 73 or 86% were positive tuberculin reactors.

Fig. 6, therefore, shows the limitations of the indices used for denoting the various prevalence rates. Owing to the fairly large number of positive radiological and bacteriological findings among tuberculin-negative persons, it has been considered desirable to present the tuberculin reactions among the bacteriologically confirmed and radiologically active cases in some detail.

FIG. 6
DISTRIBUTION OF RADIOLOGICALLY ACTIVE AND BACTERIOLOGICALLY CONFIRMED CASES BY SIZE OF TUBERCULIN INDURATION

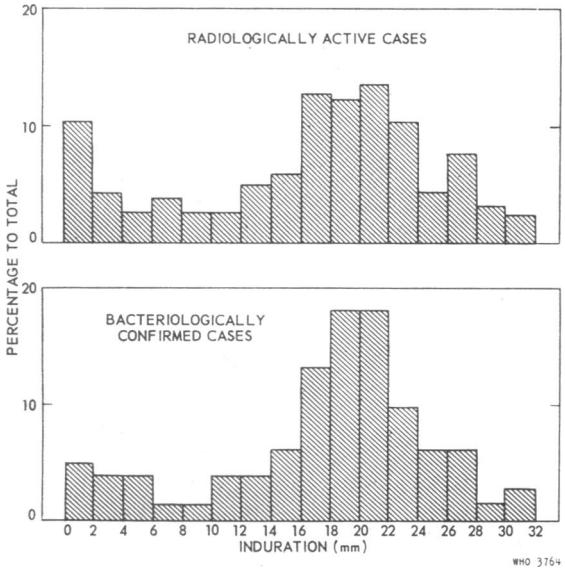


Table 10 shows that among the 85 persons with bacteriologically confirmed disease 9 had doubtfully positive smears (1-3 bacilli on direct smear); four of these were in the tuberculin-negative group (none was confirmed by culture). In addition, the tuberculin-negative group contained 4 persons with positive smears (the diagnosis was confirmed by culture in only one) and 4 with negative smears (but positive on culture). Thus only 1 out of 12 tuberculin-negative persons with bacteriologically confirmed disease gave a positive direct smear and a positive culture; this compares with 38 out of 73 tuberculin-positive persons. These observations, although the numbers are small, reveal discrepancies that call for further investigation. Meanwhile, with the tools used in the present survey such discrepancies must be regarded as unavoidable.

The distribution of the 379 persons with radiologically active disease and known tuberculin reactions by size of tuberculin induration is shown in Table 11 for males and females in the age-groups below 40 and above 40 years. It can be seen that there is a larger percentage of tuberculin-negative cases in the age-group above 40 (25% among males and 34% among females) than in the age-group below 40 (13% for males and 18% for females).

TABLE 10

DISTRIBUTION OF BACTERIOLOGICALLY CONFIRMED CASES BY SIZE OF TUBERCULIN INDURATION AND DEGREE OF POSITIVITY

Size of tuberculin induration (mm)	Smear doubtfully positive		Smear definitely positive		Smear: −ve; culture: +ve	Smear: +ve; culture: +ve
	Culture: −ve	Culture: +ve	Culture: −ve	Culture: +ve		
0	1	—	1	—	2	—
1	—	—	—	—	—	—
2	—	—	—	—	—	—
3	2[a]	—	1	—	—	—
4	—	—	—	—	—	—
5	1	—	1[a]	1	—	1
6	—	—	—	—	1	—
7	—	—	—	—	—	—
8	—	—	—	—	1	—
9	—	—	—	—	—	—
10	—	—	—	—	1	—
11	—	1	1	—	—	1
12	—	—	—	1	1	1
13	—	1	—	—	—	1
14	—	—	—	2	1	2
15	1	—	—	1	—	1
16	—	2	—	2	1	4
17	—	—	—	3	3	3
18	1[a]	—	2[a]	6	—	6
19	—	1	—	3	2	4
20	—	—	2	1	3	1
21	1	2	2	—	4	2
22	—	—	—	3	2	3
23	—	1	—	1	1	2
24	—	—	—	1	2	1
25	2	—	—	—	—	—
26	—	1	—	3	—	4
27	—	—	—	—	1	—
28	—	1	—	—	—	1
29	—	—	—	—	—	—
30+	—	—	1	1	—	1
Totals	9	10	11	29	26	39

[a] Includes one person whose culture was contaminated.

In interpreting the high frequency of radiologically active disease among tuberculin-negative subjects in the age-group 40 plus, reference should be made to the findings reported below (see Table 23),

TABLE 11

TUBERCULIN STATUS OF RADIOLOGICALLY ACTIVE CASES BY AGE AND SEX

Size of tuberculin induration (mm)	Males			Females		
	10-39 years	40 years and over	Total	10-39 years	40 years and over	Total
0	2	22	24	4	11	15
1	—	—	—	1	1	2
2	1	2	3	1	1	2
3	1	3	4	2	4	6
4	2	1	3	1	—	1
5	1	4	5	—	—	—
6	1	2	3	—	2	2
7	1	6	7	—	2	2
8	1	3	4	—	—	—
9	—	3	3	—	2	2
10	1	3	4	—	—	—
11	2	2	4	1	—	1
12	2	6	8	—	2	2
13	1	6	7	1	—	1
14	3	6	9	1	2	3
15	3	5	8	—	2	2
16	6	11	17	4	2	6
17	4	13	17	5	2	7
18	6	13	19	1	4	5
19	7	9	16	4	1	5
20	5	8	13	1	5	6
21	5	18	23	5	3	8
22	4	11	15	4	4	8
23	4	3	7	5	3	8
24	4	4	8	—	1	1
25	3	2	5	—	1	1
26	2	8	10	6	4	10
27	2	3	5	2	1	3
28	1	1	2	—	3	3
29	—	3	3	2	1	3
30+	2	2	4	—	4	4
Totals	77	183	260	51	68	119

namely, the fall in the number of bacteriologically confirmed cases of radiologically active disease with increasing age.

Retests of persons with BCG scars

Of the total of 28 994 persons tested and read, 2916, or 10%, showed BCG scars, definite or doubtful. A mass BCG vaccination campaign had been carried out during 1952 in one of the taluks and during 1954-55 in the rest of the district. 30% of the children in the age-group 10-14 years and 18% in each of the two age-groups 5-9 and 15-19 years showed BCG scars. In the age-group 0-4 hardly any (0.75%) showed such scars. The earlier mass BCG campaign seems to have been confined to school groups only, and may not have seriously affected the findings of this survey. Among the vaccinated persons in age-group 5-19 years, 61.4% showed an induration of 5 mm or less and 23.9% an induration of "0" mm. The post-vaccination allergy elicited by 1 TU of RT 23 with Tween was by no means high.

RESULTS OF X-RAY EXAMINATION

General considerations

The aim of X-ray examination in tuberculosis surveys is to obtain an estimate of the prevalence of disease. The difficulties of X-ray interpretation are well known. To reduce the extent of under-reading it is considered necessary to have two independent readers. With this procedure, many of the cases missed by one reader are picked up by the other, but at the same time the number of over-readings increases. Correlations between the readings of the two readers used in the present survey is presented in Tables 12 and 13 for males and females separately. The classification used is given in Appendix 1. The percentage agreement between the two readers for each category of X-ray reading has been calculated by taking the total placed in that category by at least one of the two readers as the denominator and the total placed in that category by both readers as the numerator. Thus in Table 12 (for males), we find that reader I read 81 films as D and reader II read 104 as D, while both of them read only 69 as D, thus showing an agreement in 59% amongst the total 116 cases read as D in males by either reader. The percentage agreements for some other categories of X-ray readings are as follows:

	Percentage agreement		
Category	*Males*	*Females*	*Both sexes*
D	59	40	55
C or D	55	37	49
C	32	23	29

In general, there is greater agreement between the readers in respect of the films of males. The greatest agreement is seen in the category of reading D, viz., 59% for males and 40% for females. The agreement for the category C or D is only slightly lower, but in this case the coverage of bacteriologically confirmed cases is considerably higher, as shown by the following results. (There were in all 84 bacteriologically confirmed cases among those X-rayed).

TABLE 12

CORRELATION BETWEEN THE RADIOLOGICAL FINDINGS OF THE TWO READERS IN MALES

		Reader II							
		Normal	Unsatis-factory films	Calcifi-cation only	A	B	C	D	Totals
Reader I	Normal	8 835	15	195	77	301	32	—	9 455
	Unsatisfactory films	45	148	—	2	—	1	—	196
	Calcification only	203	—	259	6	44	3	—	515
	A	41	—	3	38	24	18	6	130
	B	119	—	11	24	65	26	1	246
	C	16	—	1	13	38	86	28	182
	D	—	—	—	1	—	11	69	81
	Totals	9 259	163	469	161	472	177	104	10 805

TABLE 13
CORRELATION BETWEEN THE RADIOLOGICAL FINDINGS BY THE TWO READERS IN FEMALES

		Reader II							
		Normal	Unsatisfactory films	Calcification only	A	B	C	D	Totals
Reader I	Normal	8 504	21	194	170	214	30	1	9 134
	Unsatisfactory films	49	140	2	1	2	1	—	195
	Calcification only	101	—	275	14	25	3	—	418
	A	92	—	8	80	20	11	4	215
	B	66	—	5	23	35	19	—	148
	C	11	—	—	15	14	36	11	87
	D	—	—	—	—	1	4	14	19
	Totals	8 823	161	484	303	311	104	30	10 216

Category of X-ray reading	*No. of cases*	*No. bacteriologically confirmed*	*% bacteriologically confirmed*
D by both readers	83	42	50.6
D by either reader	151	54	35.8
C or D by both readers	259	60	23.2
C or D by either reader	525	71	13.5

Bacteriological confirmation may be used for choosing a suitable index of radiologically active disease. It can be seen that category D, as read by either or both readers, does not give a satisfactory coverage of the cases with positive bacteriological findings. Category C or D read by either reader gives the greatest numerical coverage, while category C or D read by both readers contains a higher percentage of bacteriologically confirmed cases. The last two categories could be used as indices of the lower and upper limits of the true prevalence of disease. If agreement between the two readers became closer, the difference between the lower and upper limits would be smaller. In the present study, the agreement between the two readers for category C or D was 49%.

Umpire reading

As recommended by Yerushalmy (1956) the 266 films on which there was disagreement, i.e., they were read as C or D by only one of the two readers, were submitted to an umpire, who was provided with both sets of readings but did not know the identity of the reader responsible for any reading. Tables 14 and 15 show the correlations between the readings of the umpire and those of the two readers separately. Out of the 110 films read as C or D by reader I only, 31 (28%) were confirmed by the umpire. Out of 156 films read as C or D by reader II only, 102 (65%) were confirmed by the umpire. It is seen that 133 readings (i.e., one half of those on which readers I and II disagreed) were confirmed by the umpire. These included 10 out of the 11 bacteriologically confirmed cases among the 266 films on which there was disagreement. Thus, the coverage of bacteriologically confirmed cases was 70 out of 84 when the method of umpire reading was used.

Choice of an index for prevalence of radiological disease

One may use any of the above categories of X-ray readings as an index to denote the disease in the community. In a search for the " best " index, correlation coefficients between the various X-ray categories and the prevalence of *(a)* infection and *(b)* sputum-positive cases were calculated. These coefficients, along with bacteriological findings and the prevalence rates for each X-ray category are shown in Table 16. Category " C or D by both readers " gave the highest coefficient of correlation with bacteriologically confirmed cases (0.49) and with tuberculin reactors (0.63), although the differences between this coefficient and the coefficients of correlation with other X-ray categories are not significant. As shown earlier, the index " C or D by both readers " misses 24 out of the total 84 bacterio-

TABLE 14

CORRELATION BETWEEN THE RADIOLOGICAL FINDINGS OF READER I AND THOSE OF THE UMPIRE READER

		Reader I							
		Normal	Unsatisfactory films	Calcification only	A	B	C	D	Totals
Umpire	Normal	10	..	..	..	..	13	..	23
	Unsatisfactory films	..	..	..	..	..	1	..	1
	Calcification only	..	..	1	..	..	..	..	1
	A	6	..	..	4	1	27	..	38
	B	13	..	1	2	16	38	..	70
	C	33	1	4	26	28	28	1	121
	D	1	1	..	7	1	1	1	12
	Totals	63	2	6	39	46	108	2	266

TABLE 15

CORRELATION BETWEEN THE RADIOLOGICAL FINDINGS OF READER II AND THOSE OF THE UMPIRE READER

		Reader II							
		Normal	Unsatisfactory films	Calcification only	A	B	C	D	Totals
Umpire	Normal	13	..	..	..	..	10	..	23
	Unsatisfactory films	1	..	..	..	..	..	..	1
	Calcification only	..	..	..	..	..	1	..	1
	A	5	..	..	18	4	9	2	38
	B	5	..	2	5	26	30	2	70
	C	2	1	..	4	22	92	..	121
	D	..	..	..	2	..	2	8	12
	Totals	26	1	2	29	52	144	12	266

TABLE 16

COMPARISON OF VARIOUS INDICES OF PREVALENCE OF RADIOLOGICALLY ACTIVE CASES

Category of X-ray reading	No. of cases in given X-ray category	Bacillary cases in given X-ray category		Infected cases [a] in given X-ray category (%)	% of total bacillary cases missed	Correlation coefficient [b] with prevalence of		Prevalence rate (%)
		No.	%			Reactors	Bacillary cases	
C or D by reader	369	63	17.1	73.2	25.0	0.59	0.41	1.76
C or D by reader II	415	68	16.4	78.4	19.0	0.61	0.38	1.97
C or D agreed by both readers	259	60	23.2	80.6	28.6	0.63	0.49	1.23
C or D by either reader	525	71	13.5	73.6	15.5	0.58	0.32	2.50
C or D agreed by both readers + those confirmed by the umpire	392	70	17.9	77.0	16.7	0.58	0.41	1.86

[a] Persons giving an induration of $\geqslant$ 10 mm in the tuberculin test.
[b] Calculated on the basis of 62 villages only.

logically confirmed cases (29%) and may thus not be the best index of radiologically active disease in the survey area.

Of the 62 villages, as many as 30 did not have a single bacteriologically confirmed case (see Table 22). Coefficients of correlation calculated separately for the villages with and without bacteriologically confirmed cases are shown in Table 17. Coefficients of correlation for both infection and bacteriologically confirmed disease with various categories of radiologically active disease are invariably higher for villages with bacteriologically confirmed cases, although the differences are not statistically significant.

A consideration of all the data presented above does not make the final choice of a suitable index (of the "best" index) of radiologically active disease in the community easier. Although there may not be much to choose between the different indices, taking all factors into consideration, two indices appeared suitable:

(*a*) films read as C or D by both readers plus those on which they disagreed but which were confirmed by the umpire;

(*b*) films read as C or D by reader II only.

TABLE 17

COEFFICIENTS OF CORRELATION BETWEEN PREVALENCE OF DISEASE, ACCORDING TO CATEGORY OF DIAGNOSIS, AND (A) BACTERIOLOGICAL PREVALENCE AND (B) PREVALENCE OF INFECTION IN VILLAGES WITH AND WITHOUT SPUTUM-POSITIVE CASES

Category of diagnosis	Coefficient of correlation				
	All villages		Villages with sputum-positive cases		Villages without sputum-positive cases
	A	B	A	B	B
C or D by reader I	0.41	0.59	0.61	0.70	0.46
C or D by reader II	0.38	0.61	0.54	0.67	0.56
C or D agreed by both readers	0.49	0.63	0.67	0.66	0.53
C or D by either reader	0.32	0.58	0.51	0.71	0.50
C or D agreed by both readers + C or D by umpire	0.41	0.58	0.65	0.65	0.52
Positive sputum		0.51		0.42	

A = bacteriological prevalence determined by sputum examination.

B = prevalence of infection determined by the tuberculin test (induration of ⩾ 10 mm).

The coefficients of correlation for these two indices with infection rates in the total population, taking four different sizes of induration as criteria of a positive tuberculin test, are shown below:

	Size of induration in tuberculin test			
	8 mm	*10 mm*	*12 mm*	*14 mm*
C or D by both readers plus those confirmed by the umpire	0.56	0.58	0.59	0.61
C or D by reader II only	0.56	0.61	0.63	0.63

The differences are not statistically significant and the choice between indices remains undecided. On general considerations, it may not be desirable to use as index the readings of a single reader because the results would not be easily comparable. It was therefore considered preferable to take the number of films read as C or D by both readers plus those confirmed by the umpire as the suitable index of the amount of radiologically active disease in the area surveyed. This index had also given a better coverage for bacteriologically confirmed cases, i.e., 70 out of the total of 84 bacteriologically confirmed cases among those X-rayed (83%). Unless otherwise stated, this index of radiologically active disease is the only one used in this paper.

Prevalence rates for radiologically active disease

The prevalence of radiologically active tuberculosis, as determined by this index, for all persons X-rayed by age- and sex-groups is shown in Table 18. The overall prevalence rate is 1.9%, respective figures for males and females being 2.5% and 1.2%. About 66% of the total radiologically active disease was in the age-group 40 years and above. Prevalence rates were higher among males than among females for all age-groups except 10-19 years. This greater prevalence among males was especially marked after the age of 30 years and increased with rise in age. The higher prevalence of disease in the female in the age group 10-19 years was also seen in the National Tuberculosis Sample Survey (Indian Council of Medical Research, 1959).

Table 19 shows the distribution of villages by the radiologically active disease rate and size of village. Eight villages with a population of over 900 did not show a single radiologically active case. Half the villages showed a prevalence rate of 1-3%. One village with a population of 152 persons X-rayed had 7 radiologically active cases, of which 4 were bacteriologically positive.

TABLE 18
SEX AND AGE PREVALENCE OF RADIOLOGICALLY ACTIVE DISEASE

Age-group	No. X-rayed			Radiologically active disease					
	Males	Females	Total	Males		Females		Total	
				No.	%	No.	%	No.	%
10-19	3 402	2 991	6 393	9	0.3	17	0.6	26	0.4
20-29	2 304	2 708	5 012	18	0.8	17	0.6	35	0.7
30-39	1 892	1 716	3 608	53	2.8	18	1.0	71	2.0
40-49	1 347	1 261	2 608	46	3.4	26	2.1	72	2.8
50-59	1 019	948	1 967	67	6.6	26	2.7	93	4.7
60+	841	592	1 433	78	9.3	17	2.9	95	6.6
Overall	10 805	10 216	21 021	271	2.5	121	1.2	392	1.9

RESULTS OF BACTERIOLOGICAL EXAMINATION

Bacteriologically confirmed cases

Table 20 shows the number and percentage of bacteriologically confirmed (" bacillary ") cases in the several age- and sex-groups as found by examination of a single " spot " sample of sputum. The percentage of " bacillary " cases, especially among the males, rises with age, in the same way as observed for radiologically active cases and infected persons. The percentage of " bacillary " cases is also higher among males in all age-groups except 10-19 years. However, the total number of " bacillary " cases found in the different age-groups is small. 0.41% of the total X-rayed population (0.56% of the males and 0.25% of the females) excreted tubercle bacilli. It can be calculated from the table that 50% of the " bacillary " cases were found in age-group 40 years and above.

TABLE 19
DISTRIBUTION OF VILLAGES BY RADIOLOGICALLY ACTIVE DISEASE

Radiological disease rate [a]	No. of villages with a *de facto* population [b] of:				Total no. of villages
	<250	250-499	500-749	750+	
0	7	1	..	..	8
>0-<1	2	6	2	2	12
1-<2	4	5	7	4	20
2-<3	2	5	2	3	12
3-<4	2	2	—	2	6
4-<5	3	—	—	—	3
5-<6	—	—	—	—	—
6-<7	—	—	—	—	—
7-	1	—	—	—	1
Total	21	19	11	11	62

[a] Number of cases of radiologically active disease per 100 persons X-rayed.
[b] Total registered population less those temporarily absent.

The X-ray findings of the two readers for the " bacillary " cases have been correlated in Table 21. One " bacillary " case was read as normal by both readers. Sputum examination had been requested by one of the readers with the remark that there was a " hair shadow " on the right apex. Four more cases were read as normal or of non-tubercular pathology by both the readers. One reader read in all as many as 9 " bacillary " cases as normal radiologically. The distribution of the 86 " bacillary " cases found positive by different techniques was:

Positive by direct smear	59
Positive by culture	66
Positive by culture and direct smear	39
Positive by direct smear, culture contaminated	4

It may be seen that 27 " bacillary " cases (46%) were found positive by culture among those negative by direct smear.

TABLE 20

AGE- AND SEX-SPECIFIC PREVALENCE OF SPUTUM-POSITIVE CASES IN THE *DE FACTO* POPULATION EXAMINED

Age-group	No. of persons X-rayed			No. of positive sputa [a]					
	Males	Females	Total	Males		Females		Total	
				No.	%	No.	%	No.	%
10-19	3 402	2 991	6 393	2	0.06	4	0.13	6	0.09
20-29	2 304	2 708	5 012	9	0.39	6	0.22	15	0.30
30-39	1 892	1 716	3 608	15	0.79	7	0.41	22	0.61
40-49	1 347	1 261	2 608	12	0.89	3	0.24	15	0.58
50-59	1 019	948	1 967	12	1.18	2	0.21	14	0.71
60+	841	592	1 433	10	1.19	4	0.68	14	0.98
Overall	10 805	10 216	21 021	60	0.56	26	0.25	86	0.41

[a] Including those found positive both by direct smear and by culture.

The distribution of villages by " bacillary " case rates is given in Table 22. It will be seen that in as many as 30 villages, comprising 5367 persons X-rayed, not a single " bacillary " case was found. These 30 villages represent about 25% of the population X-rayed. On the other hand, one village with an X-rayed population of 152 showed as many as 4 " bacillary " cases.

The number and percentage of " bacillary " cases among the radiologically active cases in different age-groups is presented in Table 23 separately for males and females. Except in the age-group 10-19, the percentage of " bacillary " cases among the radiologically active cases drops steadily with advancing age. This greater frequency of bacteriologically negative lesions with advancing age could

TABLE 21

CORRELATION BETWEEN THE RADIOLOGICAL FINDINGS OF THE TWO READERS AMONG SPUTUM-POSITIVE CASES

		Reader II								
		Normal	Unsatis-factory films	Calcifica-tion only	A	B	C	D	Not X-rayed	Total
Reader I	Normal	1	—	—	2	4	2	—	—	9
	Unsatisfactory films	—	1	—	—	—	1	—	—	2
	Calcification only	—	—	—	—	—	—	—	—	—
	A	—	—	—	1	1	1	2	—	5
	B	1	—	1	—	1	2	—	—	5
	C	—	—	—	2	1	8	8	—	19
	D	—	—	—	—	—	2	42	—	44
	Not X-rayed	—	—	—	—	—	—	—	2	2
	Total	2	1	1	5	7	16	52	2	86

TABLE 22
DISTRIBUTION OF VILLAGES BY BACTERIOLOGICAL PREVALENCE AND SIZE OF POPULATION

Bacteriological prevalence	Population				Totals
	<250	250-499	500-749	750+	
0	16	9	4	1	30
1	—	—	—	2	2
2	—	—	2	1	3
3	—	5	1	1	7
4	—	2	1	1	4
5	—	—	1	1	2
6	1	—	—	1	2
7	—	1	—	2	3
8	—	—	1	1	2
9	—	—	1	—	1
10	—	—	—	—	—
11	—	1	—	—	1
12	—	—	—	—	—
13	—	1	—	—	1
14	1	—	—	—	1
15	—	—	—	—	—
16	—	—	—	—	—
17	1	—	—	—	1
18	—	—	—	—	—
19	—	—	—	—	—
20+	2	—	—	—	2
Totals	21	19	11	11	62

be due to an accumulation of old bacteriologically negative lesions, to the fact that new lesions in older age-groups are more often negative than in younger persons, or to greater difficulty in judging the etiology or activity of a lesion from a single X-ray picture in older people.

Contamination rates

The maximum distance from the field to the National Tuberculosis Institute was over a hundred miles and from the Institute to the laboratory of the Union Mission Tuberculosis Sanatorium, 75 miles. It took 1-13 days for the sputum samples to be delivered at the laboratory. Among the 2333 sputum samples cultured, both tubes were contaminated in 395 instances (i.e., 17% of the samples) and one tube was contaminated in another 536 instances (23%). Of the contaminated samples, 616 cultures were repeated from the material left over from the first cultures and preserved in a refrigerator. A total of 2 cultures from samples of which both tubes were contaminated and 12 cultures from samples of which one tube was contaminated were found positive in these repeat cultures.

The unusually high contamination rate was considered to merit further study. The influence of the following characteristics on contamination rates was analysed:

(a) X-ray category of the examinee;

(b) age of the examinee;

(c) the interval between collection of the sputum sample and its inoculation in the culture medium;

TABLE 23
NUMBER AND PERCENTAGE OF SPUTUM-POSITIVE CASES AMONG RADIOLOGICALLY ACTIVE CASES IN DIFFERENT SEX- AND AGE-GROUPS

Age-group	Radiologically active cases		Sputum-positive cases			
	Males	Females	Males		Females	
			No.	%	No.	%
10-19	9	17	2	22.2	3	17.6
20-29	18	17	8	44.4	4	23.5
30-39	53	18	14	26.4	5	27.8
40-49	46	26	11	23.9	2	7.7
50-59	67	26	11	16.4	1	3.8
60+	78	17	8	10.3	1	5.9
Overall	271	121	54	19.9	16	13.2

TABLE 24
ESTIMATES OF PREVALENCE FOR VARIOUS EPIDEMIOLOGICAL INDICES IN TUMKUR DISTRICT

Epidemiological index	Prevalence [a] (%)	Standard error (%)	Coefficient of variation (%)	95 % confidence limits of prevalence	
				Lower (%)	Upper (%)
Induration ⩾ 10 mm	38.3	1.8	4.8	34.6	41.9
X-ray (C or D by both readers plus umpire)	1.86	0.15	8.10	1.56	2.16
Positive sputum	0.41	0.05	11.5	0.31	0.51

[a] For the index " induration ⩾ 10 mm " the prevalence relates to persons tested and read; for the other two indices it relates to the number of persons X-rayed.

(d) seasonal variation as shown by a study of weekly fluctuations in contaminations.

None of these factors could be held responsible for the high contamination rate.

Absentees from sputum examination

Sputum could not be collected from 108 persons out of 2441 persons eligible (Table 3). These included 13 radiologically active cases read as C or D by both the readers.

The number of bacteriologically confirmed cases found in this study should therefore be taken as a minimum, because reliance on the collection of a single " spot " sample of sputum, the presumption that all absentees from sputum examination had negative sputa, and the high contamination rate, all tend to reduce the number of " bacillary " cases detected.

OTHER RESULTS

Standardized rates

In order to make figures comparable, it is usual to compute standardized rates which take into account differences between the sex and age structure of the population examined and that of the actual population. Since the age and sex distribution of the population in the district in 1960 is not known, standardization in this way is not feasible. On the other hand, since the absentee rates have been found to vary in different age- and sex-groups, it was considered desirable to make due allowance for this and to calculate standardized rates assuming that the prevalence rate among the absentees was the same as among those examined in each age- and sex-group. These standardized rates worked out to be 38.3 % for infection, 1.86 % for radiologically active cases and 0.41 % for bacteriologically confirmed cases, the latter two rates being for ages 10 years and above only. These standardized rates do not differ from the prevalence rates for the population examined, owing to the high coverages obtained during the survey.

Overall estimates for the district

The population of Tumkur District, excluding the headquarters town of Tumkur, was estimated to be 1.22 million during November 1960, the middle point of the survey period. Appendix 2 gives a summary of the findings for each of the 66 units covered by the survey (see page 642).

Standard errors and coefficients of variation for three prevalence rates are presented in Table 24. A statistical note on these calculations is given in Appendix 3. It may be seen that a coefficient of variation of 5 % for the infection rate, 8 % for the radiologically active disease rate and 12 % for the " bacillary " case rate was achieved.

With a confidence of 19 in 20 it can be asserted that the number of cases of radiologically active disease in persons aged 10 years and above in the rural and semi-urban population lies between 11.8 thousand and 18.8 thousand, and is likely to be around 16.2 thousand.

Similarly with a confidence of 19 in 20 it may be asserted that the number of bacteriologically confirmed cases in persons aged 10 years and over in the above population may lie anywhere between 2800 and 4400 and is likely to be about 3600.

Variation within the district

The villages surveyed constituted a random sample of the entire district. Therefore, estimates for

TABLE 25

THE PREVALENCE OF INFECTION AND DISEASE IN THE SOUTHERN AND NORTHERN HALVES OF TUMKUR DISTRICT

	No. of groups (including towns)	*De facto* population	No. tested and read	Infected [a]		No. X-rayed	Radiologically active cases		Sputum-positive cases	
				No.	%		No.	%	No.	%
Southern half	40	15 911	12 895	3 907	30.3	10 514	150	1.43	25	0.24
Northern half	26	16 056	13 171	6 067	46.1	10 507	242	2.30	61	0.58

[a] Induration of ⩾ 10 mm in the tuberculin test.

smaller units like the taluks are not valid. But the differences between the southern half, consisting of 6 taluks, and the northern half consisting of 4 taluks were strikingly large. The findings in the two halves are presented in Table 25. It will be seen that although the populations of the two halves are nearly the same, the prevalence of infection in the northern half is 46% compared with 30% in the southern half, while the prevalence of radiologically active disease is 2.3% in the north and 1.4% in the south. The " bacillary " rates are 0.58% and 0.24% respectively. The reason or reasons for these differences are not known, but they have not been found to be due to any differences in coverage by age and sex or in the sizes of the villages in the two zones.

A further difference observed may also be recorded. Although only 25 out of 86 " bacillary " cases are in the southern half, the sex ratio of these cases in this half is different from that in the northern half. In the southern half there are 11 male and 14 female " bacillary " cases, while in the northern half there are 49 male and 12 female cases. Among the radiologically active cases in the northern half, no such preponderance in the number of males is seen.

The prevalence rates in the 10 taluks range from 1.6% to 3.7%. Results of significance tests for the differences mentioned above have not been presented in this paper, because even though such tests showed the differences to be significant, the validity of these tests is questionable as the sample has not been stratified by taluks.

Variation in prevalence rates with size of village

In Table 26 are presented the prevalence rates for infection and radiological and " bacillary " disease for villages of different size. The total number of persons X-rayed was only 1792 in the group of

TABLE 26

PREVALENCE OF INFECTION, RADIOLOGICALLY ACTIVE DISEASE AND SPUTUM-POSITIVE CASES BY SIZE OF VILLAGE

Size of village [a]	No. of villages	No. of persons tested and read	Infected [b]		No. of persons X-rayed	Radiologically active cases		Sputum-positive cases	
			No.	%		No.	%	No.	%
< 250	21	2 300	775	33.70	1 792	34	1.90	8	0.45
250-499	19	6 081	2 045	33.63	4 722	76	1.61	15	0.32
500-749	11	5 398	1 752	32.46	4 329	62	1.43	14	0.32
⩾ 750	11	10 684	4 698	43.97	8 892	185	2.08	40	0.45
All villages	62	24 463	9 270	37.89	19 735	357	1.81	77	0.39

[a] *De facto* population.
[b] Induration of ⩾ 10 mm in the tuberculin test.

" smallest " villages and the high radiological and " bacillary " disease rates may not necessarily be reliable for such villages. Thus all the three prevalences rates appear to be highest for " large " villages with populations of 750 or more. For reasons given in the preceding paragraph the results of significance tests for the differences observed are not given.

DISCUSSION

The survey in Tumkur District confirms, in general, the findings of earlier National Tuberculosis Sample surveys that there is a considerable amount of tuberculosis in the villages. Furthermore, there are appreciable variations in the prevalence rates of infection, radiological and bacteriological disease among different taluks, among villages of different sizes and in the northern and southern halves of the district. As the sample surveyed was drawn from the entire district, these differences may not necessarily be valid. All the same, if such differences are there, they may seriously interfere with the assessment of different tuberculosis control operations in different parts of the district. If the original sample had been stratified for the taluks or for the size of villages, the differences found might have been more reliable. The conclusion is drawn that stratification according to the factors mentioned should be considered necessary in selecting a sample for a survey, especially if the results are to be used for the assessment of different control programmes in different areas of the district. At any rate, there can be no serious disadvantage in stratification.

Coefficients of correlation between infection and various categories of disease on the one hand and between radiologically active and bacteriologically confirmed disease on the other, have been shown earlier. The value of some of these coefficients is not high enough to justify use of the comparatively simple tuberculin test for judging the amount of radiological and " bacillary " disease in a group or a community. It is possible that some of these coefficients were not high enough because of the relative crudeness of the methods that are available for surveys. Limitations due to reader error in tuberculin tests and X-ray readings are well known. The limitations of using a single spot sample of sputum for judging the number of " bacillary " cases have been reported earlier (Raj Narain et al., 1962). There are many other limitations of the methods available for surveys that may account for the low values of the various coefficients of correlation in this report. It is hoped that further surveys will enable the value of these coefficients of correlation to be judged better.

Some methods for defining more accurately a positive tuberculin reaction and an index of radiologically active disease have been used. The results may not appear commensurate with the labour put in. However, a basis for further work has been defined. Another survey with a sampling ratio of 20% and with more intensive sputum examination has just been completed. Correlation of the findings by the different techniques used may be helpful in judging their value and may make their application more precise.

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RÉSUMÉ

Avant que ne soient organisés des projets pilotes destinés à évaluer l'efficacité d'un certain nombre de mesures de lutte antituberculeuse, une enquête sur la fréquence globale de la tuberculose, par échantillonnage, a été effectuée dans un district de l'Etat de Mysore, Inde. Ce district a été divisé en 66 unités

représentant 34 746 personnes, qui ont été soumises au test de Mantoux (1 UT), à l'examen radiologique et à la recherche des bacilles dans les crachats.

Les auteurs discutent la valeur et les correspondances des indices d'infection donnés par ces trois types d'épreuves. Bien que les résultats ne permettent pas un choix net entre ces dernières, ils fournissent une base utile pour des enquêtes futures. Ils ont montré, en particulier, que l'on ne pouvait pas, actuellement, se fier au seul test à la tuberculine pour mettre en évidence tous les cas que peuvent dépister la radiographie et la méthode bactériologique.

L'enquête a montré que la fréquence de la tuberculose dans les villages était élevée. Des variations appréciables de la fréquence ont été observées entre les diverses petites villes, les villages de différentes grandeurs, le nord et le sud du district.

Pour que ces différences puissent être considérées comme valables, il aurait fallu que l'échantillon de population soit stratifié en fonction de la grandeur des villages ou agglomérations urbaines. C'est une nécessité dont il y aura lieu de tenir compte dans de futures enquêtes.

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Appendix 1

INSTRUCTIONS FOR READING X-RAY FILMS

All readings of X-ray films are recorded on a separate form which clearly indicates the group number, group name, film roll No., date of the X-ray exposure, date of the X-ray reading and the name of the reader. This is done to ensure complete independence of the two readings. Individual cards are not available to the readers at the time of reading.

The X-ray code used by the readers is based mainly on the code followed in the National Tuberculosis Sample Survey (Indian Council of Medical Research, 1959). In all cases where pathological changes are present, readings are recorded under the following four headings.

(a) Extent of disease: the zones involved in each lung are recorded.

(b) The physical appearance of the lesion is recorded under any one of eleven different sub-headings.

If more than one lesion is found, only the main lesion (from the point of view of tuberculosis) is recorded.

(c) Presence of calcification(s).

(d) Impressions regarding etiology.

Except where calcifications only are present, the reader should give his opinion regarding the etiology of the lesion. In making this judgement the physical appearance of the lesion is taken into account (presence of cavity, location of lesion, etc.) as well as the extent (size of areas involved; unilateral or bilateral distribution).

The following etiological classification is used:

A. Probably non-tuberculous: all lesions considered to be of non-tuberculous origin; the probability of finding tubercle bacilli is judged to be near zero.

B. Probably tuberculous but inactive: all scars and other healed lesions except calcifications (doubtful shadows, if they are recorded at all, may be classified as inactive); the probability of finding tubercle bacilli is judged to be small.

C. Probably tuberculous, possibly active: lesions that appear to be of tuberculous nature but without a definite cavity and not extensive; tubercle bacilli may be detected even with a single collection of sputum.

D. Probably tuberculous and active: lesions that appear to be of tuberculous nature, and that are extensive or bilateral, or where a definite cavity is present; the probability of finding tubercle bacilli by a single collection is judged to be high.

The last two categories (C and D) are grouped together as " Radiologically active tuberculosis ". (For a discussion of the choice of index of disease used in this paper, see p. 653.)

Appendix 2

DETAILS OF FINDINGS FOR EACH GROUP IN THE SURVEY

Group No.	Total registered population	Total tested and read	Infection rate [a]	Total X-rayed	Radiologically active disease		Bacillary cases	
					No.	Rate (%)	No.	Rate (%)
501	456	387	49.9	303	10	3.3	4	1.32
502	966	799	47.2	630	13	2.1	3	0.48
503	273	251	48.2	176	3	1.7	2	1.14
504	220	185	61.1	152	7	4.6	4	2.63
505	103	97	30.9	69	2	2.9	1	1.45
506	874	738	47.8	581	19	3.3	5	0.86
507	377	295	34.2	200	2	1.0	—	—
508	1 427	1 196	41.6	961	15	1.6	6	0.62
509	93	75	37.3	64	—	—	—	—
510	351	331	36.6	239	2	0.8	—	—
511	3 021	2 276	51.0	1 906	53	2.8	6	0.31
512 [b]	560	423	51.8	345	12	3.5	4	1.16
513	897	723	61.0	637	24	3.8	5	0.78
514	480	409	40.8	338	9	2.7	1	0.3
515	1 056	888	55.5	714	16	2.2	5	0.7
516	769	593	26.3	488	4	0.8	1	0.2
517	266	217	35.9	160	4	2.5	—	—
518	347	314	19.4	218	2	0.9	—	—
519	242	186	28.5	147	1	0.7	—	—
520	306	272	32.4	212	5	2.4	—	—
521	113	85	35.3	73	3	4.1	—	—
522	347	265	21.9	220	1	0.5	1	0.45
523	140	129	41.1	87	3	3.4	—	—
524	630	553	35.1	453	5	1.1	—	—
525	491	402	46.0	328	4	1.2	1	0.3
526	428	401	32.7	295	9	3.1	1	0.34
527	568	509	41.8	373	6	1.6	2	0.54
528	1 803	1 479	45.4	1 279	23	1.8	7	0.55
529	467	401	29.4	271	2	0.7	—	—
530	625	563	35.9	440	12	2.7	4	0.91
531	49	39	25.6	32	—	—	—	—
532 [b]	512	404	41.8	285	4	1.4	1	0.35
533	501	410	25.1	352	4	1.1	—	—
534	897	665	22.0	606	3	0.5	—	—
535	447	383	25.6	320	3	0.9	1	0.31
536	836	677	34.4	543	8	1.5	1	0.18
537	510	432	34.3	339	9	2.7	3	0.88
538 [b]	540	407	56.6	318	9	2.8	2	0.63
539	239	200	27.0	177	—	—	—	—
540	516	437	33.2	350	4	1.1	1	0.29
541	117	99	29.3	81	—	—	—	—
542	321	252	34.5	228	3	1.3	1	0.44
543	145	118	28.0	90	1	1.1	—	—
544	442	341	32.0	284	6	2.1	—	—
545	84	59	40.7	48	1	2.1	1	2.08
546	205	182	20.3	112	2	1.8	—	—
547	227	194	22.2	157	2	1.3	1	0.64
548	102	83	50.6	69	5	7.2	—	—
549	336	282	37.6	196	2	1.0	—	—
550	506	420	26.7	312	4	1.3	—	—
551 [b]	537	369	38.9	342	10	2.9	2	0.58
552	59	51	33.3	45	2	4.4	—	—
553	740	650	33.1	498	8	1.6	1	0.2
554	713	596	36.1	499	6	1.2	2	0.4
555	183	148	43.9	110	1	0.9	—	—
556	17	17	29.4	13	—	—	—	—
557	132	106	33.0	93	—	—	—	—
558	5	4	—	—	—	—	—	—
559	592	471	22.7	385	3	0.8	—	—
560	446	332	21.4	289	2	0.7	1	0.35
561	181	150	36.6	115	2	1.7	—	—
562	271	194	27.8	171	—	—	—	—
563	506	347	27.4	328	1	0.3	1	0.3
564	429	352	27.8	274	7	2.6	2	0.73
565	821	650	26.0	547	7	1.3	1	0.18
566	102	93	36.6	58	2	3.4	1	1.72

[a] Percentage of persons tested and read showing an induration of ⩾ 10 mm.
[b] Town blocks.

Appendix 3

STATISTICAL NOTE ON THE METHOD OF CALCULATING THE COEFFICIENTS OF VARIATION FOR THE VARIOUS PREVALENCES

The villages or town blocks were selected randomly in the manner described on pp. 641-642 and the entire population of the selected villages and the town blocks was included in the survey. It may be noted, therefore, that the sampling plan was that of cluster sampling, each cluster being a village or a town block and not a random sample of persons constituting the rural population of the district. The parameter to be estimated in the population is the prevalence rate, which may be denoted by p. If the number of persons examined is denoted by x_i and the number of cases in any village of the district by y_i then $p = \Sigma y_i / \Sigma x_i$, where the summation extends over all the villages of the district.

Let $\bar{x}$ and σx^2 be the mean and the variance of x_i, let $\bar{y}$ and σy^2 be the mean and the variance of y_i, and let σxy be the covariance between x_i and y_i over all the villages in the district.

The estimate of the population parameter $\hat{P}$ is given by $\hat{P} = \Sigma y_a / \Sigma x_a$, where y_a is the number of radiologically active cases diagnosed among x_a persons X-rayed in cluster a, the summation in each case running over all the n clusters ($n = 66$). For simplicity, the town blocks have been treated as villages randomly selected, since the result is unlikely to be affected appreciably by this procedure. It is known that this estimate is biased, but the bias is small and can be ignored.

The variance of this estimate is given by the formula:

$$V(\hat{P}) = \frac{p^2}{n}(C_{xx} - 2C_{xy} + C_{yy})$$

where C_{xx} is the square of the coefficient of variation of x in the population, i.e., $C_{xx} = \frac{\sigma x^2}{\bar{x}^2}$, similarly $C_{yy} = \frac{\sigma y^2}{\bar{y}^2}$ and $C^2xy = \frac{\sigma xy}{\bar{x}\,\bar{y}}$

Since the variances and the means are not known, they have to be estimated. An estimate of the variance of $\hat{P}$ is furnished by the formula

$$V(\hat{P}) = \frac{\Sigma y^2_i - 2\hat{P}\,\Sigma x_i\, y_i + \hat{P}^2\,\Sigma x^2_i}{n(n-1)\,\bar{x}^2}$$

These procedures applied to the data of the survey furnished the following results:

Epidemiological index	*Estimated prevalence (%)*	*Standard error (%)*	*Coefficient of variation (%)*
Infection	38.3	1.84	4.8
X-ray cases	1.9	0.15	8.1
Bacillary cases	4.1	0.05	11.5

Of the total number of 392 radiologically active cases among 21 021 X-rayed, 35 were from the town blocks in which 1290 persons were examined. These figures make it appear that the prevalence in the towns is higher than in the villages, but this inference is not necessarily valid since only 1290 persons were X-rayed in the towns and this number is rather inadequate for drawing any general conclusions.