Bull. Org. mond. Santé
Bull. Wld Hlth Org. 1961, **25**, 851-870

A Tuberculosis Survey in Kenya*

E. ROELSGAARD [1] & J. NYBOE [2]

The Government of Kenya, wanting to assess the extent of the tuberculosis problem in the Colony and Protectorate as an essential preliminary to a control programme, requested the assistance of WHO in carrying out a survey. The purpose was to establish the over-all prevalence for Kenya of tuberculous infection and pulmonary tuberculosis.

From a population of about six million people, 8700 were selected at random for tuberculin testing, chest X-ray and bacteriological examination.

The results of examination of this small sample indicate that among the 3.5 million Africans aged 10 years and over there are approximately 110 000 cases and suspected cases of pulmonary tuberculosis, and that 3% of the children aged 0-4 years and 13% of those aged 5-9 are infected.

The problem of tuberculosis control in Kenya is undoubtedly a big one, the population being scattered over vast areas. However, the excellent co-operation of the population throughout the present survey suggests that mass control measures might meet with considerable success.

Tuberculosis has for many years been considered one of the most important public health problems in Kenya. Information about the disease was obtained mainly from notification of infectious diseases by District Medical Officers. Although large numbers of "new" cases of tuberculosis were reported annually in this manner, it was suspected that they represented only a small fraction of the number of cases actually existing in the country. As no systematic case-finding programme had been carried out in Kenya on a large scale it was difficult to assess the reporting, which was almost entirely limited to cases who presented themselves for treatment at clinics and hospitals. Added difficulty in assessing the over-all situation arose from such factors as lack of proper diagnostic facilities in many parts of the country and the varying interest which medical officers with multifarious duties in large rural districts understandably displayed towards the disease.

With the increased interest in tuberculosis control in recent years, largely stemming from the introduction of effective and relatively inexpensive drugs for domiciliary treatment, a need was felt for further epidemiological information about tuberculosis in Kenya. The Government therefore requested the assistance of the World Health Organization (WHO) in carrying out a tuberculosis prevalence survey. The main purpose was to establish an over-all prevalence for Kenya of tuberculous infection and pulmonary tuberculosis. To this end a random sample of the African population was examined by three diagnostic methods: a tuberculin test and, among those 10 years of age or more, miniature chest X-ray examination and bacteriological examination of a sputum specimen. The field work was carried out between August 1958 and September 1959 by a WHO team consisting of a medical officer, a statistician, two nurses, an X-ray technician and a laboratory technician.

SAMPLING AND REGISTRATION

The survey consisted in the examination of a sample of the population of Kenya. In order to safeguard against bias and to ensure that the sample would be representative of the population from which it was drawn, the sampling was done according to a random procedure which in principle gave all the inhabitants the same chance of being included.

Excluded from the survey was the Northern Province, which, although it constitutes about half the area of Kenya, contains only 4% of the population. Nairobi, the capital of Kenya, was also ex-

* The field work was carried out under the direction of Dr. E. Kjølbye.

[1] Senior Medical Officer, WHO Tuberculosis Epidemiological Centre, Nairobi, Kenya.

[2] Statistician; formerly, WHO Tuberculosis Epidemiological Centre, Nairobi, Kenya.

cluded because a separate tuberculosis survey, assisted by WHO and UNICEF, was already under way there.

Funds and the time available for the project being limited, it was decided that the main objective of the survey should be to provide an estimate of the over-all prevalence of infection and disease in Kenya. Further information in the form of reliable estimates of the disease prevalence in various parts of the country would have required a considerably larger survey in terms of the number of people examined.

From purely practical considerations it was estimated that the survey team could examine about 8500 people scattered over the whole country in the approximately 12 months allocated for the work, and a sample of this size was therefore decided upon.

To keep the time spent on travelling in Kenya to a minimum, it was decided that several hundred people should be examined in each locality from which a part of the sample was drawn. The sample was therefore divided into 17 groups of 500 people each. However, in order to spread the sample as much as possible, each sample group was divided into two subgroups of 250 persons.

An attempt was made to increase the precision of the over-all prevalence estimates by stratification according to provinces,[1] using as far as possible a uniform sampling fraction (see Table 1). The census figures used for this stratification are from 1948 (East African Statistical Department). Population estimates for 1958, provided by the Government of Kenya, indicate that, although the population had increased by nearly one million over the decade, there were only minor changes in the relative percentages of inhabitants in the five provinces, which in 1958 were as follows: Rift Valley, 12.9%; Nyanza, 36.4%; Central, 29.5%; Southern, 12.4%; and Coast, 8.8%.

Within each province, a number of small administrative units (locations), corresponding to the number of sample groups, were selected at random, using the estimated population figures as weights. The same location could have been selected more than once, but actually this did not happen. In each location two sublocations were selected at random, again using probabilities proportional to the size of the population. In the sublocations selected all households were given consecutive numbers and one household was then selected at random, whereafter the subsample group was defined as the persons belonging to that household and the following households until 250 persons had been registered, everyone in the last household being included.

TABLE 1

KENYA POPULATION AND SAMPLE GROUPS, BY PROVINCE

Province	Population [a] (1948 census)		Allocation of 17 sample groups
	No. of persons	%	
Rift Valley	659 849	13.21	2
Nyanza	1 854 232	37.13	6
Central	1 397 549	27.99	5
Southern	633 764	12.69	2
Coast	448 258	8.98	2
Total	4 993 652	100.00	17

[a] Non-Africans are excluded.

All persons in the selected households were included in the sample if they slept there the night before the examination. Residents who were temporarily absent, i.e., persons who habitually slept in the house and who intended to return but were away on the night preceding the examinations, were not included in the sample and no attempt was made to locate them. Conversely, people who were living temporarily in the house were included. In short, the *de facto* and not the *de jure* population was reflected in the sample.

Registration of the sample population was done by house-to-house visits by the team statistician and local assistants. During this visit, the name, sex, estimated age and the household number for each person was recorded on an individual card.

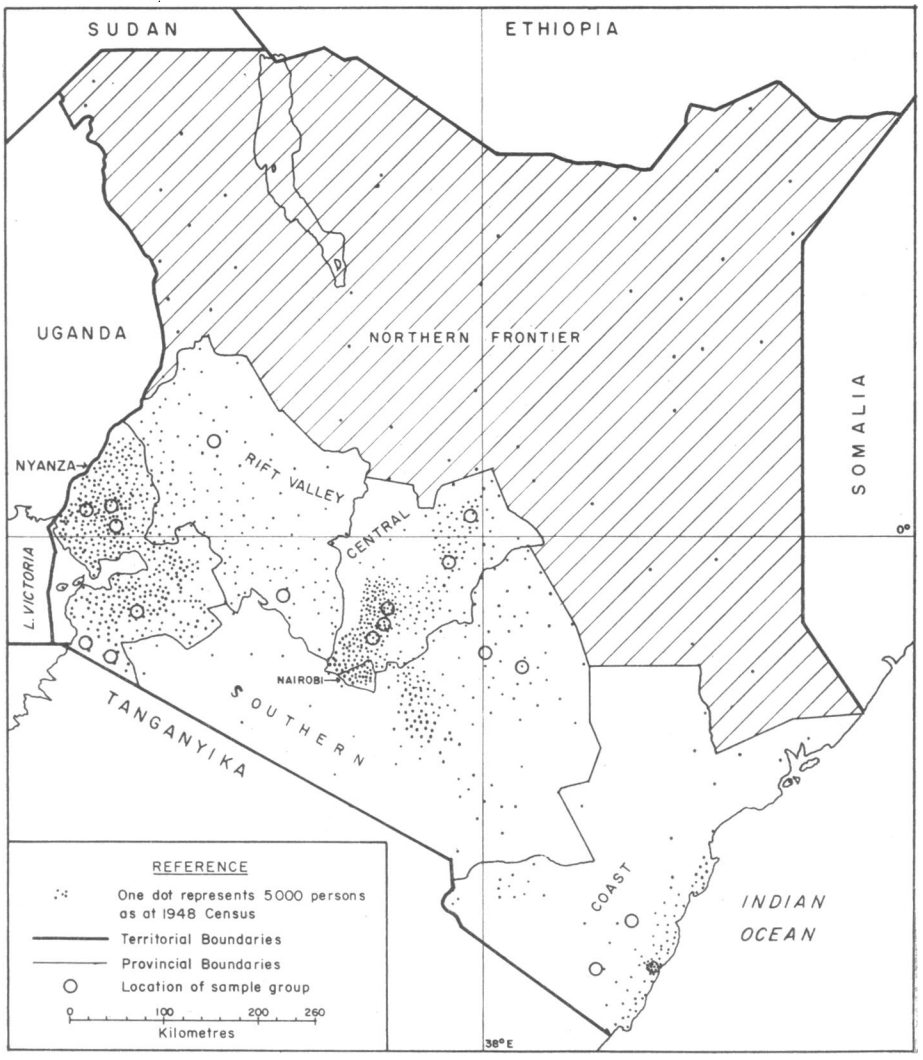
THE POPULATION EXAMINED

The geographical location of the sample groups is illustrated in Fig. 1, where the population densities of Kenya are also shown. Most of the sample groups are located in areas of high population density.

As more than 95% of Kenya's population, outside Nairobi, live in rural areas, it is not surprising that all the sample groups fell in rural communities. Many different tribes are represented in the sample, of which the largest tribal group, the Kikuyu includ-

[1] No other strata were *a priori* considered practicable.

FIG. 1
POPULATION DENSITY OF KENYA AND LOCATION OF SAMPLE GROUPS



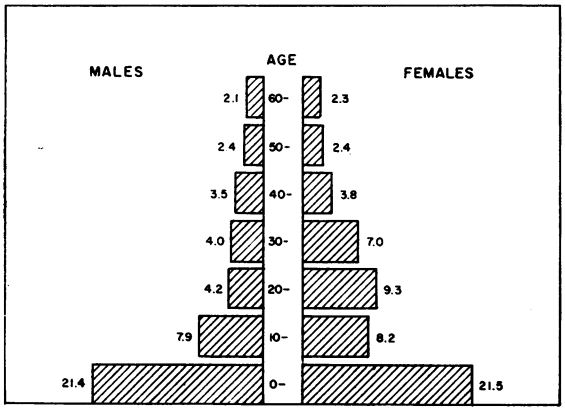
ing Embu, Meru and Kamba, comprises approximately 40%.

The age and sex composition of the total sample selected is illustrated in Fig. 2, and the corresponding data are given in Appendix Table 1. Males constitute 45% of the over-all sample. However, in the ages 20-39 there are almost twice as many females as males. If this age and sex composition gives a true picture of Kenya's rural population,[1] there would be slightly under half a million fewer men than women among the young adults in the rural African communities.

In certain areas of Kenya young adult men heavily outnumber women, for instance, in urban areas and on European-owned farms. Furthermore, some men are absent from their home communities serving in the armed forces and the police. These facts can well explain the " under-representation " of men in rural African communities. However, it is known that

[1] No census breakdown by age and sex is available.

FIG. 2
PERCENTAGE DISTRIBUTION BY AGE AND SEX OF POPULATION SELECTED FOR EXAMINATION



most of the men who work away from their communities retain close ties with their homes and frequently return for shorter or longer visits.

The age composition of the sample shows that no less than 43% of the population are under 10 years of age. This very high proportion of children in the sample, which undoubtedly reflects the situation of the Kenya population as a whole, can be explained by a reduction in infant and child mortality caused by improved living standards during the past decade.

METHODS OF EXAMINATION

Tuberculin test

Everyone attending the examination, except infants under one month, was given a Mantoux test with a dose of one tuberculin unit (Mx 1 TU). The tuberculin used was a PPD, lot RT 23, prepared by the Statens Seruminstitut, Copenhagen. The dose, in 1/10 ml diluent, to which 0.05 ‰ of Tween 80 had been added (Guld et al., 1958) was injected intracutaneously in the middle dorsal area of the left forearm.[1] The test was read after three to four days by measuring in millimetres the transverse diameter of the induration. The reader made no attempt to classify the reactions as positive or negative.

A second tuberculin test, with a dose of 20 tuberculin units (Mx 20 TU), was given to approximately half of those persons who had a reaction of less than 10 mm induration to the first test. The tuberculin used was also from lot RT 23 with Tween 80 added. The test was given in the right forearm and read in exactly the same manner as the low-dose tuberculin test.

[1] 1 TU of RT 23 in buffer diluent to which Tween 80 has been added has a biological effect approximately corresponding to that of 3 TU of the International Standard Reference Preparation of PPD-S.

Bacteriological examination

A sputum specimen was collected from all persons attending whose estimated age was 10 years or more. Each examinee was asked to cough vigorously and to spit into a small plastic box. A smear was made from all the specimens collected, stained by the Ziehl-Neelsen method, and examined by microscopy. A standard method of microscopic examination was used. The technician examined each field of focus along two horizontal lines and two vertical lines. Acid-fast bacilli were counted but the examination was discontinued before completing the four lines if more than 100 bacilli had been seen.

A second specimen was collected from everyone whose first sputum specimen was positive or doubtfully positive on examination by direct microscopy in the field; the second specimen was sent to the WHO/UNICEF-assisted Tuberculosis Diagnostic Laboratory at Nairobi for examination by culture. The culture was prepared after homogenization of the sputum with 4% sodium hydroxide. After centrifugation the sediment was inoculated into two McCartney bottles containing Löwenstein-Jensen medium prepared without potato starch. The cultures were incubated at 37°C and a final reading was taken after eight weeks.

Sensitivity tests to isoniazid (INH), para-aminosalicylic acid (PAS), and streptomycin were done on all primary cultures. Löwenstein-Jensen medium was also used for this purpose, and weighed quantities of the drug were added. The concentrations of drug (expressed in μg per ml before inspissation) were, for INH 0.2, 1, 5, and 50; for PAS 1, 2, 4, 16, and 64; and for streptomycin 8, 16, 32, 64, and 1024. The drug sensitivity tests were read after four weeks.

X-ray examination

Two 70-mm chest fluorograms were taken of everyone who attended whose estimated age was 10 years or more, one exposure with the camera in a position approximately 4 cm higher than for the other.

The photofluorograms were checked in the field by the team's X-ray technician in order to ensure that retakes were made whenever one or both of the photofluorograms were considered technically inadequate.

The photofluorograms were forwarded to the Tuberculosis Unit at the World Health Organization headquarters in Geneva and read there by one reader who had no knowledge of the results of the tuberculin testing or bacteriological examination. The reader classified shadows indicating lung pathology in order of " severity " as indicating infiltrate with cavity, infiltrate without cavity, calcified or fibrotic lesions, and pleural adhesions. Where more than one shadow was seen, the classification into type of lesion was determined by the most " severe " finding.

ORGANIZATION OF WORK

With the assistance of the District Medical Officer concerned, the co-operation of the local community leaders was always obtained before the team arrived. Meetings were held with the village authorities at which the purpose of the proposed examinations was explained, and they were told exactly in what manner they could assist. At these preliminary meetings dates were fixed for the registration and subsequent examination of the people selected.

Each member of the sample group was seen two or three times during the examinations, depending on whether or not a Mx 20 TU test was used. At the first visit the Mx 1 TU test was given, and a sputum specimen was collected from and a photofluorogram taken of everyone who was 10 years old or more. At the second visit three or four days later the tuberculin test was read and Mx 20 TU was given to approximately half of the non-reactors to Mx 1 TU, and a second sputum specimen was collected from persons whose first specimen gave positive or doubtful positive results on examination by direct microscopy. If necessary, another pair of photofluorograms was taken at this time. Mx 20 TU tests were read at a third visit.

The examinations were usually done at a central place in the district and people rarely had to walk more than a short distance to be examined. The field laboratory was set up where it was most convenient, either on the spot or in a nearby town. As the team worked for only a few days in any locality it was not possible to do follow-up examinations of cases or suspects, but all open cases diagnosed during the survey were reported to the District Medical Officer.

FINDINGS

In view of the critical importance of obtaining the completest possible attendance at the survey, a determined effort was made by the field team to examine all the people who had been selected. It will be seen from Appendix Table 2 that the completeness of attendance in all sample groups was very high indeed. Undoubtedly this is due both to the untiring efforts of the team and to the excellent co-operation from the public and from the local health authorities. The over-all rate of attendance for bacteriological examination was 99.9% and for tuberculin testing 99.2%.

Tuberculin testing

During the past few years it has been repeatedly demonstrated that, owing to non-specific tuberculin sensitivity, the tuberculin test does not enable a clear distinction to be made between infected and uninfected persons in tropical countries (Edwards & Palmer, 1953; Nyboe, 1990). This, however, is not the case in Kenya. It will be seen from Fig. 3 and Appendix Table 3, where frequency distributions by size of reaction to Mx 1 TU according to age for the total survey in Kenya are shown, that in all ages the reactions seem to fall into two groups—small reactions and large reactions. The small reactions are distributed with a mode at 0 mm, and the frequency decreases rapidly with increasing size. Probably very few of the reactions belonging to this group are over 12 mm. The large reactions approximate the Gaussian distribution with a mean at 18-19 mm. These two types of reaction presumably signify absence or presence of infection with pathogenic tubercle bacilli.

In all age-groups the two types of reaction are relatively well separated from one another, although a certain overlapping occurs, and errors in the classification of individual reactions into these two types cannot therefore altogether be eliminated. If, however, the limit between positive and negative reactions is set at 10 mm induration, the frequency of such errors will be small, and the number of negative reactions classified as positive will to some extent balance the positive reactions classified as negative. The number of 1 TU reactions larger than 9 mm, taken as a percentage of all reactions, is therefore used in the following discussion as a measure of the prevalence of infection.

Estimates of the prevalence of tuberculous infection in Kenya according to age and sex are shown in Fig. 4. The prevalence increases almost linearly with age up to 20 years, where it reaches 40%. In this age range there is no consistent difference between prevalence in the two sexes but after the age of 20 the prevalence is consistently higher for males than for

FIG. 3

FREQUENCY DISTRIBUTIONS BY SIZE OF REACTIONS TO MANTOUX 1 TU TEST ACCORDING TO AGE

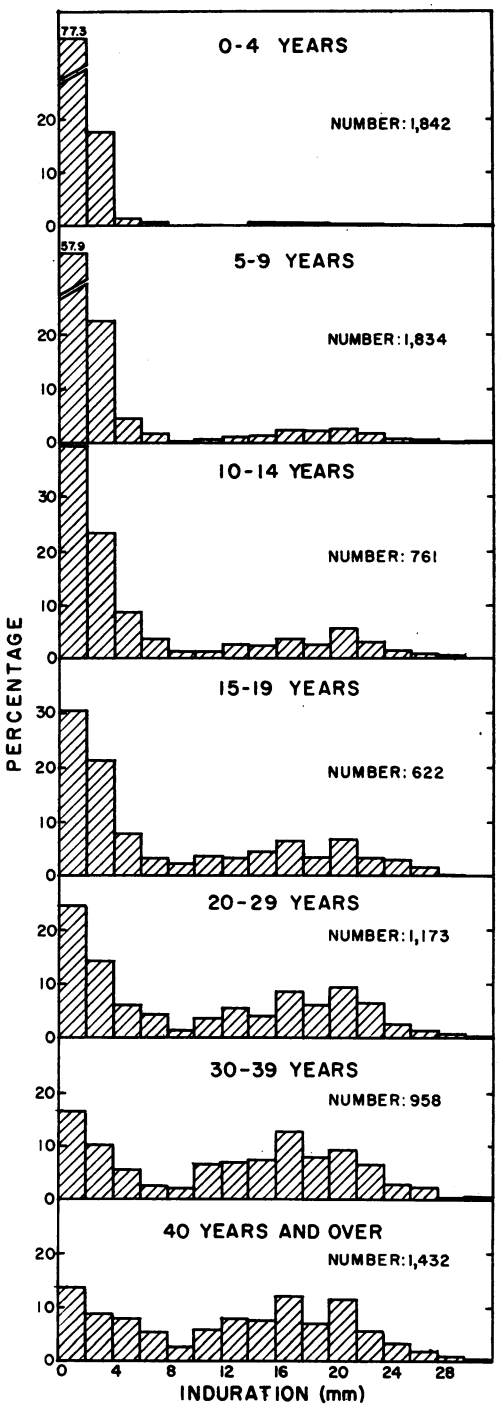
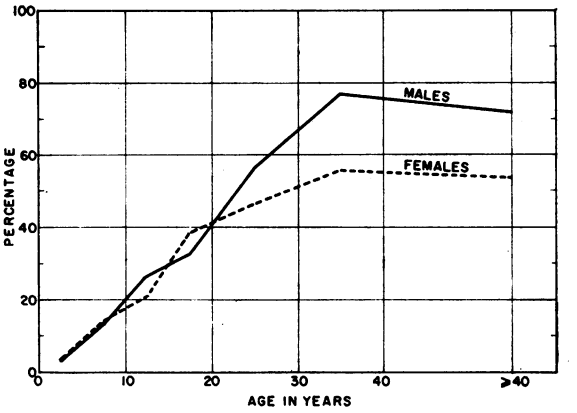


FIG. 4

ESTIMATED PREVALENCE OF TUBERCULOUS INFECTION IN KENYA BY AGE AND SEX



females; the maximum level reached among males is 77%, whereas the corresponding value for females is 56%.

The risk of infection in recent years is reflected in the prevalence of reactors to tuberculin among young people. Data showing this prevalence for each province are given in Table 2. The risk of infection is undoubtedly somewhat lower for Nyanza than for the other provinces (an observation that is further supported by the result of X-ray and bacteriological examinations). In Southern Province, on the other hand, this risk would seem to be higher than in the rest of the country but, as the data are based on two sample groups only and there is a very great variation between these two, the estimate for this province is not very precise.

TABLE 2

PREVALENCE OF INFECTED CHILDREN AGED 0-14 YEARS, BY PROVINCE

Province	Percentage infected
Rift Valley	11.5
Nyanza	7.5
Central	13.0
Southern	15.1
Coast	9.9
Total	10.7

The frequency of local complications with the low-dose tuberculin test in terms of vesicular reactions was found to be fairly high. It will be seen from Table 3 that about 30% of all positive reactions in the age-group 0-4 years had such complications and that the magnitude of this problem decreased gradually with age. Whether this trend signifies a higher frequency of complications the shorter the time interval between infection and testing, or whether it is due simply to a stronger allergic reaction in younger people cannot be determined from these data. There is no doubt, however, that the larger the reactions the more frequently do vesicular complications occur irrespective of age.

The fact that infected and non-infected people can be clearly separated by the low-dose tuberculin test indicates that there is relatively little non-specific tuberculin sensitivity in Kenya. Although such sensitivity was not elicited by the low-dose test, it could be studied by means of the high-dose tuberculin test (Mx 20 TU). Results of testing with this dose are given in Appendix Table 4 by age for all areas. These data very clearly show an increasing sensitivity to Mx 20 TU with increasing age among persons with small or no reaction to the Mx 1 TU test. It was also found (see Fig. 5) that sensitivity to Mx 20 TU varies considerably from province to province; this sensitivity being much more marked in the Coast and Southern Provinces than in Rift Valley, Nyanza, and Central Province.

TABLE 3

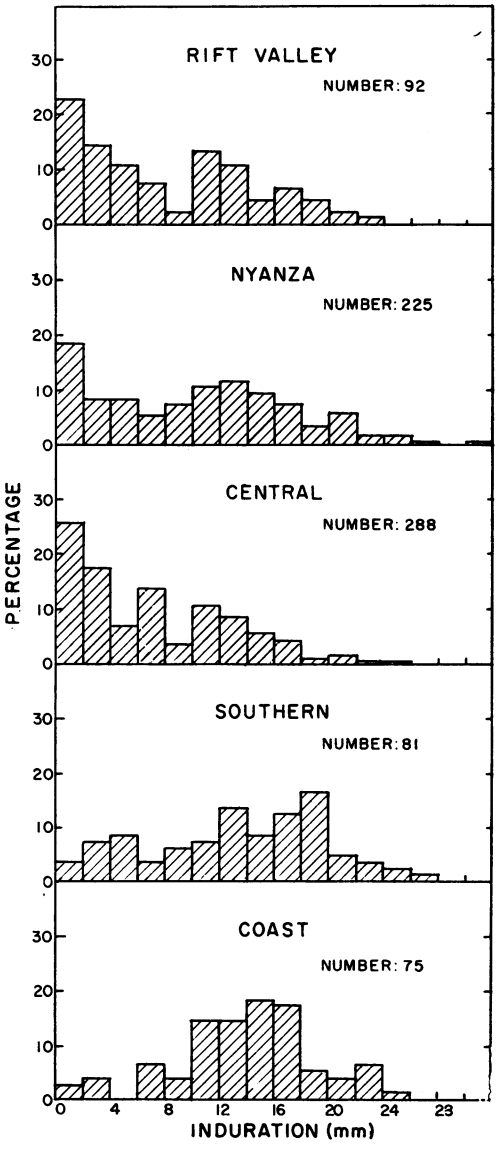
PREVALENCE[a] OF VESICULAR REACTIONS TO MANTOUX 1 TU TEST BY AGE AND SEX

Age (years)	Males	Females	Both sexes
0-4	29	31	30
5-9	18	28	23
10-14	20	24	22
15-19	21	14	17
20-29	20	15	16
30-39	14	14	14
40 +	9	10	9
All ages	15	15	15

[a] The prevalence is expressed as the percentage of vesicular reactions among the total number of reactions measuring 10 mm induration or more.

FIG. 5

FREQUENCY DISTRIBUTIONS, ACCORDING TO PROVINCE, BY SIZE OF REACTIONS TO MANTOUX 20 TU TEST IN PERSONS AGED 10-29 YEARS REACTING WITH LESS THAN 10 mm INDURATION TO MANTOUX 1 TU TEST



Bacteriology

As mentioned earlier, the attendance at the bacteriological examination was unusually good; in fact only three persons out of 4960 selected were not examined. Altogether 4957 sputum specimens were

TABLE 4

RESULTS OF EXAMINATION BY DIRECT MICROSCOPY OF SPUTUM SPECIMENS, BY SAMPLE GROUP

Province and district	No. of sputa examined	No. positive
Rift Valley:		
Nakuru	319	2
Elgeyo-Marakwet	306	2
Nyanza:		
Central Nyanza	275	—
North Nyanza	258	—
North Nyanza	266	—
South Nyanza	309	2
South Nyanza	308	1
South Nyanza	254	—
Central:		
Meru	289	3
Meru	317	2
Fort Hall	296	1
Fort Hall	297	5
Fort Hall	283	3
Southern:		
Kitui	326	6
Kitui	282	—
Coast:		
Kwale	286	2
Kilifi	286	3
Total	4 957	32

TABLE 5

RESULTS OF EXAMINATION BY DIRECT MICROSCOPY OF SPUTUM SPECIMENS, BY AGE AND SEX

Age (years)	No. of sputa examined from			No. positive on direct microscopy from		
	Males	Females	Both sexes	Males	Females	Both sexes
10-14	393	368	761	1	—	1
15-19	285	341	626	—	5	5
20-29	367	810	1 177	6	2	8
30-39	353	606	959	6	3	9
40-49	296	334	630	3	2	5
50-59	216	213	429	1	—	1
60 +	176	199	375	2	1	3
All ages	2 086	2 871	4 957	19	13	32

examined. Of these, 32 were found to contain acid-fast bacilli by direct microscopy. Examination by culture later confirmed that all the persons concerned excreted *Mycobacterium tuberculosis*.

The bacteriological diagnosis was based on culture morphology, absence of growth at room temperature, catalase activity, and drug sensitivity pattern to INH, PAS, and streptomycin. Animal pathogenicity tests were not done.

Table 4 shows the distribution of the 32 cases by sample group. It will readily be seen that, although the numbers are small, there is some geographical variation in the prevalence of open cases. In Central, Southern and Coast Provinces the prevalence is approximately the same, slightly below 1%, but in Nyanza it is very considerably lower—roughly one-fifth of that value—and Rift Valley lies between these two extremes. The prevalence of open cases [1] in the sample is 0.6%. As this value is derived from the examination of a random sample it is possible to compute that the corresponding prevalence for Kenya's African population over 10 years old is between 0.3% and 0.9%.[2]

Table 5 shows the result of the bacteriological examinations by age and sex. The over-all prevalence of open cases among males is twice as high as among females, and this difference is statistically significant.[3] This higher rate among males is most pronounced in the age-group 20-39 years. The prevalence for both sexes combined appears to be uniformly high for all age-groups, but the number of cases is too small to give a definite trend in the prevalence by age.

Drug sensitivity tests were done on all the 32 primary cultures. The results of these sensitivity tests for INH, PAS, and streptomycin are presented in Table 6. Confluent growth was obtained in control

[1] " Open cases " here denotes persons who were found to excrete tubercle bacilli in sputum, demonstrated by direct microscopy of one specimen only.

[2] The confidence intervals in this report are computed as the mean prevalence ± two times its standard error. The mean prevalence and its standard error are computed using the ratio method for a stratified sample (Yates, 1953: sections 6.10 and 7.10.).

[3] $\chi^2 = 3.95$ for one degree of freedom.

TABLE 6

DRUG SENSITIVITY OF ISOLATED STRAINS OF *MYCOBACTERIUM TUBERCULOSIS*

Strain No.	Amount of growth [a] on tube containing												Record of previous treatment
	INH [b]				PAS [b]					Streptomycin [b, c]			
	0.2	1	5	50	1	2	4	16	64	8	16	32	
1	0	0	0	0	0	0	0	0	0	0	0	0	No
2	0	0	0	0	0	0	0	0	0	0	0	0	No
3	+	+	+	0	++	0	+	0	0	0	0	0	No
4	+	0	+	0	+	0	+	0	0	0	0	0	No
5	0	0	0	0	0	0	0	0	0	0	0	0	No
6	+	+	+	0	+++	++	+	0	0	0	+	0	No
7	0	0	0	0	0	0	0	0	0	0	0	0	No
8	+	+	+	0	0	0	0	0	0	0	0	0	No
9	+	+	+	0	++	0	0	0	0	0	0	0	No
10	+	+	+	0	0	0	0	0	0	0	0	0	No
11	+	0	0	0	0	0	0	0	0	+	0	0	No
12	+	0	0	0	0	0	0	0	0	+	0	0	No
13	+	+	+	0	++	0	0	0	0	++	+	0	No
14	0	0	0	0	0	0	0	0	0	0	0	0	No
15	0	0	0	0	0	0	0	0	0	0	0	0	No
16	0	0	0	0	0	0	0	0	0	+	+	0	Yes
17	++++	++++	++++	++++	0	0	0	0	0	0	0	0	Yes
18	0	0	0	0	0	0	0	0	0	0	0	0	No
19	+	0	0	0	0	0	0	0	0	0	0	0	No
20	+	+	+	0	+++	0	0	0	0	0	0	0	No
21	0	0	0	0	++++	++	++	+	+	+	0	0	No
22	+	0	0	0	++	++	++	0	0	0	0	0	No
23	0	0	0	0	0	0	0	0	0	++	+	+	No
24	+	+	+	0	+++	+++	++	++	++	++	0	0	No
25	+++	+	0	0	+++	+++	++	++	0	0	0	0	No
26	++++	++++	++++	0	+++	+++	++	+	+	0	0	0	Yes
27	++++	++++	0	0	++++	+++	+++	+	+	0	0	0	Yes
28	0	0	0	0	0	0	0	0	0	0	0	0	No
29	+++	0	0	0	0	0	0	0	0	0	0	0	No
30	0	+	0	0	+	+	0	0	0	0	0	0	Yes
31	++++	++++	++++	0	++++	++++	++++	+++	0	0	0	0	Yes
32	0	0	0	0	++	++	+	0	0	0	0	0	No

[a] 0 = no growth;
+ = 1-19 colonies;
++ = 20-40 discrete colonies;
+++ = innumerable colonies (i.e., over 40);
++++ = confluent growth.

[b] Expressed in μg per ml of medium.

[c] Tubes containing 64 and 1024 μg of streptomycin per ml of medium were also used but no growth was obtained from any of the strains at these concentrations.

TABLE 7

RESULTS OF X-RAY EXAMINATION AND TUBERCULIN TESTING, BY AGE

Age (years)	No. of persons examined	Number of persons with lung pathology							
		Mx 1 TU reaction measuring 10 mm or more				Mx 1 TU reaction measuring less than 10 mm			
		Infiltrate		Calcified or fibrotic lesion	Pleural adhesion	Infiltrate		Calcified or fibrotic lesion	Pleural adhesion
		With cavity [a]	Without cavity			With cavity [a]	Without cavity		
10-14	759	1	1	12	4	1	2	7	3
15-19	624	3	6	15	2	0	4	0	2
20-29	1 177	5	21	24	13	2	9	7	4
30-39	957	7	24	24	26	3	8	6	10
40-49	630	10	18	30	24	7	8	3	10
50-59	427	4	25	18	16	6	11	5	12
60 +	370	9	25	10	13	4	22	4	9
All ages	4 944	39	120	133	98	23	64	32	50

[a] Including 9 cases classified by the X-ray reader as " doubtful cavity ".

tubes, without drugs in the media, for all strains except No. 1, which failed entirely to grow in the drug sensitivity test. As no universally accepted criteria for drug resistance exist, the observations made in the laboratory at Nairobi are presented in some detail to permit individual readers to apply their own definitions of drug resistance to the data.

The criteria for drug resistance used at present in Kenya are those suggested by Pepys et al. (1960). Applying these criteria to the data, six strains would be considered resistant to INH, eight to PAS, and one to streptomycin. Four of these strains would be classified as resistant to both INH and PAS.

During the examination people were not questioned about previous treatment, but information on this point was obtained afterwards from District Medical Officers for the 32 persons found to be bacillary excretors. Six of these cases were known by the authorities to have been registered and treated for tuberculosis, but no records existed for the remaining 26 cases.

Three of the six cases who had been treated previously excreted tubercle bacilli resistant to both INH and PAS (strain Nos. 26, 27, and 31 in Table 6); of the remaining three strains one (No. 17) was resistant to INH only, and two (Nos. 16 and 30) were drug-sensitive.

X-ray examination

Clear evidence has already been presented to show that the low-dose tuberculin test very effectively divides the population of Kenya into reactors and non-reactors to tuberculin. This being so, one would expect very few people with tuberculous lung lesions to be found among non-reactors to tuberculin. It became evident, however, very early in the analysis of the survey data that an unusually large number of persons with negative tuberculin reactions showed X-ray evidence of lung pathology. It will be seen from Table 7 that altogether 169 people, or slightly less than 4%, out of 4944 examined by X-ray belong to this category. On the other hand, they constitute 30% of the total number of persons found to have X-ray evidence of lung pathology.

In other words, two relatively large groups of people, both with X-ray evidence of lung pathology, have been established—on the one hand, persons who react to tuberculin as evidence of previous infection with tubercle bacilli; on the other hand, persons who do not react to tuberculin, the majority of whom in all likelihood have not been infected with tubercle bacilli or at least do not harbour live tubercle bacilli. As the tuberculin test was, without doubt, equally reliable in both groups it would seem

TABLE 8

RESULTS OF X-RAY EXAMINATION, BY PROVINCE AND SAMPLE GROUP

Province and district	No. of persons examined	Number of persons with lung pathology [a]				
		Infiltrate			Calcified or fibrotic lesion	Pleural adhesion
		With cavity	Without cavity	Total		
Rift Valley:						
Nakuru	314	2	8	10	9	3
Elgeyo-Marakwet	306	—	4	4	7	9
Nyanza:						
Central Nyanza	274	2	11	13	10	18
North Nyanza	258	—	4	4	9	5
North Nyanza	263	—	7	7	10	5
South Nyanza	308	1	7	8	7	9
South Nyanza	308	2	6	8	12	6
South Nyanza	254	2	5	7	4	8
Central:						
Meru	289	2	10	12	7	3
Meru	317	1	10	11	12	6
Fort Hall	296	1	4	5	9	1
Fort Hall	296	6	8	14	11	5
Fort Hall	283	5	9	14	13	3
Southern:						
Kitui	326	8	17	25	4	10
Kitui	282	1	1	2	7	2
Coast:						
Kwale	286	2	2	4	—	1
Kilifi	284	4	7	11	2	4
Total	4 944	39	120	159	133	98

[a] Only persons with a reaction to Mx 1 TU of 10 mm or more are included.

reasonable to conclude that the first group represents people who have or are suspected of having tuberculous disease, and the second group consists mainly of persons with non-tuberculous lung disease. The X-ray findings for this latter group will therefore be disregarded in what follows. Further justification for excluding these findings is provided by the observation (presented in detail later in this report) that children who are household contacts of this group of people show no higher prevalence of tuberculous infection than do children from the general population.

Undoubtedly there are a certain number of people with non-tuberculous lung pathology among those suspected of tuberculosis. Likewise, some people who are in fact suffering from tuberculous lung pathology have possibly been excluded, as it is known that in rare instances tuberculous cases do not react to tuberculin. As they cannot be identified, however, they cannot be removed from the respective groups.

The result of X-ray examination by sample groups is given in Table 8. Although the prevalence of lung pathology varies from province to province this

TABLE 9
RESULTS OF X-RAY EXAMINATION, BY AGE AND SEX

Age (years)	No. examined		No. with lung pathology [a]							
			Males				Females			
	Males	Females	Infiltrate		Calcified or fibrotic lesion	Pleural adhesion	Infiltrate		Calcified or fibrotic lesion	Pleural adhesion
			With cavity	Without cavity			With cavity	Without cavity		
10-14	391	368	1	—	6	2	—	1	6	2
15-19	283	341	1	3	7	—	2	3	8	2
20-29	367	810	4	11	7	5	1	10	17	8
30-39	353	604	5	10	8	12	2	14	16	14
40-49	296	334	6	14	15	15	4	4	15	9
50-59	215	212	3	9	12	15	1	16	6	1
60 +	175	195	6	15	7	9	3	10	3	4
All ages	2 080	2 864	26	62	62	58	13	58	71	40

[a] Only persons with a reaction to Mx 1 TU of 10 mm or more are included.

difference is largely offset by a variation of similar magnitude between sample groups within provinces and it is not statistically significant.

From these data the over-all prevalence for Kenya of persons suspect for active tuberculosis, i.e., persons with X-ray evidence of pulmonary pathology (infiltrates with or without cavity) and a positive tuberculin reaction, is estimated at 3.2%. The confidence limits of this estimate are 2.2% and 4.2%.[1] In other words, assuming that the total population of Kenya over 10 years old is 3.5 million, the total number of cases of lung tuberculosis and suspects lies somewhere between 75 000 and 150 000.

Table 9 gives the results of X-ray examination by age and sex. The over-all prevalence of persons suspected of active lung tuberculosis is considerably higher among males than among females. This observation holds true throughout the entire age range, and for both sexes there is an increase in prevalence with increased age. Identical trends are seen for calcification and pleural adhesions.

DISCUSSION

A certain amount of information about the tuberculosis problem in Kenya is available from routine reporting. All newly diagnosed cases of infectious disease, including tuberculosis, must be notified weekly through the District Medical Officers from all parts of Kenya to Medical Headquarters in Nairobi. In 1957 an administrative directive came into force requiring that all cases of tuberculosis should be entered in a special tuberculosis register by the District Medical Officers. A summary of reported cases of tuberculosis in all forms for the period 1957-59 is given in Table 10. According to this information the average annual incidence for the period is 1.06 per thousand. These reported cases were established by radiological findings, while a small proportion were diagnosed exclusively by clinical examination. To what extent the differences between provinces are real or are due to varying intensity of reporting cannot be determined.

A reliable estimate of the prevalence of cases cannot be obtained from the reported annual incidence because the average survival time of newly reported cases is unknown. Towards the end of 1959, however, the total number of cases on the tuberculosis register was approximately 20 000, of whom 5000 had been lost sight of. Haynes (1951) estimated that there were approximately 23 000 proved cases of tuberculosis in the country and 32 000 suspected cases, giving a total of 55 000 proved or suspected cases. This figure was suggested

[1] The odds are 1 in 20 that the true prevalence lies outside these limits, without regard to possible diagnostic errors.

TABLE 10

NEW CASES OF TUBERCULOSIS (ALL FORMS) REPORTED IN KENYA, 1957-59

Province	Estimated population, 1958 (thousands)	Number of cases			Annual average incidence per thousand, 1957-59
		1957	1958	1959	
Rift Valley	801	545	599	643	0.74
Nyanza	2 180	1 057	1 141	737	0.45
Central	1 856	3 143	3 888	3 937	1.97
Southern	742	551	730	600	0.85
Coast	603	784	925	851	1.42
Northern	219	94	104	100	0.45
Total	6 401	6 174	7 387	6 868	1.06

with reservations mainly to give an idea of the magnitude of the problem. Haynes believed that about three-quarters of the cases were of the pulmonary type and the remainder extra-pulmonary.

Kent (1959), from the information available to him, surmised that the total number of cases of pulmonary tuberculosis in Kenya was perhaps in the vicinity of 100 000.

The purpose of the present survey was to make an assessment of the tuberculosis problem in Kenya and to this end the three common diagnostic tools were employed. The main findings can be generalized in the following terms:

2.9% $\pm$ 0.5% of the children aged 0-4 years are infected;

0.6% $\pm$ 0.14% of the population over 10 years old are important sources of infection; and

3.2% $\pm$ 0.5% over 10 years of age are suspect for tuberculosis on radiological evidence.

These epidemiological indices are estimates only and not exact values, but the fact that they are derived from the examination of a random sample permits exact computations of their precision as indicated above by the standard deviations of these statistics.

The precision of these estimates is not very high but in order to increase the precision appreciably a very considerably larger sample would have to be examined. This, however, was not found feasible.

It might perhaps be useful to discuss briefly certain features of the sample as well as some of the diagnostic problems in relation to these estimates of infection and disease.

The sample showed an unexpected difference between males and females with regard to age composition in so far as males in the age-group 20-39 years were markedly under-represented. As explained earlier, this may be accounted for by the concentration of males in large towns, on European-owned farms, in the armed forces and in the police, and by the fact that by chance none of these groups was included in the sample.

Assuming that the prevalence of tuberculosis is as high among males in these special groups as among males in the rural African population, it can be computed that the over-all estimate of the prevalence for the country would not be seriously affected if adjustment were made for the " under-representation " of males in the age-group 20-39. However, there is evidence to suggest that at least in some of the population groups where males are in the majority in Kenya—namely, in towns—the prevalence of tuberculosis is not the same as for males in rural areas but is very considerably lower. This evidence comes from the Nairobi City Council area where a tuberculosis survey was carried out in 1958-59.

The prevalence of infected people in Nairobi is somewhat higher for most ages than in rural Kenya, but the prevalence of active tuberculosis, as evidenced by X-ray and bacteriological examination, shows opposite trends. In fact the prevalence of open cases was found to be almost ten times higher in rural Kenya than in Nairobi. From these observations in rural areas and in Nairobi it would seem logical to hypothesize that people who work outside their home community and then become seriously ill tend to return to their place of origin.

The validity of prevalence estimates depends not only on the composition of the sample but also upon the reliability of the diagnostic methods used. As no independent and absolute standard for measuring the reliability of diagnostic techniques exists, the results of the three methods of examination have been correlated to determine the extent to which they directly or indirectly support one another. As a first step the results of low-dose tuberculin testing and bacteriological examination have been compared. Table 11 shows the prevalence of reactors to Mx 1 TU among children in households with open cases of tuberculosis compared with children living

TABLE 11

PREVALENCE OF INFECTED [a] CHILDREN IN HOUSEHOLDS WITH AND WITHOUT OPEN CASES [b] OF TUBERCULOSIS

Households	Age of children					
	0-4 years		5-9 years		10-14 years	
	No. tested	Infected (%)	No. tested	Infected (%)	No. tested	Infected (%)
With open cases	34	26	30	70	16	44
Without open cases	1 808	2.4	1 803	12.4	745	23.0
Total	1 842	2.9	1 833	13.3	761	23.4

[a] The criterion for infection is a reaction to Mx 1 TU of 10 mm or more.

[b] An open case of tuberculosis is here defined as a person with tubercle bacilli in the sputum demonstrated by direct microscopy of one sputum specimen.

in households where no such cases were found. The prevalence of infected children is about ten times higher in the age-group 0-4 years among contacts of open cases (26%) than it is among children who are not in household contact with such cases (2.4%). In the age-group 5-9 years the prevalence of reactors is 70% in the contact group and 12% in the non-contact group. In older children the difference in prevalence of infection between these two groups becomes less pronounced, as one would expect because the children are now increasingly exposed to sources of infection outside their own homes.

One may go one step further and consider the result of both low-dose and high-dose tuberculin testing in relation to bacteriological examination. In Table 12 the sample groups are placed together in three categories; the first is composed of five sample groups in which no open cases were found; the second category comprises seven sample groups in which one or two open cases were found; and the third category contains the remaining five sample groups in which three or more open cases were found. For each of these three categories the percentage of reactors among children to the low-dose tuberculin test is given as well as of reactors to the high-dose test among those who did not react to the low dose.

An increase in the prevalence of reactors to both Mx 1 TU and Mx 20 TU with increasing age is found in each of the three categories but, whereas the level of reactors to the low dose of tuberculin shows a clear relationship to the number of open cases found in the sample groups, no such relationship is apparent in the response to the high dose. One would definitely, however, have expected similar trends in the prevalence of reactors to the two doses if both indicated infection with *Mycobacterium tuberculosis*. In the absence of such similarity one must conclude that the two tests are measuring two different things. As ample evidence has been presented to show that the

TABLE 12

AGE-SPECIFIC PREVALENCE OF REACTORS TO MANTOUX 1 TU AND MANTOUX 20 TU [a] ACCORDING TO NUMBER OF OPEN CASES FOUND IN SAMPLE GROUP

No. of open cases found in sample group	No. of sample groups	Percentage of reactors to					
		Mx 1 TU			Mx 20 TU		
		0-4 years	5-9 years	10-14 years	0-4 years	5-9 years	10-14 years
0	5	1.9	9.4	15.8	7.0	25.5	43.1
1-2	7	3.2	12.6	24.1	7.0	19.5	35.8
3 or more	5	3.7	18.2	28.5	7.6	20.9	38.0

[a] " Reactors " to both the Mx 1 TU and the Mx 20 TU tests are defined as persons with reactions measuring 10 mm or more. For the Mx 1 TU test, this limit is justified by the shape of the size distribution, which clearly indicates that there are two kinds of reaction. For the Mx 20 TU test, this limit is not justified by the shape of the size distribution although it is believed that here also two kinds of reaction are involved—namely, buffer reactions and tuberculin reactions. No clear separation can be made between these two kinds of reaction, but with a limit as indicated above practically all buffer reactions are excluded and a rough measure of the degree of sensitivity to the high dose of tuberculin is obtained.

low-dose tuberculin test in Kenya is a good indicator of tuberculous infection, it is natural to assume that sensitivity to the high-dose test is non-specific.

There is little doubt that the very marked correlation between the risk of infection and the prevalence of human excretors of tubercle bacilli could not have been demonstrated if extra-human sources of infection played an important part in the dissemination of infection in Kenya. Further evidence to show that bovine infection, in particular, cannot be a very serious problem is provided by a study carried out in 1958 (Šula et al., 1960). Šula et al. collected enlarged cervical lymph nodes from children with symptoms of tuberculous adenitis. These glands were taken under sterile conditions in clinics and hospitals in various parts of Kenya and were sent to the Tuberculosis Research Institute in Prague, where they were carefully examined both bacteriologically and histologically. Out of 57 specimens examined, tubercle bacilli were isolated and typed in 41 instances. All these strains were found to be of the human type.

Although X-ray examination of the chest cannot be used as a sure means of distinguishing between tuberculous and non-tuberculous lung disease, it has nevertheless a generally accepted place in the routine examinations for tuberculosis. It is a convenient screening method for separating the few who are suspected of harbouring lung disease from the many who are examined. This is particularly true in mass case-finding programmes where the great majority of those examined are healthy individuals. In epidemiological inquiries such as the present survey the X-ray examination can give a direct measurement of the work-load involved in a possible case-finding programme that might be introduced in the wake of a survey, in that all the persons found to have X-ray evidence of active pulmonary disease should provisionally be considered suspect for tuberculosis and receive further examination and possibly treatment.

Because of its low specificity, however, X-ray evidence cannot provide a very reliable index of the tuberculosis problem as such. This is particularly so in a country where the general etiology of lung diseases has not been established and where consequently the proportion of lung conditions that are of tuberculous origin is unknown.

In order to study the extent to which the result of X-ray examination in the survey is relevant to the tuberculosis problem in Kenya, the X-ray findings have been correlated with the results of tuberculin tests and bacteriological examination.

To clarify the relationship between risk of infection and close contact with persons with X-ray evidence of lung disease, all the households of the sample were classified into four types (Table 13). The first type of household contains at least one person with both X-ray evidence of active lung disease and a positive tuberculin reaction; the second type contains at least one person with X-ray evidence of active lung disease but a negative tuberculin reaction; the third type contains at least one person with X-ray evidence of inactive pulmonary pathology; and the fourth type has no persons suspected of lung disease of any kind. For each of these four types of household the percentage of reactors to Mx 1 TU among children aged 0-4 and 5-9 years is given as a measure of the risk of infection.

In households of type 1 the risk of infection among children aged 0-4 is about four times higher than in type 4 households; and, even judged from children in the 5-9-year group, this difference in risk of infection in the two types of household is considerable. In marked contrast to this finding, it will be seen that the risk of infection in households of type 2 is no greater than in type 4.

Judging from these observations it would seem therefore that in Kenya it is possible, by means of X-ray examination and tuberculin testing combined, to identify one group of people with a high propor-

TABLE 13

PREVALENCE OF INFECTED CHILDREN FROM FOUR TYPES OF HOUSEHOLD

Type of household[a]	Age of children			
	0-4 years		5-9 years	
	No. tested	Infected (%)	No. tested	Infected (%)
1	168	9.5	201	22.9
2	77	0.0	65	9.2
3	370	1.9	371	13.5
4	1 227	2.4	1 196	11.9

[a] *Type 1:* Household with at least one person who is suspected of having lung tuberculosis as indicated by a positive tuberculin reaction and X-ray evidence of active tuberculosis.

Type 2: Household with at least one person who is suspected of having non-tuberculous lung disease as evidenced by a negative tuberculin reaction and X-ray signs of lung pathology.

Type 3: Household with at least one person with X-ray evidence of inactive lung disease (calcified or fibrotic lesions or pleural adhesions).

Type 4: Household with no person suspected of lung disease of any kind.

If a household could be classified into more than one type it was allocated to the type with the lowest number.

tion of infectious cases of tuberculosis (those with X-ray evidence of active lung disease and a positive reaction to tuberculin) and another group with few, if any, open cases of tuberculosis (those with X-ray evidence of active lung disease and a negative tuberculin test). Both these groups undoubtedly present a problem in public health—the former is very relevant to the tuberculosis problem in Kenya, whereas the latter group consists, perhaps predominantly, of people with non-tuberculous lung conditions who nevertheless require follow-up examination and possibly treatment of some kind.

Finally, the risk of infection in households of type 3 is no greater than in households of type 4, as indeed it should not be if the interpretation of the X-ray findings is correct.

The X-ray findings have also been analysed in relation to the tuberculin allergy level. Table 14 shows the prevalence of persons with X-ray evidence of active lung disease according to the size of tuberculin reaction for three age-groups.

With increasing size of the tuberculin reaction there is a very marked increase in the prevalence of lung disease in the age-groups 10-19 and 20-39 years, where the prevalence is about five times greater for persons with reactions of 25 mm or more than for those with reactions of 10-14 mm. This would seem further to support the assumption that a substantial part of the active lung disease diagnosed radiologically among the reactors to tuberculin is of tuberculous origin—at least in these age-groups.

In the group aged 40 and over there is a less pronounced increase in prevalence of active lung disease with increasing reaction size, and the prevalence level is consistently higher than in the younger age-groups, even among non-reactors to tuberculin. Lung pathology among the non-reactors is believed to be mainly non-specific (not tuberculous in origin) but it is inconceivable that a similar proportion of non-specific lung pathology should not exist among the reactors to tuberculin. It follows that a relatively large proportion of the lung pathology among older people diagnosed radiologically is of non-tuberculous origin.

TABLE 14

PREVALENCE [a] OF PERSONS WITH X-RAY EVIDENCE OF ACTIVE LUNG DISEASE ACCORDING TO SIZE OF TUBERCULIN REACTION

Age (years)	Size of Mx 1 TU reaction (mm)				
	0-9	10-14	15-19	20-24	25+
10-19	0.7	1.1	2.3	3.5	6.1
20-39	2.3	2.3	4.4	5.9	11.2
40 and over	10.7	9.1	9.3	11.2	15.9

[a] The prevalence is expressed as the percentage of persons who have X-ray evidence of active lung disease among the total number of persons in the indicated age-group and with the indicated size of tuberculin reaction.

In summarizing these observations, it may be said that in Kenya a substantial part of the active lung disease diagnosed radiologically among reactors to tuberculin under 40 years of age is tuberculosis, but that tuberculosis contributes less and less to the total prevalence of active lung disease (diagnosed by X-ray) with increasing age. Whether this is due mainly to more over-reading of X-rays from older than from younger individuals or has real biological significance cannot be ascertained from these data.

Of the 32 cases of tuberculosis that were diagnosed on bacteriological examination during the survey all had a reaction to Mx 1 TU of 12 mm induration or more, with a mean size of reaction for the group of 20.8 mm. Four out of these 32 cases (12.5%) were not classified by the X-ray reader as having lung pathology. Of the remaining cases, 21 had cavity and all 28 cases had very extensive lung lesions, 17 with evidence of bilateral processes. At a second reading of the four pairs of photofluorograms that were declared negative at the first reading, another reader, who had been informed that the persons in question were bacillary excretors, saw evidence of pulmonary pathology in all four instances although he declared that two of the four pairs of X-ray pictures were not very clear. As mentioned earlier, the initial finding by direct microscopy of a sputum specimen in the field was later confirmed by culture, and the isolated strains were classified as *Mycobacterium tuberculosis*.

Examination by direct microscopy of a sputum specimen is a less efficient method than culture for demonstration of tubercle bacilli and it might be of some interest, therefore, to know how many more excretors one might have found had all the sputum specimens been examined by culture. Partly from the examination by culture of several hundred sputum samples collected during the survey, and partly from information supplied by the laboratory, it is estimated that approximately twice the number of persons found to excrete bacilli by direct microscopy would have been found if systematic examination by culture had been done throughout the survey.

Of the 32 strains of tubercle bacilli isolated during the survey, six were resistant to INH and eight to PAS, but four of these were resistant both to INH and PAS. Only one strain showed resistance to streptomycin. It is known that three of the four strains resistant to both INH and PAS came from people who had been treated previously, as did one of the two strains resistant to INH only. Seven strains isolated from people with no record of treatment showed drug resistance—one to both INH and PAS, four to PAS only, one to INH only, and one to streptomycin.

As the 32 open cases constitute a random sample of all open cases of tuberculosis in Kenya it would be tempting to deduce from these figures something about the prevalence of primary drug resistance in the country. However, great caution should be exercised on this point since the absence of any record of previous anti-tuberculosis treatment by no means excludes the possibility that treatment in some form has in fact been given.

One of the important purposes of a prevalence survey of the kind described here is to attempt to identify high-risk groups, i.e., groups which in a case-finding programme would yield considerably more cases for a given number of persons than would be found in the general population as a whole. As no practical clues to selective case-finding exist in Kenya in the form of high-risk occupations or other social factors, the practical approach to this problem must be epidemiological. Therefore all households in which at least one infected child under 10 years of age was living were specially studied in the analysis; and it was found that 53% of all infectious cases, 38% of all cavity cases, and 26% of all persons with X-ray evidence of active lung disease belonged to these households. These families consisted of 192 households out of a total of 1652, slightly less than 12%. In other words, by examining a relatively small proportion of the population, a very considerable number of the total existing cases of tuberculosis would be diagnosed. This could be done, for instance, in conjunction with a BCG vaccination campaign, where all children under 10 were tuberculin tested and case-finding was done in households with infected children. Whether selective case-finding of this kind could bring about a saving in time and cost compared with indiscriminate case-finding and still prove reasonably effective would have to be studied under field conditions.

CONCLUSIONS

One aspect of the findings that might have some bearing on future control activities in Kenya is the remarkable co-operation obtained from the population throughout the survey. To what extent such co-operation would be obtained in a prolonged control programme involving chemotherapy is, of course, uncertain. Undoubtedly, however, it is a good omen for the success of an intensive effort of short duration such as a BCG vaccination campaign.

With an estimated total African population of about six million in Kenya (3.5 million aged 10 or more) there are approximately 110 000 cases and suspected cases of pulmonary tuberculosis among adults and older children. Of these, nearly 40% are sources of infection (likely to be positive on examination by culture). In addition there is reason to believe that a disease problem exists in children under 10. In view of the low resistance generally ascribed to small children it is of particular interest to note that about 3% in the age-group 0-4 years are infected, or altogether about 38 000 children in the country. No information is available from the survey about tuberculous disease in the age-group 5-9 years, but it is known that approximately 13% are infected.

The problem, however, is not adequately measured in terms of infection and disease alone. The situation is complicated by the fact that tuberculosis is of high endemicity in a rural population that is scattered over vast areas. This would certainly tend to make any control effort relatively expensive.

In judging the over-all situation it would be unwise to assume that the present high rate of dissemination of infection will not be maintained undiminished over a period of years unless large-scale measures for control are instituted. Undoubtedly a mass BCG vaccination campaign could form a relatively inexpensive and useful part of any intensified tuberculosis control programme that might be planned in Kenya today.

RÉSUMÉ

La tuberculose est depuis plusieurs années l'un des principaux problèmes de santé publique au Kenya. Cherchant à évaluer la fréquence globale de la tuberculose pulmonaire et de l'infection, le gouvernement a organisé avec l'aide de l'OMS une enquête sur un échantillon aléatoire de la population (omettant à dessein la province

nord du pays, peu peuplée, et la ville de Nairobi, objet d'une enquête particulière). On choisit environ 8700 personnes, sur une population de 6 millions, qui furent soumises à des tests tuberculiniques, et à des examens radiologique et bactériologique.

Le test de Mantoux (Mx 1 UT) (PPD du lot RT23, correspondant à 3 UT de la Préparation internationale de référence PPD-S) fut appliqué à tous les participants, sauf aux nourrissons de moins d'un mois. Des crachats recueillis auprès de chaque personne âgée de 10 ans au moins soumise à l'enquête furent examinés au microscope sur place. Un second échantillon prélevé sur les sujets positifs à ce premier examen fut envoyé au laboratoire central de Nairobi, pour culture. Des radiographies des sujets de 10 ans et plus furent envoyées à l'OMS pour lecture, les ombres étant classées selon qu'elles indiquaient une infiltration avec ou sans cavité, des lésions calcifiées ou fibreuses, et des adhérences pleurales.

Un excellent esprit de collaboration animait la population: 99% des sujets désignés pour participer à l'enquête se présentèrent aux trois examens.

Au Kenya, de fortes réactions à Mx 1 UT sont un critère d'infection. La fréquence globale passait de 3% dans le groupe d'âge de 0-4 ans, à 13% de 5-9 ans, et de 40% à 20 ans. Dans les groupes d'âge supérieurs, la fréquence était, de façon constante, plus élevée chez les hommes (77%) que chez les femmes (56%). Sur les 5000 personnes dont les crachats furent examinés, 32 paraissaient être des cas de tuberculose infectieuse. L'examen microscopique direct montrait des bacilles acido-résistants; la culture confirma qu'il s'agissait de *Myco. tuberculosis*. La fréquence des cas infectieux ainsi établie (0,6%) aurait été au moins double, si des examens par culture avaient été pratiqués au cours de toute l'enquête.

Dans les maisons où vivaient des cas infectieux, 26% des enfants de 0-4 ans avaient de fortes réactions au Mx 1 UT, contre 2,4% dans les autres ménages. Dans le groupe d'âge de 5-9 ans, les deux pourcentages étaient 70 et 12, dans le groupe de 10-14 ans, 44 et 23, ce qui montre l'importance croissante avec l'âge de l'infection extra-domiciliaire.

Parmi les quelque 5000 personnes radiographiées, 246 présentaient des infiltrations, mais 159 seulement de ces dernières avaient une réaction positive au Mx 1 UT. Parmi les contacts domestiques de ces 159, 9,5% des enfants de 0-4 ans étaient tuberculino-positifs; ce chiffre était de 2,4% dans les ménages où aucune autre personne n'était suspecte de tuberculose; dans le groupe de 5-9 ans, ces pourcentages étaient de 23 et 12. Le contact dans les ménages avec des personnes présentant des infiltrations, mais tuberculino-négatives, n'a pas élevé la proportion des enfants infectés. Seules les 159 personnes (3,2% du total examiné) qui avaient des infiltrations et étaient tuberculino-positives ont été considérées comme ayant très probablement une tuberculose.

En conclusion, sur environ 3,5 millions d'Africains au Kenya, âgés de 10 ans et plus, on compte environ 110 000 cas de tuberculose pulmonaire, certains ou présumés. Environ 40% de ces cas sont probablement positifs à la culture, et de ce fait, une source d'infection.

REFERENCES

East African Statistical Department, *East African population census, 1948*, Nairobi

Edwards, L. B. & Palmer, C. E. (1953) *Lancet*, **1**, 53

Guld, J., Bentzon, M. W., Bleiker, M. A., Griep, W. A., Magnusson, M. & Waaler, H. (1958) *Bull. Wld Hlth Org.*, **19**, 845

Haynes, W. S. (1951) *Tuberculosis in Kenya*, Nairobi, Government Printer

Kent, P. W. (1959) *E. Afr. med. J.*, **36**, 649

Nyboe, J. (1960) *Bull. Wld Hlth Org.*, **22**, 5

Pepys, J., Mitchison, D. A. & Kinsley, B. J. (1960) *Tubercle (Lond.)*, **41**, 32

Šula, L., Stott, H., Kubín, M. & Kiaer, J. (1960) *Bull. Wld Hlth Org.*, **23**, 613

Yates, F. (1953) *Sampling methods for censuses and surveys*, 2nd ed., London

APPENDIX TABLE 1
POPULATION SELECTED FOR EXAMINATION, BY AGE AND SEX

Age (years)	Males	Females	Both sexes
0- 4	921	978	1 899
5- 9	942	892	1 834
10-14	394	368	762
15-19	285	341	626
20-29	367	810	1 177
30-39	354	606	960
40-49	296	334	630
50-59	216	213	429
60 +	177	199	376
All ages	3 952	4 741	8 693

APPENDIX TABLE 2
SAMPLE GROUPS SELECTED AND EXAMINATIONS DONE

Province and district	Sample group number	No. in sample group		No. tuberculin tested		No. radiologically examined [a]	No. bacteriologically examined [a]
		All ages	10 and over [a]	Mx 1 TU	Mx 20 TU		
Rift Valley:							
Nakuru	1	502	319	500	149	314	319
Elgeyo-Marakwet	8	505	306	503	169	306	306
Nyanza:							
Central Nyanza	2	509	275	503	72	274	275
North Nyanza	3	514	258	509	189	258	258
North Nyanza	4	513	266	508	173	263	266
South Nyanza	5	527	309	524	139	308	309
South Nyanza	6	510	308	508	145	308	308
South Nyanza	7	503	254	501	193	254	254
Central:							
Meru	9	507	289	502	158	289	289
Meru	10	508	317	503	171	317	317
Fort Hall	11	518	296	509	164	296	296
Fort Hall	12	507	298	504	150	296	297
Fort Hall	13	505	284	502	339	283	283
Southern:							
Kitui	14	514	327	508	209	326	326
Kitui	15	507	282	503	81	282	282
Coast:							
Kwale	16	516	286	510	125	286	286
Kilifi	17	528	286	524	157	284	286
Total		8 693	4 960	8 621	2 783	4 944	4 957

[a] Only those who were 10 years old or more were eligible for bacteriological and X-ray examinations.

APPENDIX TABLE 3

FREQUENCY DISTRIBUTION BY SIZE OF REACTIONS TO MANTOUX 1 TU TEST ACCORDING TO AGE AND SEX

Age (years)	Size of reaction (induration in mm)																									Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 +	
MALES																												
0-4	554	121	138	33	8	6	4	—	1	—	1	—	—	—	2	2	2	1	—	4	5	—	4	1	—	—	2	889
5-9	424	102	161	57	40	10	11	6	7	1	5	5	4	8	4	7	9	14	12	4	14	7	8	9	2	4	7	942
10-14	123	24	57	28	22	13	8	9	2	5	2	3	6	8	4	4	10	7	8	2	17	6	8	6	6	1	5	394
15-19	67	12	43	18	15	12	7	8	5	4	4	6	3	4	9	8	7	7	8	6	7	8	6	2	2	3	2	283
20-29	69	3	26	13	17	11	5	7	5	2	11	5	9	16	9	11	19	18	20	14	17	12	14	9	5	8	8	363
30-39	25	2	10	14	9	7	2	4	7	2	18	13	20	18	16	16	21	34	16	18	21	15	15	12	6	2	10	353
40 +	65	5	24	19	15	16	18	17	5	10	25	21	29	41	35	31	52	56	36	18	50	25	20	17	10	10	16	686
All ages	1 327	269	459	182	126	75	55	51	32	24	66	53	71	95	79	79	120	137	100	66	131	73	75	56	31	28	50	3 910
FEMALES																												
0-4	635	113	124	34	12	—	5	1	—	—	—	—	1	—	3	5	3	3	4	1	3	1	1	—	2	1	1	953
5-9	448	88	136	53	16	17	6	3	1	2	4	3	4	4	6	5	8	10	13	8	9	14	10	6	6	3	8	891
10-14	134	22	51	39	18	13	10	3	—	2	2	2	1	3	4	5	2	10	5	3	11	9	6	2	3	1	6	367
15-19	91	18	41	29	11	11	1	3	2	2	6	6	7	6	6	5	12	14	6	2	17	9	7	6	6	7	8	339
20-29	181	30	81	45	23	19	29	16	5	7	13	15	20	18	18	12	25	39	21	19	53	30	38	15	13	5	20	810
30-39	112	18	38	35	20	16	11	7	6	6	13	20	17	13	17	23	31	35	24	18	36	20	20	14	8	10	17	605
40 +	114	12	45	36	37	43	24	16	14	8	13	21	25	16	17	23	27	36	24	21	57	27	24	20	9	15	22	746
All ages	1 715	301	516	271	137	119	86	49	28	27	51	67	75	60	71	78	108	147	97	72	186	110	106	63	47	42	82	4 711

APPENDIX TABLE 4

FREQUENCY DISTRIBUTION BY SIZE OF REACTION TO MANTOUX 20 TU TEST, ACCORDING TO AGE, FOR PERSONS WITH REACTIONS OF LESS THAN 10 mm TO MANTOUX 1 TU TEST

Age (years)	Size of reaction (induration in mm)																									Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 +	
0-4	425	101	118	45	24	15	10	12	13	7	15	6	9	10	6	5	3	2	2	1	1	—	—	—	—	—	—	830
5-9	239	67	97	55	42	27	25	16	24	14	24	16	21	23	15	15	16	9	15	2	9	—	—	2	—	—	—	773
10-14	63	11	25	20	15	15	23	9	6	6	21	13	19	12	7	11	14	5	9	4	3	—	—	1	1	—	—	313
15-19	23	5	12	9	4	8	10	6	5	5	13	11	16	11	7	9	8	10	3	1	3	2	—	3	1	1	—	186
20-29	37	3	8	18	7	7	10	8	7	9	12	12	17	8	11	18	13	8	9	6	9	9	6	3	2	2	3	262
30-39	23	2	8	5	2	2	5	2	2	—	5	6	9	7	10	13	12	7	12	7	9	3	10	2	1	3	2	169
40 +	23	4	16	4	4	4	3	5	9	7	3	6	7	6	9	16	16	20	11	18	15	16	9	3	7	4	5	250
All ages	833	193	284	156	98	78	86	58	66	48	93	70	98	77	65	87	82	61	61	39	49	30	25	14	12	10	10	2 783