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An Investigation of Household Contacts of Open Cases of Pulmonary Tuberculosis amongst the Kikuyu in Kiambu, Kenya *

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In economically under-developed countries in Africa the housing conditions, even in areas of low population density, can generally be described as overcrowded: also, they are usually poorly lighted and ill-ventilated. Malnutrition, especially protein lack, is quite common. It was considered important to assess the risk experienced under these circumstances by household contacts of sputum-positive tuberculosis patients.

It was found that household contacts, especially of the younger age-groups, were infected five to ten times more frequently and experienced a prevalence of active pulmonary tuberculosis five to ten times greater than did the general population from which they derived.

Examination of household contacts of tuberculosis patients as defined in this study revealed a further 15 % of sputum-positive tuberculosis cases—a finding that underlines the importance of carrying out such a procedure as a routine measure.

INTRODUCTION

At the beginning of 1959 a trial amongst Africans of the effect of prophylactic isoniazid on household contacts of open cases of pulmonary tuberculosis was started in the Kiambu area of Kenya. For the purpose of this trial an index case was defined as the first person found within a household to excrete in the sputum tubercle bacilli identified by microscopy as well as by culture. Contacts were defined as persons living and sleeping regularly in the same house or group of houses (household) as the index case. Persons who were sleeping in the household on an average of less than two nights a week were excluded from the definition.

Seventy-four index cases with their 401 contacts were admitted to the trial in the first year. This paper is concerned only with the results of the examination of these persons undertaken at the time of admission to the trial. It does not concern any follow-up, which will be the subject of a separate publication. Its object is to determine the prevalence of infection and disease amongst the contacts, to compare this with the prevalence amongst the general population in the same district, and to find out whether there is any evidence of primary drug-resistance either amongst the index cases or amongst their sputum-positive contacts.

The routine examinations were the same for both index cases and contacts—namely, a tuberculin test, an X-ray examination of the chest and a bacteriological examination of the sputum.

METHODS

Tuberculin test

The tuberculin test was done by the Mantoux method, using one tuberculin unit (TU) of PPD, batch RT 23,[1] in a dose of 0.1 ml given in the mid-dorsal region of the left forearm. All tuberculin tests were read after three to four days by one of two readers who showed a high correlation in their findings when dual and independent readings were carried out between them.

The result of the test was recorded by measuring the transverse diameter of the induration in milli-

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[1] One unit of RT 23 is defined as 0.02 μg of the dry substance. This when stabilized with Tween 80 corresponds fairly well to 3 TU of PPD-S, 5 TU of RT 19-20-21, and 7 TU of RT 22 (Guld et al., 1958).

metres. All persons having reactions with an induration of 8 mm or over (tuberculin reactors) to 1 TU were considered to have been previously infected specifically with the tubercle bacillus. Tests were carried out and the results read on 398 of the 401 contacts.

X-ray examination

Two 70-mm films were taken of each person, the X-ray tube and camera being raised about 4 cm between each exposure. The films were read by two readers independently, and in the event of disagreement in their readings a final decision was reached by both readers sitting together as a panel. All films showing doubtful lesions were included in the final analysis as normal.

An active tuberculous lesion was defined as one that showed opacities of an infiltrative type in the postero-anterior view of the chest X-ray film of a tuberculin reactor. This infiltration might be associated with evidence of cavitation, atelectasis, pleural involvement or mediastinal glandular enlargement. An inactive lesion was defined as one which showed the appearances of calcification and/or fibrosis without any evidence of fresh infiltration or cavitation. Cavitation was recorded when it was possible to identify the demarcation of circular translucency against the lung surroundings. In all, 397 of the 401 contacts were X-rayed.

Examination of sputum

One sputum sample was collected under close supervision from each person and every effort was made to ensure that it contained secretion from the bronchi. A laryngeal swab was taken from children who were unable to follow the instructions to cough vigorously. All specimens were kept under refrigerated conditions until cultured within 24 to 72 hours of collection. The initial bacteriological investigations consisted of microscopic examination and culture of the sputum and drug-sensitivity and catalase tests on each culture which grew acid-fast bacilli. A specimen was collected from each of the 401 contacts.

Microscopic examination was undertaken by the same two technicians using a standard technique. All smears were stained by the Ziehl-Neelsen method, using picric acid as counterstain. Half of the slide on which a uniform smear had been made was examined along two horizontal and two vertical lines and the acid-fast bacilli in each field of focus were counted. Positive slides were graded as follows: if 100 bacilli or more were counted whilst traversing the four lines, the result was recorded as heavily positive (++); if less than 100 bacilli were counted, it was recorded as positive (+).

Each specimen, after homogenization with 4% sodium hydroxide, was plated on two tubes of Löwenstein-Jensen's medium and incubated at 37°C. The tubes were inspected at three, five and eight weeks. At the first of these inspections at which growth was observed, the growth was graded as either heavily positive (++) or positive (+). A heavily positive grading was accorded if the total number of colonies in both tubes combined was equal to or exceeded 100; a positive grading was accorded when this figure was less than 100.

Tests of sensitivity to isoniazid, *p*-aminosalicylic acid (PAS) and streptomycin were performed on all positive cultures by a method similar to that described by Mitchison & Selkon (1957). The drug concentrations for the test strain and for H37Rv were as follows:

	Drug concentration in μg/ml
Isoniazid	
Test strain	0.2 1 5 50
H37Rv	0.05 0.1 0.2 1
PAS	
Test strain	1 2 4 16 64
H37Rv	0.12 0.25 0.5 1 2
Streptomycin	
Test strain	8 16 32 64 1024
H37Rv	2 4 8 16 32

Resistance to isoniazid was defined as growth occurring on 1 μg/ml or a higher concentration, or growth on 0.2 μg/ml provided that a repeat test on the same strain yielded growth on 0.2 μg/ml or a higher concentration. Organisms were considered resistant to PAS if a resistance ratio of 8 or more was found, and resistant to streptomycin if a resistance ratio of 8 or more was obtained, or a resistance ratio of 4 followed by one of 4 or more in a repeat test. The resistance ratio was defined as the ratio of the lowest concentration of the drug inhibiting growth—minimal inhibitory concentration (MIC)—of the test strain to the corresponding figure for the standard strain (H37Rv). In reading sensitivity tests growth was defined as the appearance of 20 colonies or more.

RESULTS

Examination o index cases

The 74 index cases of pulmonary tuberculosis were drawn from two different sources. Twenty-five

derived from amongst patients attending the Kiambu tuberculosis clinics, and the remaining 49 were found during a mass case-finding survey of the population in a section of the Kiambu district. All the patients were questioned very carefully as to whether they had had previous treatment for tuberculosis and if so as to the treatment they had received. Twenty-seven patients admitted to having had previous chemotherapy; 15 of these were taken over from clinics and 12 were detected in the mass survey. The remaining 47 patients denied that they had ever had antituberculous drug therapy.

Table 1 shows the percentage distribution by age and sex of the index cases, and Table 2 the condition of the cases according to radiological and bacteriological assessment. Of the 74 index cases, 53% had cavitated disease on X-ray examination and 62% had heavily positive sputum results (smear++ and culture ++). The radiological findings were closely mirrored by the bacteriological findings, which showed that heavily positive sputum results were obtained from 79% of the cavitated cases, but from only 43% of the non-cavitated cases.

Fig. 1 shows the distribution of the tuberculin reactions amongst the index cases.

The tuberculin test was done in all 74 index cases, and the result was read and recorded in 73 of them. It will be noted that, with one exception, who showed no reaction, all patients showed an induration of over 10 mm. The non-reactor was a female in the last month of pregnancy. The mean size of the induration amongst the tuberculin reactors was 18.2 mm.

TABLE 1

PERCENTAGE DISTRIBUTION BY AGE AND SEX OF 74 INDEX CASES AND 401 CONTACTS[a]

Age-group (years)	Index cases (%)			Contacts (%)		
	Male	Female	Both sexes	Male	Female	Both sexes
0-5	—	—	—	24	18	21
6-9	17	11	13	23	22	22
10-14	17	25	22	22	17	19
15-19	23	5	12	6	9	8
20-29	10	11	11	6	9	7
30-39	10	25	19	6	12	10
⩾ 40	23	23	23	13	13	13
All ages	100	100	100	100	100	100

[a] See Appendix Tables 1 and 2 for further details.

Examination of contacts

Immediately following the detection of the index case the household was visited by a health visitor. Subsequent repeat visits were frequently made to all the households and these visits confirmed that all contacts had been included at the initial visit. Each of the 401 such persons living in the household was registered and an appointment made for a Mantoux test, an X-ray of the chest, and a bacteriological examination of the sputum. These examinations were performed at the latest within a month of the detection of the index case.

In all, 401 contacts were examined, an average of 5.4 to each index case. The distribution of the contacts by age and sex is shown in Table 1. It will be observed that 62% of all contacts were children of 14 years and under. The preponderance of females over males between the ages of 15 and 39 years is due to the number of males in this age-group who were away from home, working elsewhere.

The tuberculin reactor rate according to age and sex amongst the contact population is given in Table 3.

The gradual rise of the reactor rate, for each sex, with increase in age can be observed; but most remarkable is the significant difference [1] in the rate between the sexes in children of under six years. In each of the other age-groups there was no significant difference in the tuberculin reactor rate between the sexes. Fig. 1 shows the distribution of the size of tuberculin reactions according to sex, and demonstrates a clear division between infected and uninfected persons, with a very low percentage of persons showing small intermediate reactions.

There were 39 (10%) contacts who were considered to show active lesions in their X-ray films; 33 of these lesions had been seen by both of the readers independently, and the remaining six were seen by one or other reader and were considered by the panel to show active lesions. There were 16 (4%) other contacts whose films were reported by one of the readers at the initial reading to show radiological lesions; 12 (3%) of these were considered by

[1] The χ^2 test is used throughout this paper when comparing proportions, and the result of the test is given in the following terms: not significant ($P>0.05$); significant ($0.05 \geqslant P > 0.001$); highly significant ($0.001 \geqslant P$).

TABLE 2

RADIOLOGICAL AND BACTERIOLOGICAL CONDITION OF 74 INDEX CASES

Radiological condition	Bacteriological condition				Total
	Smear ++ Culture ++	Smear ++ Culture +	Smear + Culture ++	Smear + Culture +	
Cavitation and bilateral disease	20	1	3	1	25
Cavitation and unilateral disease	11	1	2	—	14
No cavitation and bilateral disease	9	—	2	1	12
No cavitation and unilateral disease	6	2	4	11	23
Total . . .	46	4	11	13	74

FIG. 1

DISTRIBUTION OF SIZE OF REACTIONS TO MANTOUX 1 TU AMONGST INDEX CASES AND CONTACTS, ACCORDING TO SEX

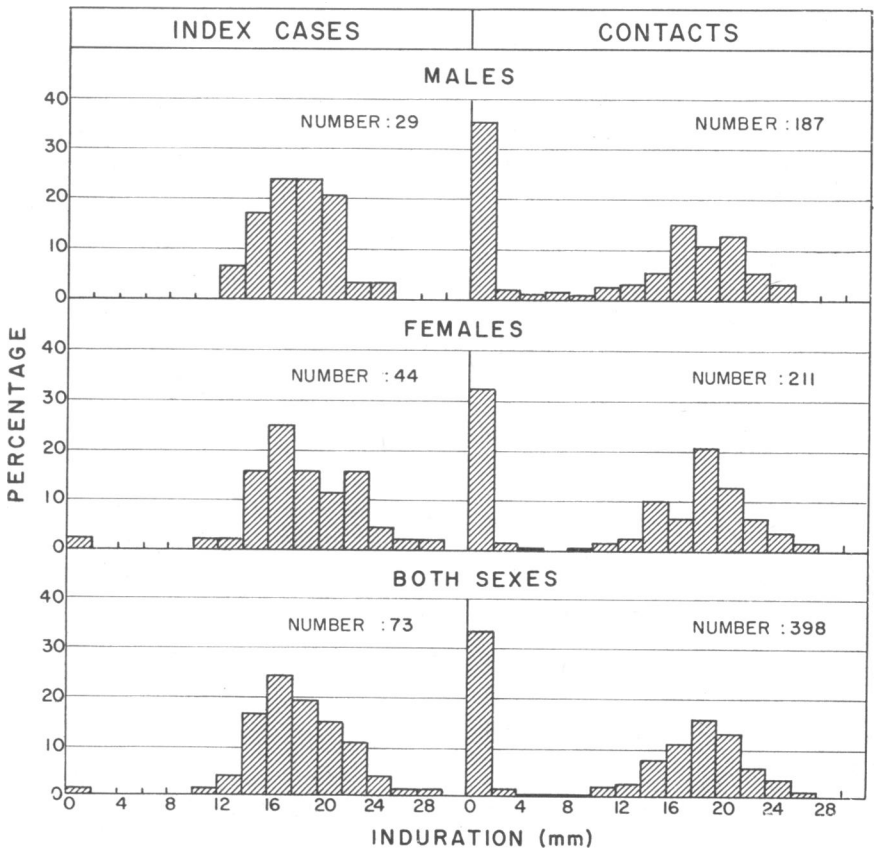


TABLE 3

TUBERCULIN REACTOR RATE (⩾ 8 mm) AMONGST 401 CONTACTS, ACCORDING TO AGE AND SEX [a]

Age-group (years)	Tuberculin reactor rate (%) [b]		
	Male	Female	Both sexes
0-5	16	46	30
6-9	64	57	60
10-14	78	56	68
15-19	(50)	(80)	69
20-29	(90)	(79)	83
30-39	(92)	81	84
⩾ 40	76	89	83
All ages	60	66	63

[a] See Appendix Table 3 for further details.
[b] The parentheses denote that the total number of observations on which the calculations were based was less than 25.

TABLE 4

PREVALENCE OF ACTIVE LESIONS AMONGST CONTACTS, ACCORDING TO AGE AND SEX [a]

Age-group (years)	Prevalence of active lesions (%) [b]		
	Male	Female	Both sexes
0-5	5	22	13
6-9	16	15	16
10-14	12	14	13
15-19	(0)	(0)	0
20-29	(0)	(5)	4
30-39	(17)	4	8
⩾ 40	0	4	2
All ages	9	11	10

[a] See Appendix Table 4 for further details.
[b] The parentheses denote that the total number of observations on which the calculations were based was less than 25.

the panel to be within the limits of normality and four (1%) were considered to show doubtful lesions (for the purpose of the analysis these four have been regarded as showing no lesion). Twelve contacts (3%) showed radiological evidence of calcification only. The 39 lesions were described as pure infiltrates on 21 occasions, infiltrates with enlarged hilar or paratracheal glands on 11, enlarged hilar glands only on five and infiltrates with cavitation on two occasions.

The prevalence of active lesions amongst the contacts according to age and sex is shown in Table 4.

By far the greatest preponderance of radiological abnormalities was found amongst children under 15 years of age. As in the case of tuberculin reactors, the females under six years of age showed a higher rate of active lesions than did the males; this difference between the rates was significant. Of the 24 tuberculin reactors under six years 10 (42%) showed active lesions.

Eleven (3%) of the 401 contacts had tubercle bacilli found in their sputum by culture and four of these were in addition smear-positive. Two of these 11 contacts were reported to show no demonstrable lesion on the 70-mm film and re-examination of their films did not bring to light any definite lesion. A further contact, who had no X-ray lesion and who has not been regarded as a sputum-positive case, was reported to have 12 acid-fast bacilli seen by microscopy, but a negative culture.

Table 5 shows the prevalence of sputum-positive cases according to age and sex amongst the contacts; it will be observed that sputum-positive cases occurred with more frequency amongst children of

TABLE 5

PREVALENCE OF SPUTUM-POSITIVE PERSONS AMONGST CONTACTS, ACCORDING TO AGE AND SEX [a]

Age-group (years)	Prevalence of sputum-positive cases (%) [b]		
	Male	Female	Both sexes
0-5	0	3	1
6-9	0	9	4
10-14	7	3	5
15-19	(0)	(0)	0
20-29	(0)	(0)	0
30-39	(0)	0	0
⩾ 40	0	7	4
All ages	2	4	3

[a] See Appendix Table 5 for further details.
[b] The parentheses denote that the total number of observations on which the calculations were based was less than 25.

TABLE 6

TUBERCULIN REACTOR RATE (⩾ 8 mm) AND PREVALENCE OF ACTIVE LESIONS AMONGST CONTACTS, ACCORDING TO PRESENCE OR ABSENCE OF CAVITATION IN THE INDEX CASE [a]

Radiological state of index case	Contacts					
	Tuberculin reactor rates (%)			Prevalence of active lesions (%)		
	0-9 years	10-19 years	⩾ 20 years	0-9 years	10-19 years	⩾ 20 years
Cavitated	61	79	88	19	9	6
Non-cavitated	31	57	79	9	9	3

[a] See Appendix Table 6 for actual numbers.

under 15 years of age. The number of such cases amongst the contacts was too small to permit any close comparison between the sexes, but it should be noted that the only sputum-positive case detected amongst the children under six years of age was a female, as were all the four cases found in the 6-9-year age-group.

There is no apparent simple explanation to be found in the home conditions of Kikuyu children to account for a greater amount of infection and disease amongst females than amongst males in the lowest age-group. The upbringing of Kikuyu children and infants of about five years of age or under is similar in all respects for the two sexes, although after about the age of six there is a divergence in their activities and outlook. The difference might be explained if it could be shown that the female children had been in contact with index cases more infectious than had the male children: an analysis of the 37 female and 43 male tuberculin-tested contacts of under six years of age shows a tendency in this direction. This difference between the sexes in respect of reactor rates in children under six years was not observed in the sample survey undertaken in the Kiambu district at about the same time as this study. (In the sample survey children under six years of age were not examined by X-ray, and therefore it is not possible to make any comparison between the prevalences of radiologically active lesions in this age-group.)

Contact infection and disease according to severity of disease and sex of index case

As might have been expected, the severity of the disease of the index case, as indicated by the radiological and bacteriological findings, had an influence on the reactor rate amongst the household contacts.

Table 6 shows that in contacts of under 20 years of age the reactor rate was highly significantly greater in the contacts of cavitated than in those of non-cavitated cases. The same tendency was observed when active tuberculous lesions in the contacts were considered. The prevalence of active lesions in children under 10 years of age who were in contact with a case showing X-ray evidence of cavitation was higher than in those in contact with a case without evidence of cavitation. This difference was not significant. Above the age of nine years there was little apparent difference in the prevalence of active lesions amongst contacts in the two groups.

The contacts, all ages combined, of index cases who had a heavily positive sputum on both smear and culture had a highly significantly greater reactor rate and a significantly greater proportion of active lesions than had the contacts of index cases whose sputum was not heavily positive on both smear and culture.

The differences, as shown in Table 7, were more marked in children under 10 years of age. These differences were not due to a preponderance of 0-5-year female contacts among the contacts of the heavily sputum-positive index cases; and they were uninfluenced by any history of previous treatment amongst the index cases.

The sex of the index case influenced the risk of infection amongst the household contacts. Table 8 shows that the child contacts of female index cases had a higher reactor rate than had those of male index cases.

The difference was significant for all contact children under 10 years of age, and the trend could be observed for each of the two age-groups analysed

TABLE 7

TUBERCULIN REACTOR RATE (⩾ 8 mm) AND PREVALENCE OF ACTIVE LESIONS AMONGST CONTACTS, ACCORDING TO DEGREE OF POSITIVITY OF SPUTUM OF THE INDEX CASE [a]

Bacteriological state of index case	Contacts					
	Tuberculin reactor rate (%)			Prevalence of active lesions (%)		
	0-9 years	10-19 years	⩾ 20 years	0-9 years	10-19 years	⩾ 20 years
Smear ++ and culture ++	67	78	90	21	13	5
All others	27	57	75	8	6	4

[a] See Appendix Table 7 for actual numbers.

in the table. The ratio of males to females in the 0-5-year age-group was higher amongst contacts of male index cases than amongst contacts of female index cases. This might have explained the observed difference in the reactor rates, because as previously noted the reactor rate in this age-group is considerably higher in females than in males. However, even when an adjustment is made for the difference in sex ratio, the rating of significance is unaffected

Infection and disease amongst contacts as compared with the general population

Early in 1959 a survey to determine the over-all prevalence of pulmonary tuberculosis was undertaken on a 1% random sample of the general African population in the Kiambu district (WHO/UNICEF-Assisted Tuberculosis Project, Nairobi, 1960). It has therefore been possible to compare the prevalences of infection and of active tuberculous lesions amongst contacts with those found to be generally existent in the district.

TABLE 8

TUBERCULIN REACTOR RATE (⩾ 8 mm) AMONGST CHILD CONTACTS IN RELATION TO MALE AND FEMALE INDEX CASES

Age-group (years)	Contacts of male index cases			Contacts of female index cases		
	Total	Reactors		Total	Reactors	
		No.	%		No.	%
0-5	25	5	20	55	19	35
6-9	31	13	42	59	41	70
0-9	56	18	32	114	60	53

Fig. 2 shows that the tuberculin reactor rate in contacts is considerably higher than that in the general population in all age-groups. The difference is more marked in the younger age-groups—i.e., in that age-segment where infection is considered to be mainly of household origin. The differences are highly significant for females of all ages and for males up to the age of 19 years. The reactor rate of contacts under six years is 10 times higher than that of the general population of the same age, and between the ages of six and nine years is about five times higher. Even between the ages of 10 and 19 years the reactor rate is twice as high in contacts as in the general population.

The mean size of the diameter of the reactions shown by those with an induration of 8 mm or more is given in Table 9.

The mean size of the reactions (⩾ 8 mm) for all age-groups combined was 18.3 mm for contacts and 17.7 mm for the general population. (The corresponding figure for the index cases, all age-groups combined, was 18.2 mm.) Neither amongst the contacts nor amongst the general population was there any significant difference in any age-group between the mean size of the reactions shown by the two sexes. There was a remarkable similarity between the mean size of the reactions shown by the contacts and the general population under 20 years. Presumably, tuberculous infections in both groups of these young people were relatively recent and no difference in the size of the reactions would be expected. Over the age of 19 years the same mean size was maintained amongst contacts while the mean size tended to fall in the general population. It is thought that repeated infection of the contacts by open cases tended to maintain a high level of tuberculin sensitivity in the older age-groups, whilst

FIG. 2

TUBERCULIN REACTOR RATE (⩾ 8 mm) AMONGST KIAMBU CONTACTS COMPARED WITH THAT IN KIAMBU GENERAL POPULATION, ACCORDING TO AGE

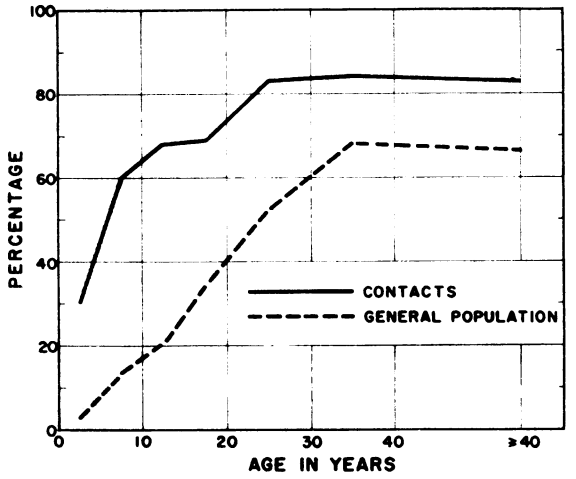


TABLE 9

MEAN SIZE OF TUBERCULIN REACTIONS (⩾ 8 mm) AMONGST CONTACTS (C) COMPARED WITH THAT IN KIAMBU GENERAL POPULATION (GP), ACCORDING TO AGE AND SEX [a]

Age-group (years)	Population	Mean size of tuberculin reactions (mm) [b]		
		Male	Female	Both sexes
0-5	C	(16.0)	(18.7)	17.9
	GP	(18.1)	(17.6)	17.9
6-9	C	18.9	17.8	18.4
	GP	18.7	18.7	18.7
10-19	C	17.6	19.2	18.3
	GP	17.5	18.9	18.3
20-39	C	(18.3)	18.2	18.3
	GP	17.2	18.3	17.9
⩾ 40	C	(17.5)	(19.1)	18.4
	GP	15.6	17.9	16.9
All ages	C	17.9	18.6	18.3
	GP	16.9	18.4	17.7

[a] See Appendix Table 3 for further details.

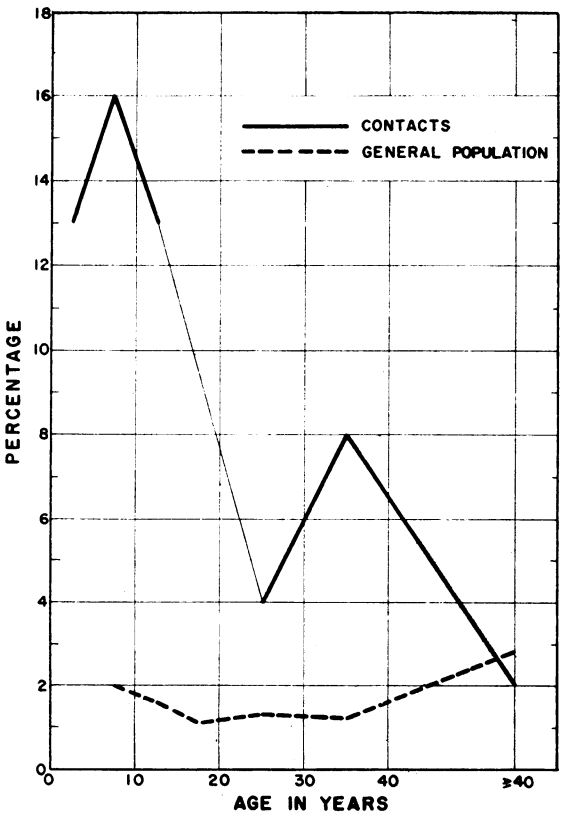
[b] The parentheses denote that the total number of observations on which the calculations were based was less than 25.

among the general population, in whom there was no such close association with open cases, the tuberculin sensitivity tended to wane in the middle-aged and elderly.

Fig. 3 shows the prevalence of active tuberculous lesions amongst contacts as compared with that in the general population. Under 20 years the prevalence of active lesions was highly significantly greater in the contacts than in the general population, the difference in the prevalence being less marked over that age. The same pattern could be noted if each sex was considered separately. The prevalences of active lesions in children under six years of age could not be compared, but amongst contact children between six and nine years active lesions were eight times more common, in the 10-19 age-group seven times more common, between 20

FIG. 3

PREVALENCE OF ACTIVE TUBERCULOUS LESIONS AMONGST KIAMBU CONTACTS COMPARED WITH THAT IN KIAMBU GENERAL POPULATION, ACCORDING TO AGE



and 39 years five times more common, and in the age-group 40 or over about as common as in the general population.

There were 3% of sputum-positive cases amongst the contacts, as compared with 0.5% amongst the general population—a highly significant difference. A similar trend, which did not, however, attain significance, was observed in each age-group considered separately.

Drug-resistance

Forty-five (61%) of the 74 index cases were excreting organisms fully sensitive to isoniazid (INH), streptomycin (SM), and *p*-aminosalicylic acid (PAS). The organisms cultured from the remaining 29 cases (39%) were resistant to one or more of the three drugs. Resistance to INH was commonly found, 26 of the strains being resistant to this drug—14 of them to INH alone, eight to both INH and PAS, one to both INH and SM, and three to all three drugs. Thirteen cases were excreting organisms resistant to PAS—two of them to PAS alone, eight to both PAS and INH, and three to all three drugs. Five cases were excreting organisms resistant to SM—one to SM alone, one to both SM and INH, and three to all three drugs.

The high percentage of cases excreting bacilli resistant to one or more of the drugs reflects neither the true pretreatment nor the true over-all sensitivity pattern of smear-positive tuberculous subjects in the area because 25 of the cases were taken over from the tuberculosis clinics. If these 25 cases are excluded from the analysis and only the 49 smear-positive cases detected in the mass survey are analysed, then it is found that 14 (29%) of the strains were resistant to INH, five (10%) of them being also resistant to PAS. The fact that possibly one-quarter of the smear-positive cases in the area may be harbouring resistant organisms indicates a very serious state of affairs, and the question immediately arises as to what extent this resistance has resulted from previous treatment of the cases concerned or is due to their having been infected by organisms that were already drug-resistant.

In relation to the history of previous treatment Fig. 4 illustrates the bacillary sensitivity pattern of the 74 index cases, and Fig. 5 the degree and type of drug-resistance in the 29 index cases excreting resistant organisms.

Twenty-seven of the 74 index cases admitted to having had previous drug treatment. Of these, 23 (85%) were harbouring strains resistant to one or more drugs: 22 of the strains were resistant to INH—11 to INH alone, seven to both INH and PAS, one to both INH and SM, and three to all three drugs. Of the 22 INH-resistant strains, 14 were catalase-negative. One further patient was harbouring organisms resistant to PAS only. It is reasonable to presume that the emergence of resistant organisms in these cases was the direct result of previous chemotherapy.

The remaining 47 index cases denied having had previous drug treatment. Of these, six (13%) were harbouring resistant strains. Three of these strains were catalase-positive and resistant (in low degree) to INH only, growing on initial and repeat tests in a concentration of 0.2 μg/ml INH, but inhibited by 1.0 μg/ml. One strain was catalase-negative and highly resistant to both INH and PAS. One strain was resistant to PAS only (resistance ratio 8), growing in a concentration of 4 μg/ml PAS but inhibited by 16 μg/ml. The sixth strain was resistant to SM (resistance ratio 4, followed by 8 on repeat test), but sensitive to the other two drugs. In the repeat test the organisms grew on a concentration of 32 μg/ml and were inhibited by 64 μg/ml.

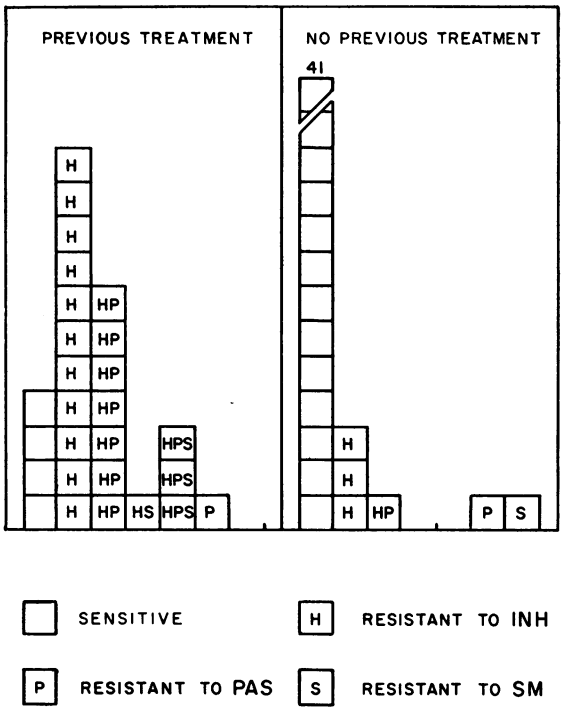
According to the criteria of resistance used in this study, 8.5% of the patients who denied having had previous treatment were excreting INH-resistant organisms, 4% PAS-resistant organisms, and 2% SM-resistant organisms.

Among the contacts of 11 of the index cases were found 11 sputum-positive (culture or culture and smear) persons, 11 contact cases in all. In this connexion it should be remembered that an index case was defined as the first person *found* within a household to excrete tubercle bacilli. It is thus possible that the initial disease of a contact case predated that of the index case. Table 10 gives the details of these contact cases in relation to their corresponding index cases.

It will be observed that in five of the families (index cases 36, 44, 46, 51 and 69) the organisms excreted by both the index case and the contact case were sensitive to all drugs and catalase-positive. Four other index cases (5, 7, 14 and 30) were excreting catalase-negative organisms resistant to INH; in one of these the organisms were also resistant to PAS and in another to both PAS and SM. The corresponding four contact cases were excreting catalase-positive organisms sensitive to all drugs; whilst it is apparent that these contacts had not been infected by resistant organisms, it is unknown when and by whom they were infected. If it is assumed that they

FIG. 4

BACILLARY SENSITIVITY PATTERN OF 74 INDEX CASES IN RELATION TO HISTORY OF PREVIOUS TREATMENT



were each infected by their index case, then it is apparent that either they were infected before their index case developed bacillary resistance and catalase negativity as a result of treatment, or else they were subsequently infected by catalase-positive drug-sensitive organisms excreted by the index case in a mixed population of sensitive and resistant organisms.

Finally, there were two index cases (27 and 80) who were excreting catalase-negative INH-resistant organisms and whose contact cases were excreting catalase-positive INH-resistant organisms. The contact case to index case 80 had organisms highly resistant to both PAS and INH, whilst the index case was excreting bacilli resistant to INH only: owing to the difference in the drug resistance of the organisms harboured by these two persons it is debatable whether the contact was infected by his index case or *vice versa*. In this family there were, however, four other persons who had previously been under chemotherapy and, although they were all sputum-negative at the time of examination, it is possible that one of these infected the contact. The contact case to index case 27 had organisms resistant only to INH, whilst the index case had organisms resistant to all three drugs. No other member of this family showed any evidence of pulmonary tuberculosis, and only

FIG. 5. DEGREE AND TYPE OF DRUG-RESISTANCE AMONGST THE 29 INDEX CASES EXCRETING DRUG-RESISTANT ORGANISMS IN RELATION TO HISTORY OF PREVIOUS TREATMENT

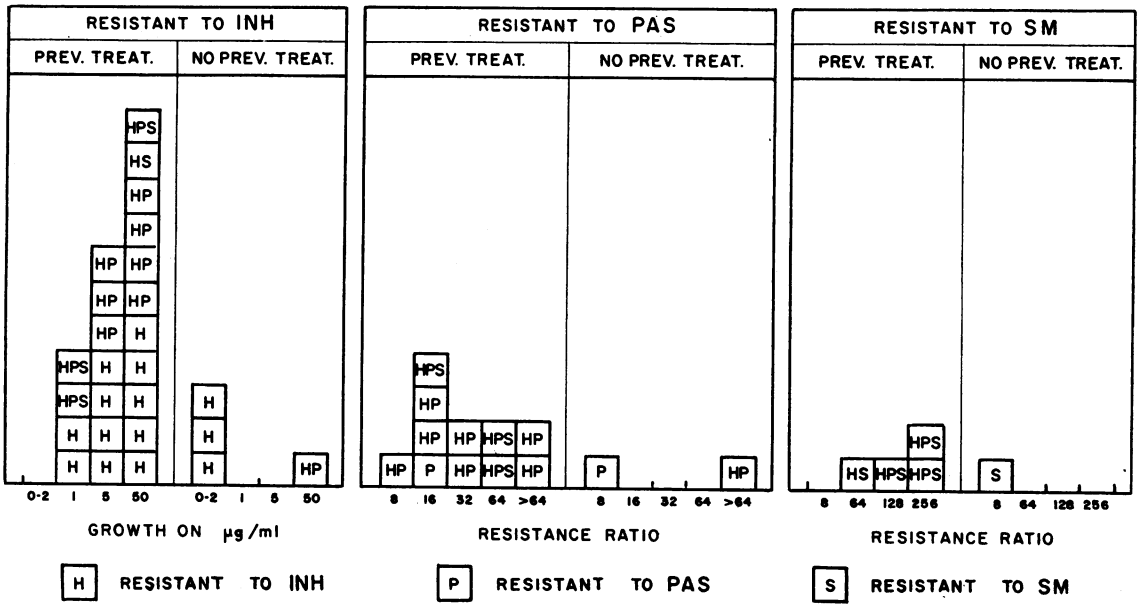


TABLE 10

TUBERCULIN REACTIONS, RADIOLOGICAL AND BACTERIOLOGICAL FINDINGS OF 11 CONTACT CASES IN RELATION TO THEIR INDEX CASES

Type of case	Sex	Age (years)	Previous treatment		Mantoux 1 TU (mm)	X-ray finding		Sputum					Catalase
			Drugs taken	Total months		Cavity	Unilateral (U) Bilateral (B) No lesion (0)	Smear	Culture	Sensitivity (MIC test organism/MIC H37Rv)			
										INH	PAS	SM	
No. 36													
Index	F	35	Nil	—	14	+	U	++	++	<0.2/0.2 S	<1/2 S	16/8 S	Pos.
Contact	M	11	INH, PAS	4	19 V [a]	0	U	0	+	<0.2/0.2 S	2/2 S	16/8 S	Pos.
No. 44													
Index	M	60	Nil	—	14	+	B	++	++	<0.2/0.2 S	<1/1 S	<8/8 S	Pos.
Contact	F	50	Nil	—	24	0	U	++	++	<0.2/0.1 S	2/1 S	<8/8 S	Pos.
No. 46													
Index	M	80	Nil	—	14	+	B	++	++	<0.2/0.2 S	2/1 S	<8/8 S	Pos.
Contact	F	6	Nil	—	9	0	U	0	+	<0.2/0.2 S	4/2 S	<8/8 S	Pos.
No. 51													
Index	F	12	Nil	—	22	+	B	++	++	<0.2/0.2 S	4/2 S	16/8 S	Pos.
Contact	F	6	Nil	—	21 V	0	U	0	+	<0.2/0.1 S	2/1 S	16/8 S	Pos.
No. 69													
Index	F	7	Nil	—	20 V	0	U	+	+	<0.2/0.2 S	4/2 S	<8/8 S	Pos.
Contact	F	9	Nil	—	17	0	0	++	++	<0.2/0.1 S	4/2 S	<8/4 S	Pos.
No. 5													
Index	M	11	INH, PAS, SM	33	16	0	U	++	+	>50/0.1 R	64/1 R	<8/8 S	Neg.
Contact	F	12	INH, PAS	13	16	0	U	0	+	<0.2/0.1 S	<1/1 S	16/8 S	Pos.
No. 7													
Index	F	36	INH, PAS, SM	23	14	0	U	++	++	>50/0.1 R	16/1 R	1024/4 R	Neg.
Contact	F	5	Nil	—	19 V	0	U	0	+	<0.2/0.1 S	<1/1 S	<8/4 S	Pos.
No. 14													
Index	M	51	INH, PAS	6	16	+	B	++	+	>50/0.1 R	<1/1 S	<8/8 S	Neg.
Contact	F	8	Nil	—	16	+	U	++	++	<0.2/0.1 S	<1/1 S	<8/4 S	Pos.
No. 30													
Index	M	28	INH, PAS, SM	32	17	+	B	++	++	>50/1 R	<1/1 S	<8/8 S	Neg.
Contact	F	50	Nil	—	23	0	0	0	++	<0.2/0.1 S	2/1 S	<8/8 S	Pos.
No. 27													
Index	F	32	INH, PAS, SM	10	15	+	B	++	++	5/0.2 R	64/1 R	1024/8 R	Neg.
Contact	M	10	Nil	—	19 V	0	U	0	+	5/0.1 R	4/1 S	<8/8 S	Pos.
No. 80													
Index	F	10	INH, PAS	9	23	+	U	++	++	50/0.1 R	<1/1 S	<8/8 S	Neg.
Contact	M	12	Nil	—	21	0	U	0	+	50/0.1 R	16/0.5 R	<8/8 S	Pos.

[a] V = vesicular reaction.

the index case had had previous treatment; it is possible that the contact case was infected before the organisms of the index case became resistant to PAS and SM. On the other hand, it is possible that in spite of denying having received any previous treatment for pulmonary tuberculosis the contact cases of index cases 27 and 80 had treated themselves periodically with the index case drugs. This has been known to occur on other occasions and can by no means be excluded in these two instances, particularly as antituberculous drugs must have been readily available in the houses for periods of over nine months.

DISCUSSION

The risk run by contacts of open cases of pulmonary tuberculosis has been emphasized, particularly in Western countries, by numerous authors—notably, McPhedran & Opie (1935) from Philadelphia; Brailey (1940) from the Johns Hopkins Hospital, Baltimore; Schlesinger & D'Arcy Hart (1930) from London; Dow & Lloyd (1931) in an English working-class population; and Daniels et al. (1948) in the Prophit Tuberculosis Survey 1935-44. Reports from Africa have not been very numerous, but Wilcox (1932) has reported a high prevalence of the disease amongst contacts in Tanganyika, and Grounds (1960) has reported a similar finding in the Kisii district of Kenya.

Andersen & Geser (1960) undertook an analysis of the data collected by two WHO prevalence survey teams in eight different territories and one large city in Africa. All persons in these surveys were Mantoux-tested (5 TU of PPD, batch RT 19-21) and sputum was collected for microscopic examination from persons judged to be over 12 years of age. The analysis did not include radiological examinations or culture results of sputa, as these were not invariably carried out. Using an induration of 13 mm or over to the tuberculin test as the criterion of infection, these authors found that there was a tendency for tuberculous infection to accumulate in certain households; they concluded, however, that the extent of such accumulation in the countries surveyed did not appear to justify the concentration of preventive measures (e.g., BCG vaccination) on any limited category of households, whatever the criterion for their selection. They were of the opinion that, as X-ray examinations were not undertaken, no direct answer could be provided as to whether or not case-finding amongst household contacts would be a useful control measure. They indicate that it may not be of such great importance in these territories as it is believed to be elsewhere. They found no household accumulation of sputum-positive cases and no real evidence from the household reactor rates to suggest that such cases, of any degree of infectiousness or at any clinical stage, were unevenly distributed. They believe that the evidence adduced gives some grounds for a certain scepticism with regard to the usefulness of contact examinations, at any rate until contrary evidence comes forward. In the present study a different evaluation of the importance of contact examination emerges from the use of more refined basic material—direct smear-positive diagnoses in index cases/infectious cases being corroborated by culture isolation of *Mycobacterium tuberculosis* in all instances, collection of sputum from all persons in the study instead of only from those of over 12 years of age, and examination of sputa by culture in the case of all household contacts. For example, it has been shown that examination of household contacts of index cases as defined in this study produced a further 15% of sputum-positive cases—a yield six times as high as would be expected from examination of the general population.

As Clarke (1952) has pointed out, many of the published contact studies, particularly those carried out solely from clinics, have left some doubt as to whether all possible contacts have been included in the study group: and he makes the point that failure to include all contacts is liable to invalidate any conclusions drawn from such a study. The present study has included all known household contacts found through repeated home-visiting of the households of the 74 index cases.

It is accepted that the tuberculin test provides a measure of the degree of tuberculous infection in a population group, and this is particularly so if the prevalence of small tuberculin reactions is low, as it is in Kiambu, and if the reactor rate amongst children rather than adults is considered. The tuberculin reactor rates amongst the child contacts in this study were 30% and 60% amongst those under six years and between the ages of six and nine years, respectively. Schlesinger & D'Arcy Hart (1930) found that 37% of child home contacts in London under six years of age, and 78% between the ages of six and ten years, were infected. McPhedran & Opie (1935), using a high dose (100 TU) of Old Tuberculin, found 69% of white child contacts under five years of age, and 86% between five and nine years, infected. Andrews et al. (1960), in an investi-

gation amongst close family contacts in Madras, found an age infection prevalence very similar to that observed in this study. They used a minimum induration of 5 mm to 5 TU of RT 22 as the criterion for a positive reaction. Grounds (1960) examined 414 of 519 known contacts in the Kisii district of Kenya, and using 10 TU of Old Tuberculin found the percentage of infected persons in all age-groups over five years to be 10% to 15% less than that found amongst the Kiambu contacts.

It is of paramount importance to note that 10 (42%) of the 24 reactors of under the age of six years had active tuberculous lesions, one being culture-positive, and that eight (53%) of the 15 positive reactors of three years of age and under had active lesions. This finding emphasizes the practical value of the Mantoux test amongst child contacts who have not been subjected to BCG vaccination.

The mean size of the tuberculin reaction ($\geqslant 8$ mm) was similar in the household contacts for all age-groups and in the general population for all age-groups under 20 years; but in older persons amongst the general population it tended to get comparatively smaller with advancing age. This was presumably due to a waning of tuberculin sensitivity amongst persons who had been infected a considerable time previously and who had not been exposed to repeated infection. On the other hand, the mean size of the induration remained constant amongst the contacts throughout all ages, and it is reasonable to assume that the maintenance of tuberculin sensitivity amongst the older contacts was the result of their constant exposure to open cases.

By far the highest proportion of active tuberculous lesions was observed in the X-rays of contact children under 15 years of age, the prevalence rate being 14% in these children, as compared with only 3% in the contacts of 15 years or over. In persons of over 40 years of age the prevalence of active lesions was the same in the contacts as in the general population. This observation was closely mirrored by the prevalence of open tuberculosis, which was 4% amongst children under 15 years and 1% amongst older contacts. It was apparent, because of the young age of those principally affected in the present study, and also because of the type of lesion observed radiologically, that a considerable proportion of the disease amongst the contacts was the immediate result of primary infection.

Our findings differ from those in the majority of other contact studies, in which old as well as young contacts have shown a high prevalence of tuberculosis, suggesting that superinfection plays a prominent part in the development of the disease in the older age-groups. In this study it does not appear that middle-aged or elderly contacts were at great risk of developing active tuberculous lesions or open disease, and this suggests that superinfection amongst these persons is not of particularly dangerous import. Indeed, the report on the tuberculosis survey of Kiambu (WHO/UNICEF-Assisted Tuberculosis Project, Nairobi, 1960) suggested that open and active disease amongst the elderly was frequently due to endogenous breakdown of old-standing lesions.

The present investigation has produced evidence that within a tuberculous household certain factors related to the sexes may influence the risk of infection run by members of the household. The observation that female index cases infected more children in the family than did the male index cases is possibly to be expected in view of the closer relationship between the females, particularly adult females, and children. The finding that, under the age of six, female contacts were more likely than male contacts to contract both infection and disease has not been explained.

It was fortunate that a tuberculosis prevalence survey was being carried out in Kiambu at the time the present investigation was started. In that survey techniques similar to those adopted for the examination of contacts in this study were used, and this fact made it possible to assess the chances of infection and disease amongst contacts as compared with the community at large. It was established beyond doubt that the contact group experienced a far greater degree of infection and morbidity than did the general population—especially in the younger age-groups.

The prevalence of infection, as indicated by the tuberculin reactor rate, and of active lesions which occurred amongst contacts was related to the radiological and bacteriological character of the index case. Thus, the younger contacts of cavitated index cases had a tuberculin reactor rate approximately twice as high and showed about twice as many active lesions as the contacts of non-cavitated index cases. Similarly, the younger contacts of index cases with sputum heavily positive on both smear and culture had a reactor rate twice as high and showed two to three times as many active lesions as did those in contact with index cases less heavily sputum-positive. As a measure of the risk run by contacts it should be mentioned that the younger contacts in even the two less infectious groups—index cases without cavitation

and index cases not heavily sputum-positive—experienced a tuberculin reactor rate and a prevalence of active lesions approximately four times as high as did the general population. Furthermore, it should be noted that by examining the 401 contacts of 74 index cases there were discovered no less than 41 persons with radiological or bacteriological evidence of active disease.

Pepys, Mitchison & Kinsley (1960) have shown that there is a high prevalence of isoniazid- and PAS-resistant strains of tubercle bacilli in East Africa. The question which must be answered in this context is the varying extents to which drug-resistant cases arise from infection by resistant organisms or from previous chemotherapy. Although it is not yet possible to answer this question, the material presented in this paper is of interest and puts the position in some perspective. The question of possible previous treatment was investigated most carefully in regard to each index case: this was done at the first interview, prior to receipt of the sputum sensitivity report. Each patient was asked in the presence of his family, who could corroborate his statements, it he or any member of his family had been in hospital, had had a chest X-ray, or had ever had isoniazid, PAS or streptomycin. In order to make easier the identification of any previous therapy he was shown and asked to taste the PAS powder and isoniazid pills. All cases were given routine therapy immediately so that there should be no incentive for anyone to deny having had treatment in order to avoid its being temporarily withheld. If a case who had denied having received treatment was subsequently found to be excreting bacilli resistant to one or more of the drugs on entry to the trial, both he and the members of his family were carefully requestioned. The reasons for making inaccurate statements with regard to previous treatment are manifold, and many of them can be appreciated, but it is believed that in this series of 74 cases the information obtained is as accurate as was possible.

There can be little doubt that the great amount of drug-resistance found in the area was the result of previous drug treatment as 23 of the 29 drug-resistant strains were found amongst patients who admitted to having had previous chemotherapy, and, of these, 22 were isoniazid-resistant, 14 being catalase-negative. It is reasonable to assume that the emergence of bacillary resistance amongst these patients occurred during drug treatment.

Of the 47 index cases who had denied having received previous treatment, there were four excreting organisms resistant to isoniazid. In three of these the organisms were resistant to isoniazid alone and in low degree and were catalase-positive; in one, the organisms were resistant to isoniazid and PAS in high degree and were catalase-negative. These persons must be regarded as having been infected with drug-resistant strains. Thus, of the persons denying having had previous treatment, 8.5% were excreting isoniazid-resistant strains—a figure that approaches closely the prevalence of 6-9% of initially isoniazid-resistant strains found by Pepys, Mitchison & Kinsley (1960) amongst patients from Kenya who were admitted to a series of chemotherapy trials in East Africa. Fox et al. (1957), in a survey undertaken in Great Britain in which the same criteria of resistance were used, found that only 0.7% of previously untreated patients were excreting isoniazid-resistant organisms.

There were 11 cases of open tuberculosis found at the initial examination amongst the 401 contacts (11 contact cases), and two of these, both of whom denied having had previous treatment, were excreting resistant organisms. As both were in contact with an index case also excreting resistant organisms it was reasonable to assume that a resistant strain had been primarily responsible for the disease in the contact, or *vice versa*. There was, however, an element of doubt as to the correctness of this assumption as in each of the instances the strains isolated from the index case and the contact differed in their drug-sensitivity patterns. It is certainly not unknown, and may be quite common, for persons living in the household of a tuberculous patient to dose themselves periodically with his medicine for a variety of complaints, particularly of a respiratory nature; this is a possibility which cannot be excluded in these two cases.

On the whole it is considered that chemotherapy with specific drugs taken in a haphazard way was responsible for the majority of resistant cases in Kiambu, but that primary infection with resistant organisms did occur. Further studies are continuing to determine the extent to which it does.

SUMMARY

1. The paper describes the initial examination of 74 index cases (sputum-positive on both smear and culture) and their 401 household contacts. Twenty-five of the index cases derived from a rural tuberculosis clinic and 49 from a case-finding programme in the same area. The routine examination under-

taken on each person consisted of a Mantoux test, an X-ray of the chest (70 mm) and bacteriological examination of one sputum specimen. The investigation was carried out in the Kiambu district, where a 1% random sample survey of the general population was undertaken at the same time, using the same techniques and methods of examination.

2. Half (53%) of the index cases had radiological evidence of cavitated disease; in more than half (62%) the sputum was heavily positive on both smear and culture. With one exception all were reactors ($\geqslant$ 8 mm) to the tuberculin test.

3. It is believed that the present study includes all the household contacts of the 74 index cases; 62% of the contacts were children under 15 years of age.

4. There was a gradual rise in the reactor rate in contacts with increasing age up to the age of 30 years. The reactor rate amongst them was considerably higher than for corresponding age-groups in the general population and the difference was highly significant in the younger age-groups. It was ten times higher in contact children under six years of age and six times higher in children under ten.

5. The mean size of the reaction amongst contact tuberculin reactors was 18.3 mm and was similar throughout all age-groups. In the general population the mean size closely followed the contact figure up to the age of 20 years, but tended to become smaller with further increase in age. The corresponding figure for the index cases, all ages combined, was 18.2 mm.

6. Radiological lesions regarded as being due to active tuberculosis were observed in the X-rays of 39 (10%) of the contacts, 34 of these being children under 15 years of age. Between the ages of six and 19 years, active lesions were observed seven times more often amongst contacts than amongst persons in the general population. The differences became progressively less marked in the older age-groups until in the age-group over 40 years they disappeared.

7. Eleven (3%) of the contacts were found to be excreting tubercle bacilli in their sputum. The prevalence of sputum-positive contacts was highest in children under 15 years and was, for all ages, six times higher than in the general population.

8. There was evidence, of significant degree, that female index cases were more infective to their child contacts than were male index cases. Female contacts under the age of six years had a significantly higher reactor rate and also a significantly greater proportion of active lesions than did the males of the same age-group.

9. Children of under the age of ten years in contact with cavitated index cases were twice as heavily infected, and showed twice as many active lesions on X-ray examination, as those in contact with non-cavitated index cases. A similar difference amongst the contacts was found if a differentiation was made in the degree of sputum positivity amongst the index cases.

10. Forty-seven of the index cases had no history of previous treatment for tuberculosis and six (13%) of them were found to be excreting resistant organisms (three to INH alone, one to INH and PAS, one to PAS alone and one to SM alone). Twenty-seven index cases admitted to having had previous drug treatment and, of these, 23 were excreting resistant organisms (11 to INH alone, seven to INH and PAS, one to INH and SM, three to all three drugs, and one to PAS alone).

11. Nine of the 11 sputum-positive contact cases were excreting organisms sensitive to all three drugs although four of their index cases were harbouring resistant organisms. The remaining two sputum-positive contacts, who denied having had previous drug treatment, were excreting strains highly resistant to INH. The route of infection of these two cases has been discussed.

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RÉSUMÉ

Dans les régions économiquement sous-développées de l'Afrique, l'entassement, le manque d'air et de lumière caractérisent les logements, même dans les zones peu peuplées. La malnutrition, sous forme de carence protéique surtout, est très répandue. Il a paru intéressant d'évaluer les risques de contagion tuberculeuse des 401 contacts de 74 cas avérés vivant dans ces conditions défavorables.

L'enquête des auteurs, dans la région de Kiambu (Kenya) a montré que le nombre des contacts domestiques infectés, surtout ceux des groupes d'âge inférieurs, et la fréquence des cas de tuberculose pulmonaire ouverte, étaient 5-10 fois supérieurs à ceux que l'on observait dans l'ensemble de la population.

La moitié environ des cas avérés présentait des lésions cavitaires et, chez 62%, les crachats étaient fortement positifs à l'examen et à la culture. Tous sauf un réagissaient positivement à la tuberculine. Parmi les contacts, la proportion des sujets réagissant à la tuberculine augmentait jusqu'à 30 ans. Elle était nettement supérieure à celle que l'on observait dans la population en général. L'examen radiologique révélait des lésions chez 39 sujets (soit 10% environ), dont 34 de moins de 15 ans. Environ 3% des contacts excrétaient des bacilles dans les crachats. Dans l'ensemble, les femmes étaient plus infectantes pour leurs enfants que les hommes, et les fillettes s'infectaient plus facilement que les garçons.

Parmi les cas avérés, 47 n'avaient pas subi de traitement antituberculeux. Cependant, 6 d'entre eux excrétaient des bacilles résistants (3 à l'isoniazide seulement, 1 à l'isoniazide et au PAS et 1 à la streptomycine, et 1 au PAS seulement). Neuf des contacts à crachats positifs excrétaient des bacilles sensibles aux trois médicaments, quand bien même 4 des cas avérés avec lesquels ils vivaient, excrétaient des bacilles résistants.

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APPENDIX TABLE 1

AGE AND SEX DISTRIBUTION OF 74 INDEX CASES AND 401 CONTACTS

Age-group (years)	Index cases			Contacts		
	Male	Female	Both sexes	Male	Female	Both sexes
0-5	—	—	—	45	37	82
6-9	5	5	10	44	46	90
10-14	5	11	16	41	36	77
15-19	7	2	9	12	20	32
20-29	3	5	8	10	19	29
30-39	3	11	14	12	26	38
⩾ 40	7	10	17	25	28	53
All ages	30	44	74	189	212	401

APPENDIX TABLE 2

DISTRIBUTION OF 74 INDEX CASES ACCORDING TO THE NUMBER OF CONTACTS IN THEIR HOUSEHOLDS

Number of contacts in household	Number of households with :		
	Male index case	Female index case	Total
1	3	2	5
2	4	6	10
3	4	5	9
4	6	8	14
5	4	5	9
6	3	4	7
7	—	2	2
8	2	2	4
9	2	5	7
10	1	2	3
11	—	1	1
12	—	1	1
18	1	—	1
26	—	1	1
Total	30	44	74

APPENDIX TABLE 3

DISTRIBUTION OF SIZE OF REACTIONS TO MANTOUX 1 TU AMONGST 401 CONTACTS AND IN THE GENERAL POPULATION OF KIAMBU IN SPECIFIED AGE-GROUPS, ACCORDING TO SEX

Age-group (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	Not tested	
A. MALE CONTACTS																
0-5	34	1	—	1	—	1	2	—	1	2	—	—	1	—	2	45
6-9	15	—	1	—	—	2	—	2	5	5	8	4	2	—	—	44
10-14	7	2	—	—	1	2	1	1	11	5	7	3	1	—	—	41
15-19	5	—	1	—	—	—	1	1	2	—	1	1	—	—	—	12
20-29	—	—	—	1	—	—	—	1	3	2	2	—	1	—	—	10
30-39	1	—	—	—	—	—	1	1	2	4	1	1	1	—	—	12
⩾ 40	4	1	—	1	1	—	1	4	4	2	5	1	—	1	—	25
All ages	66	4	2	3	2	5	6	10	28	20	24	10	6	1	2	189
B. FEMALE CONTACTS																
0-5	18	2	—	—	—	1	1	2	—	6	4	1	2	—	—	37
6-9	19	—	1	—	1	—	1	3	4	10	6	—	1	—	—	46
10-14	15	1	—	—	—	—	—	3	3	9	2	2	—	1	—	36
15-19	4	—	—	—	—	1	—	2	—	3	5	2	1	2	—	20
20-29	4	—	—	—	—	1	1	1	2	2	3	5	—	—	—	19
30-39	5	—	—	—	—	—	—	7	3	7	2	1	1	—	—	26
⩾ 40	3	—	—	—	—	—	2	3	2	6	5	3	3	—	1	28
All ages	68	3	1	—	1	3	5	21	14	43	27	14	8	3	1	212
C. MALE GENERAL POPULATION OF KIAMBU																
0-5	479	61	5	1	—	1	—	3	3	5	4	2	1	—	—	565
6-9	231	56	3	2	—	1	—	3	8	10	9	5	1	—	—	329
10-14	146	45	7	—	—	1	4	6	20	15	9	4	1	—	—	258
15-19	59	25	5	1	2	4	1	6	24	8	12	5	—	2	—	154
20-29	33	11	6	2	—	6	14	25	31	28	22	7	5	3	—	193
30-39	17	7	1	1	2	7	20	19	24	24	20	10	5	—	—	157
⩾ 40	24	13	12	5	9	26	25	25	45	19	22	9	4	—	—	238
All ages	989	218	39	12	13	46	64	87	155	109	98	42	17	5	—	1894
D. FEMALE GENERAL POPULATION OF KIAMBU																
0-5	429	37	1	1	1	—	1	1	5	6	2	1	—	1	—	486
6-9	231	40	4	1	—	1	3	3	12	10	11	3	5	1	—	325
10-14	151	30	6	2	—	1	1	5	10	7	20	8	3	—	—	244
15-19	105	32	1	2	—	3	3	10	12	20	13	10	9	2	—	222
20-29	138	28	7	4	2	7	6	21	30	39	42	27	8	4	—	363
30-39	65	19	15	6	4	5	4	18	36	23	35	16	7	6	—	259
⩾ 40	90	33	16	10	6	8	19	25	39	35	44	28	10	7	—	370
All ages	1209	219	50	26	13	25	37	83	144	140	167	93	42	21	—	2269

APPENDIX TABLE 4

NUMBER OF ACTIVE LESIONS SEEN ON X-RAY EXAMINATION AMONGST CONTACTS AND IN THE GENERAL POPULATION OF KIAMBU, ACCORDING TO AGE AND SEX

Age-group (years)	Contacts						General population of Kiambu					
	Number X-rayed			Number of active lesions			Number X-rayed			Number of active lesions		
	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes
0-5	43	37	80	2	8	10	Not X-rayed			—	—	—
6-9	44	46	90	7	7	14	329	325	654	5	8	13
10-14	41	36	77	5	5	10	258	244	502	3	5	8
15-19	12	20	32	—	—	—	154	222	376	3	1	4
20-29	9	19	28	—	1	1	193	364	557	2	5	7
30-39	12	26	38	2	1	3	158	259	417	—	5	5
⩾ 40	25	27	52	—	1	1	239	372	611	10	7	17
All ages	186	211	397	16	23	39	1 331	1 786	3 117	23	31	54

APPENDIX TABLE 5

NUMBER OF SPUTUM-POSITIVE PERSONS AMONGST CONTACTS AND IN THE GENERAL POPULATION OF KIAMBU, ACCORDING TO AGE AND SEX

Age-group (years)	Contacts						General population of Kiambu					
	Number examined bacteriologically			Number of sputum-positive persons			Number examined bacteriologically [a]			Number of sputum-positive persons		
	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes
0-5	45	37	82	—	1	1	No examination			—	—	—
6-9	44	46	90	—	4	4	35 (329)	46 (325)	81 (654)	2	3	5
10-14	41	36	77	3	1	4	32 (258)	41 (244)	73 (502)	1	1	2
15-19	12	20	32	—	—	—	21 (154)	22 (222)	43 (376)	—	—	—
20-29	10	19	29	—	—	—	23 (193)	49 (364)	72 (557)	—	1	1
30-39	12	26	38	—	—	—	17 (158)	34 (259)	51 (417)	—	1	1
⩾ 40	25	28	53	—	2	2	49 (239)	52 (372)	101 (611)	4	3	7
All ages	189	212	401	3	8	11	177 (1 331)	244 (1 786)	421 (3 117)	7	9	16

[a] The general population sample X-rayed comprised 3117 persons, as indicated by the figures in parentheses. Sputum was collected for examination from those with X-ray evidence of pulmonary pathology and also from a randomly selected 10 % of those X-rayed.

APPENDIX TABLE 6. NUMBER OF TUBERCULIN REACTORS (⩾ 8 mm) AND NUMBER OF ACTIVE LESIONS AMONGST CONTACTS, ACCORDING TO PRESENCE OR ABSENCE OF CAVITATION IN THE INDEX CASE

A. Tuberculin reactors

Radiological state of index case	Contacts					
	Number tuberculin-tested			Number of reactors		
	0-9 years	10-19 years	⩾ 20 years	0-9 years	10-19 years	⩾ 20 years
Cavitated	83	56	52	51	44	46
Non-cavitated	87	53	67	27	30	53
Total	170	109	119	78	74	99

B. Active X-ray lesions

Radiological state of index case	Contacts					
	Number X-rayed			Number with active lesions		
	0-9 years	10-19 years	⩾ 20 years	0-9 years	10-19 years	⩾ 20 years
Cavitated	83	56	52	16	5	3
Non-cavitated	87	53	66	8	5	2
Total	170	109	118	24	10	5

APPENDIX TABLE 7. NUMBER OF TUBERCULIN REACTORS (⩾ 8 mm) AND NUMBER OF ACTIVE LESIONS AMONGST CONTACTS, ACCORDING TO DEGREE OF POSITIVITY OF SPUTUM OF THE INDEX CASE

A. Tuberculin reactors

Bacteriological state of index case	Contacts					
	Number tuberculin-tested			Number of reactors		
	0-9 years	10-19 years	⩾ 20 years	0-9 years	10-19 years	⩾ 20 years
Smear ++ and culture ++	81	55	62	54	43	56
All others	89	54	57	24	31	43
Total	170	109	119	78	74	99

B. Active X-ray lesions

Bacteriological state of index case	Contacts					
	Number X-rayed			Number with active lesions		
	0-9 years	10-19 years	⩾ 20 years	0-9 years	10-19 years	⩾ 20 years
Smear ++ and culture ++	81	55	62	17	7	3
All others	89	54	56	7	3	2
Total	170	109	118	24	10	5