The Evolution of Tuberculosis in Southern Rhodesia

D. H. SHENNAN, M.D., D.P.H.
Assistant Medical Officer of Health, Eastern Province, Southern Rhodesia.

PART III

EXAMINATION: A COMPREHENSIVE TUBERCULIN SURVEY OF THE AFRICAN SCHOOL CHILDREN OF MANICALAND

The purpose of this study was to determine the extent to which tuberculous infection has invaded Manicaland (the Eastern Province of Southern Rhodesia), the amount of disease resulting and the influence of environmental factors in precipitating active disease. It is based on results of tuberculin-testing done in association with BCG vaccinations.

Unfortunately it is difficult or impossible to measure accurately many of the variables in which we are interested, such as the degree of parasitic infestation, degree of remoteness of an area, degree of crowding in huts, and hygienic habits. In some cases it has been possible to measure other factors with a relationship to these, such as altitude for parasite infestation and the effect of climate; in others, such as crowding and hygienic habits, it has been frankly impossible to allow for them.

Method

All tests were done and read by the author. The testing covered, over 3½ years, all African school children in the province except about 5,000 in four separate areas who were only given the Heaf test, using old tuberculin diluted 1/15. The remainder, numbering 44,106, were given the Mantoux test with 5 T.U. of old tuberculin (1/2,000) and were used as the material for this survey.

Induration of 6 mm. or more was regarded as a positive reaction, on the basis of the size distribution of 2,173 reactions which were measured (Figure II). WHO monograph No. 12 (1953) describes tuberculin sensitivity to allergens other than the tubercle bacillus, which cause reactions generally smaller than those resulting from true tuberculo-allergy. Figure II shows that this element is present here and the two curves join at 6 mm., the reaction size given by the smallest number of children. Six mm. is therefore the best criterion for the minimum diameter of a reaction due to allergy to the tubercle bacillus. The slight dip at 11 mm. is probably due to the same aversion for this figure as is indicated in the estimation of ages (below).

For approximately the first 6,000 tests the ages of the children were estimated. For subsequent schools the teachers were asked to record the ages from the school registers. A comparison was later made between the age curves, both for boys and girls, by the two methods, and these are given in Figure III. A leaning towards lower ages from 15 upwards is probably due to a desire to remain within the Education Department's age limit. By both methods there is an interesting reluctance to choose age 11, and in estimating there is a tendency to avoid odd numbers. In general, the curves for ages given by teachers are more symmetrical than those for ages estimated, especially in the case of girls.

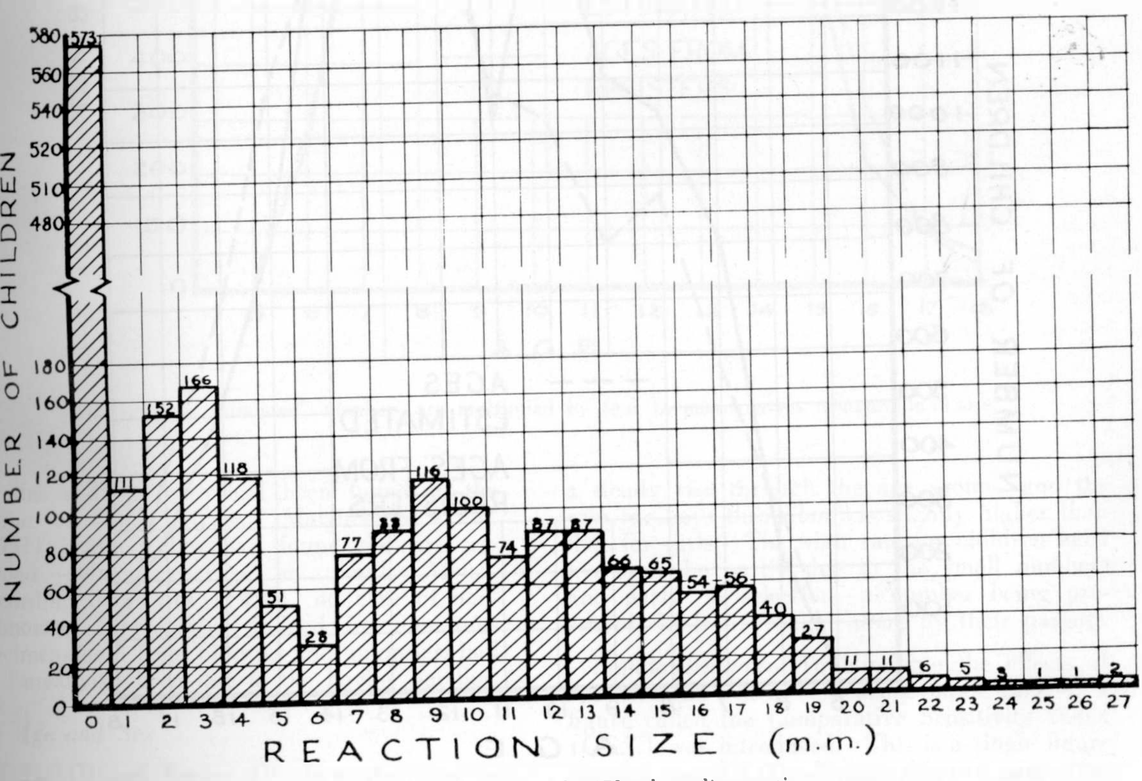


Fig. 2—Size distribution of 2,173 tuberculin reactions.

As the survey progressed, children with BCG marks began to be noticed; these had moved from schools already completed. In the last part of the survey, therefore, all children previously given a Mantoux test or BCG vaccination were excluded beforehand. The number of children included in the survey was not large enough to influence the figures significantly.

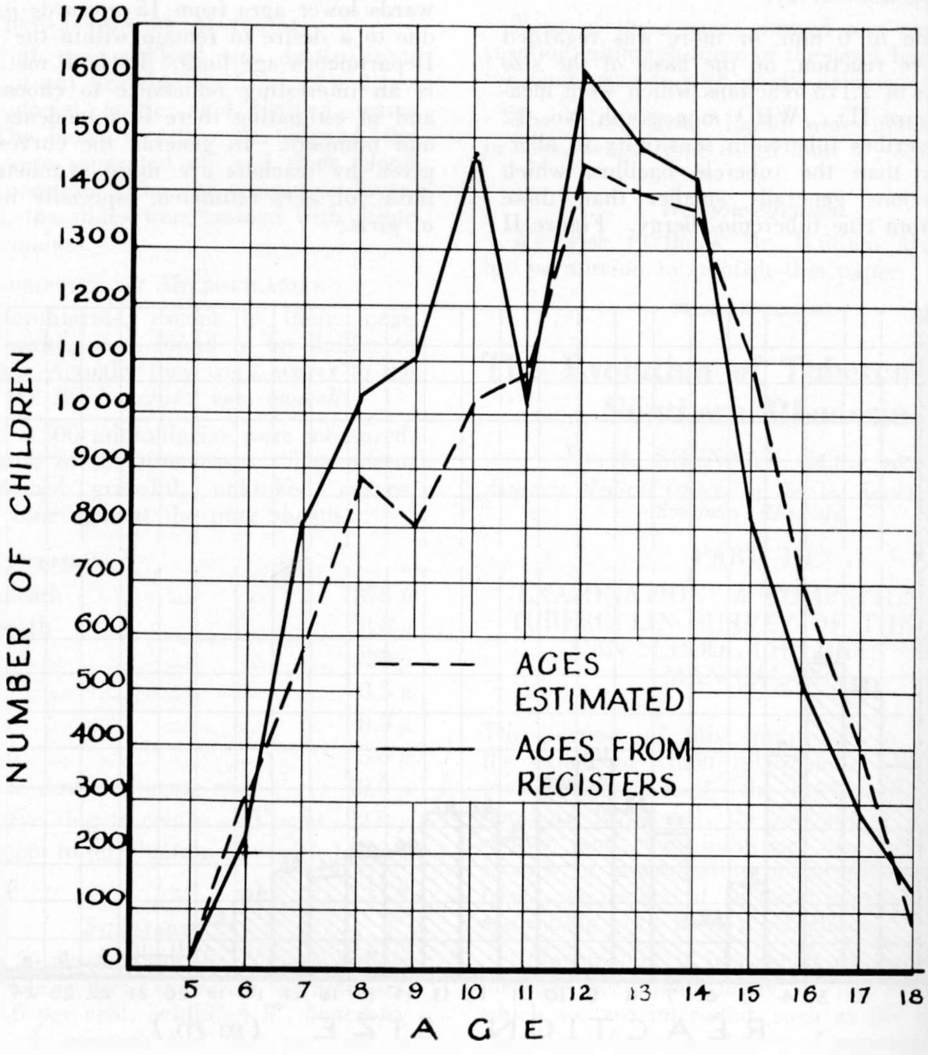
Results

The overall tuberculin sensitivity rate in the 44,106 children was 40.6 per cent.

Bovine infection probably plays a small part, if any, in this. Cattle are infected, as has been shown by the tuberculin testing of dairy herds; Rumeau (1957) reports that tuberculosis is "prevalent" in urban and suburban dairy cattle of the Rhodesias and South Africa. On the other hand, human infection appears to be rare. Haynes (1951) reviews the literature on bovine bacillus infection in Africa. Most observers, he says, have found little evidence of it: four cases out of 297 tested in Uganda had the bovine

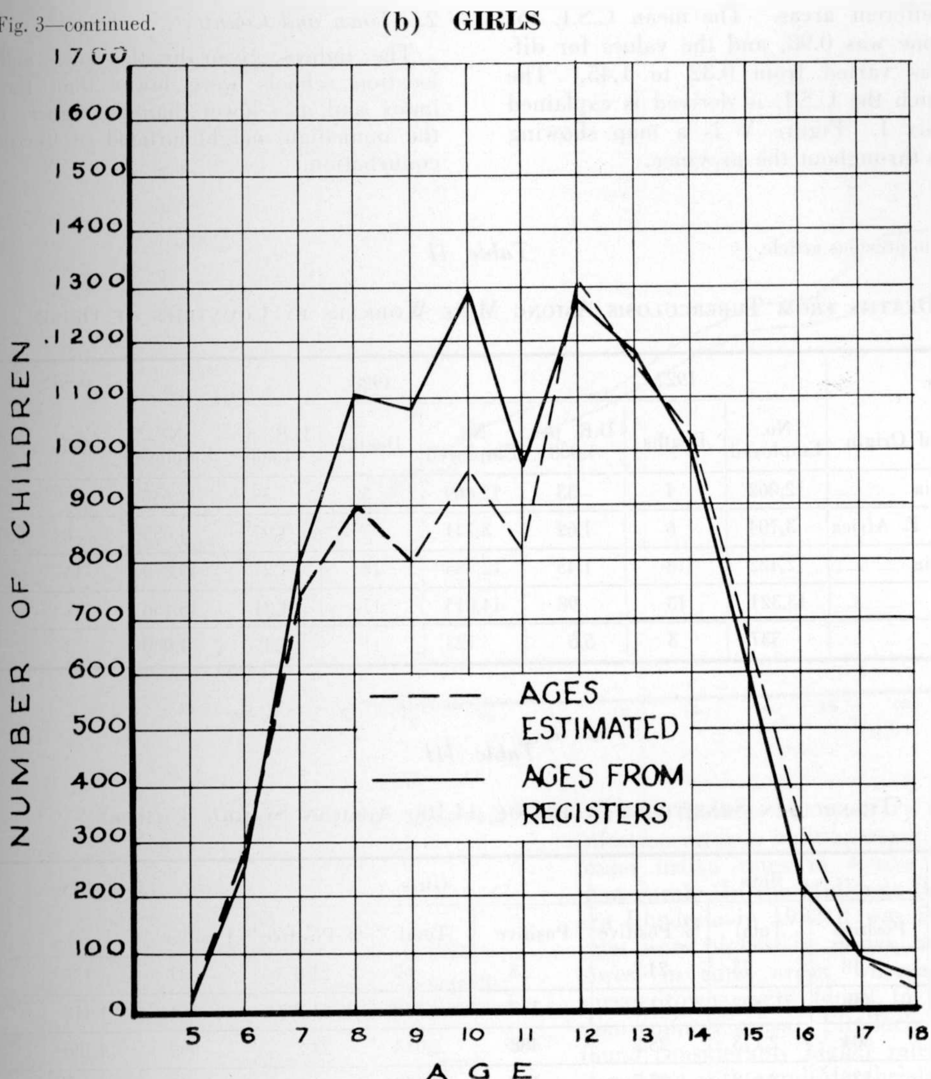
Fig. 3—Age distribution of school children. Curves obtained by estimating and by taking ages in school registers.

(a) **BOYS**



Note.—"Ages estimated" numbers are multiplied by four to make the curves comparable in size.

Fig. 3—continued.



NOTE.—"Ages estimated" numbers are multiplied by four to make curves comparable in size.

bacillus and one case had been found in the Union of South Africa. Martinaglia *et al.* (1957) believed they had found the first recorded pulmonary case in South Africa. According to Davies (1952), no case of non-pulmonary tuberculosis, judged by numerous specimens both from biopsies and autopsies, had in Tanganyika been due to the bovine bacillus.

1. *Age and Sex*

Table III and Figure IV show the rates in boys and girls from ages five to 18. There is a steady rise through the age groups, and the rate for boys throughout is slightly higher than that for girls. The high rate for children aged five may be partly due to the small numbers and partly to selection—a number being pre-school children brought along by their parents.

Standardisation.—To eliminate the effects of age and sex when comparing other factors, a figure called the Comparative Sensitivity Index (C.S.I.) was introduced. This is a single figure varying round 1.00 which enables an easy comparison to be made between the standardised rates in different areas. The mean C.S.I. for all tests done was 0.98, and the values for different areas varied from 0.32 to 1.45. The way in which the C.S.I. is derived is explained in Appendix I. Figure V is a map showing the indices throughout the province.

2. *Town and Country*

The indices given by the town and village location schools were lower than the overall index and also lower than the figures found in the immediate neighbourhood of the particular conurbation.

Please refer to previous article.

Table II

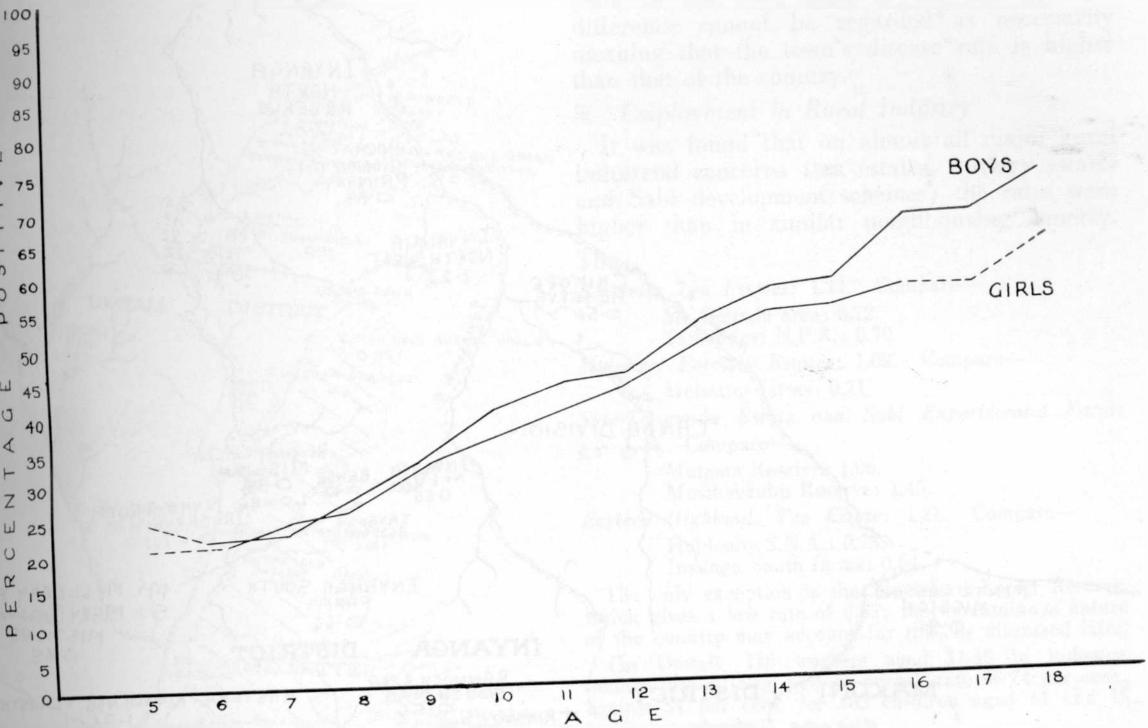
Deaths from Tuberculosis Among Mine Workers by Countries of Origin

Country of Origin	1927			1928			1929		
	No. Employed	Deaths	D.R. per 1,000	No. Employed	Deaths	D.R. per 1,000	No. Employed	Deaths	D.R. per 1,000
S. Rhodesia	12,062	4	.33	12,669	5	.39	12,645	5	.40
Portuguese E. Africa	3,704	6	1.62	3,741	7	1.97	4,055	8	1.97
N. Rhodesia	12,422	18	1.45	12,555	16	1.27	13,875	13	.94
Nyasaland	13,321	13	.98	14,015	17	1.21	15,156	17	1.12
Other	537	3	5.6	723	1	1.4	1,080	1	.9

Table III

Tuberculin Sensitivity Rates of 44,106 African School Children

Age	Boys			Girls			Both Sexes		
	Positive	Total	% Positive	Positive	Total	% Positive	Positive	Total	% Positive
5	18	73	24.7	13	62	21.0	31	135	23.0
6	146	683	21.4	155	730	21.2	301	1,413	21.3
7	504	2,173	23.2	488	2,013	24.2	992	4,186	23.7
8	725	2,618	27.7	632	2,370	26.7	1,357	4,988	27.3
9	843	2,499	33.7	722	2,244	32.2	1,565	4,743	33.0
10	1,190	2,971	40.0	917	2,544	36.0	2,107	5,515	38.2
11	987	2,272	43.5	720	1,860	38.7	1,707	4,132	41.3
12	1,372	3,087	44.4	1,019	2,373	42.9	2,391	5,460	43.8
13	1,398	2,710	51.5	985	2,047	48.1	2,383	4,757	50.1
14	1,377	2,456	56.1	835	1,583	52.7	2,212	4,039	54.7
15	858	1,498	57.3	491	920	53.4	1,349	2,418	55.8
16	593	898	66.0	208	370	56.2	801	1,268	63.2
17	330	495	66.7	89	158	56.3	419	653	64.2
18	211	290	72.7	68	109	62.4	279	399	69.9
All Ages	10,552	24,723	42.7	7,342	19,383	37.9	17,894	44,106	40.6



In the following sections Native areas are designated as follows:

Reserve: Native Reserve.

S.N.A.: Special Native Area.

N.P.A.: Native Purchase Area.

In the first two of these land is farmed communally; in the third it has been divided into farms owned individually.

Figures obtained for the three main centres were:

Umtali town: 0.88. Compare—

Zimunya Reserve: 1.03.

Rowa N.P.A.: 1.20.

Nutwell S.N.A. and Jenya Reserve: 1.20.

Umtasa South Reserve: 1.21.

Rusape town: 0.82. Compare—

Chiduku Reserve: 1.16.

Manyika Reserve: 1.22.

Makoni Reserve: 1.09.

Chipinga town: 0.72. Compare—

Tamandayi N.P.A.: 0.70.

Chikore (Mission Land): 0.76.

Mount Selinda (Native area adjacent to mission): 0.72.

These findings are contrary to usual ideas of infection rates in built-up areas. Haynes (1951) found urban rates in Kenya generally higher than rural. In the Midlands Province of Southern Rhodesia in 1953 it was found that reactor rates were highest on mines, next in towns, and lowest in rural areas, whereas in the present survey towns were found to have lower rates than country areas. Similarly, Webster (1954) found considerably higher rates in Bulawayo as compared with rural Matabeleland. *The Central African Journal of Medicine* (1957), on the other hand, does quote figures from the Belgian Congo and Ruandi Urundi showing slightly higher rates in the latter area (50 per cent.) than in Leopoldville (48 per cent.). The disease rate, also, was higher—twice as high—in the Ruanda Urundi as in Leopoldville.

Urban and Rural Disease Rates.—An analysis of the notifications of tuberculosis in the Eastern Province for 1958 shows 50 cases out of a population of 29,000 for Umtali municipality (172/100,000) as compared with 434 cases out of about 400,000 population for the remainder of the province (108/100,000). When one considers that ascertainment is probably more com-

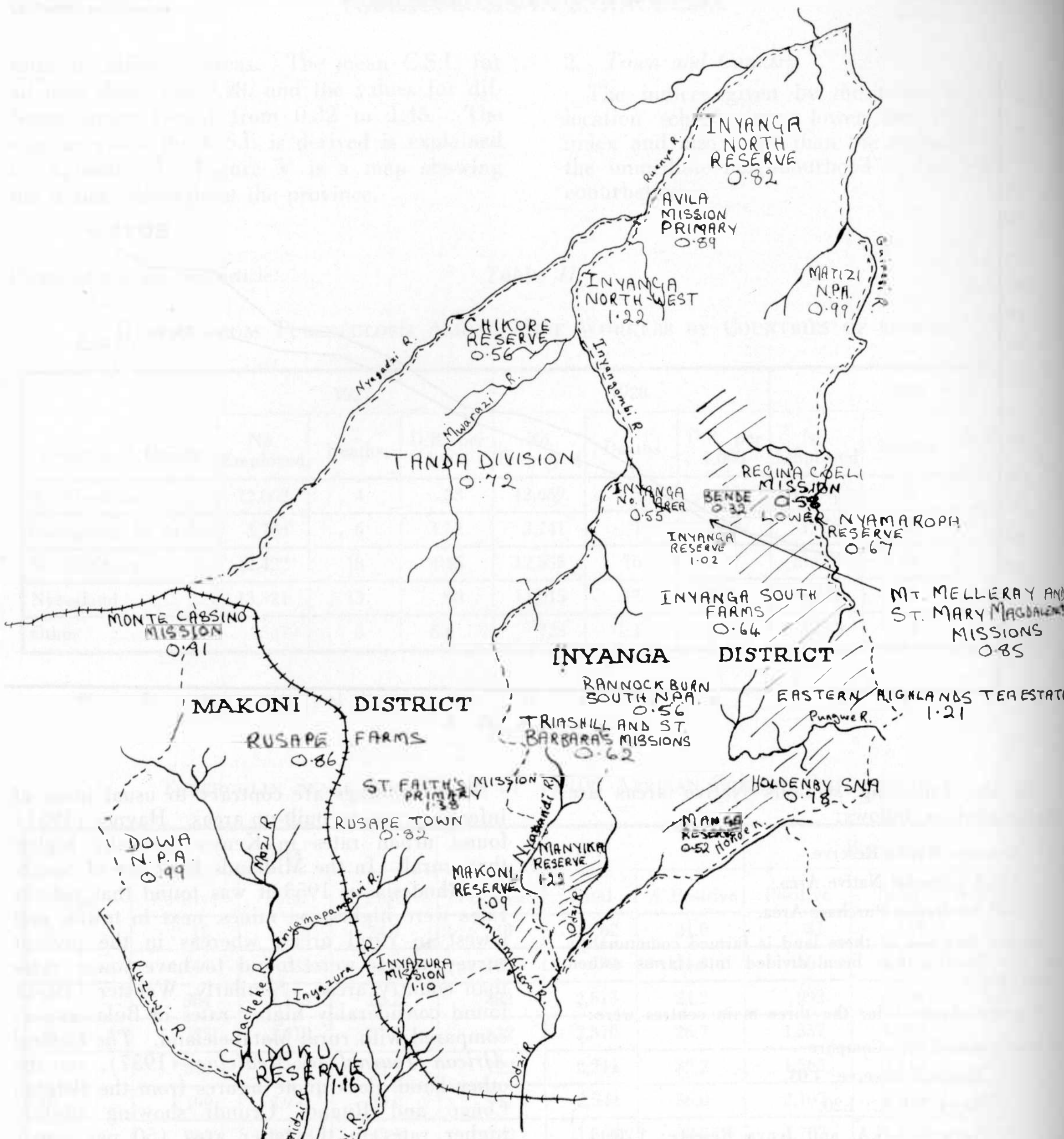
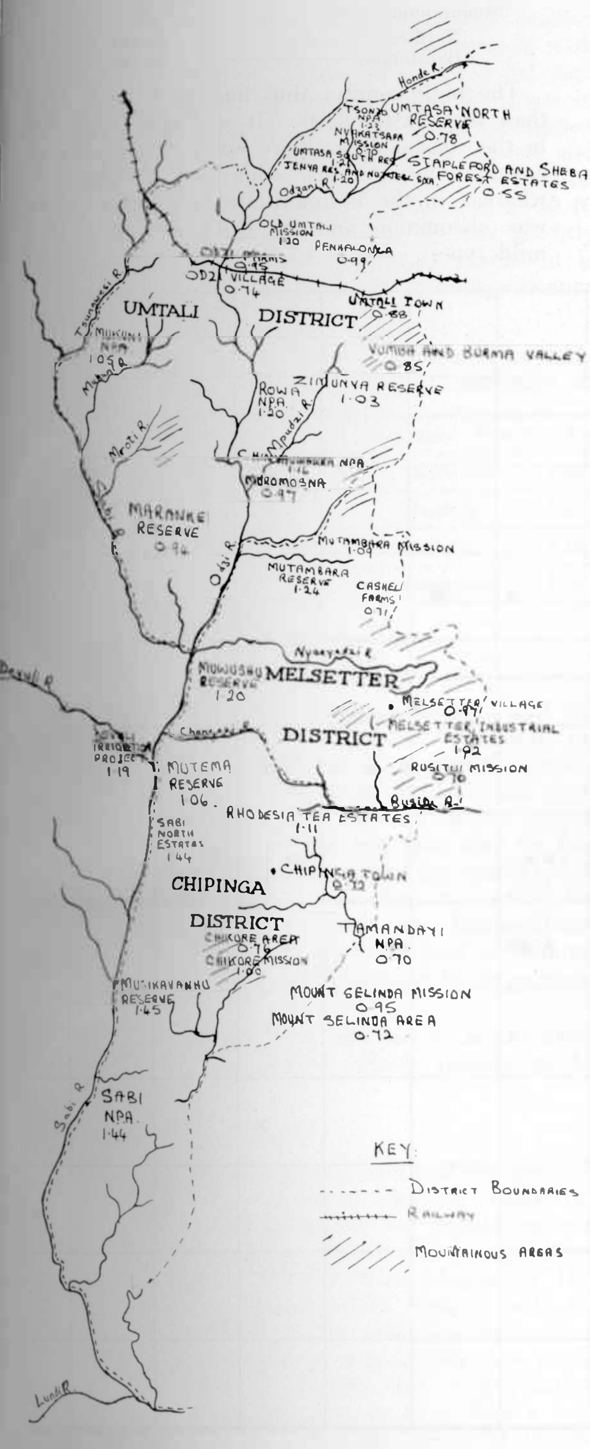


Fig. 5—Map showing C.S.I.s (a) Inyanga and Makoni districts.



. 5 (contd.)—Map showing C.S.I.s (b) Umtali, Melsetter and Chipinga districts.

plete in the town than in the country, this difference cannot be regarded as necessarily meaning that the town's disease rate is higher than that of the country.

3. *Employment in Rural Industry*

It was found that on almost all major rural industrial concerns (tea estates, forestry estates and Sabi development schemes) the rates were higher than in similar neighbouring country. Thus:

Rhodesia Tea Estates: 1.11. Compare—
Mt. Selinda area: 0.72.
Tamandayi N.P.A.: 0.70.

Melsetter Forestry Estates: 1.02. Compare—
Melsetter farms: 0.71.

Sabi-Tanganda Estate and Sabi Experimental Farm: 1.44. Compare—
Mutema Reserve: 1.06.
Musikavanhu Reserve: 1.45.

Eastern Highlands Tea Estate: 1.21. Compare—
Holdenby S.N.A.: 0.78.
Inyanga South farms: 0.64.

The only exception is the Stapleford Forest Reserve, which gives a low rate of 0.55; the mountainous nature of the country may account for this, as discussed later.

(In Umtali, 116 workers aged 11-15 in industry, mainly jute milling, had an overall rate of 74 per cent., against 51 per cent. for 183 children aged 14 and 15 in Umtali schools.)

4. *Employment on Farms*

Employment on European farms, on the other hand, does not increase rates:

Rusape area farms: 0.86. Compare—
Chiduku Reserve: 1.16.
Dowa N.P.A.: 0.99.
Makoni Reserve: 1.09.

Cashel farms: 0.71. Compare—
Mutambara Reserve: 1.32.

(Though this difference is partly due to altitude.)

Odzi farms: 0.89. Compare—
Maranke Reserve: 0.94.
Makoni Reserve: 1.09.
Chiduku Reserve: 1.16.

Inyanga farms: 0.64. Compare—
Inyanga Reserve: 1.02.
Bannockburn South N.P.A.: 0.56.

5. *Altitude*

For this and all the subsequent studies, towns, villages, rural industrial concerns and farm schools have been excluded because of their different conditions and the bias that these have been shown to cause in the rates. Mission central schools also have had to be excluded, as they take boarders from many parts of the country and so would not be representative of the particular area. Thus we are now concerned only with Native areas, which include Native reserves, Native purchase areas and Special

Native areas. The number of children involved is about 26,000 and the overall C.S.I. is 0.98.

Allan (1932) studied reactor rates in two coastal areas of the Transkei and in two adjacent mountainous areas over 5,000 feet. The rates, when standardised for ages, compare as follows:

Coastal:

Southern Transkei	74 per cent.
Eastern Transkei	81 per cent.

Mountainous:

Northern Transkei	40 per cent.
Basutoland	40 per cent.

The high country thus has much lower rates than the coastal parts. It was also found that in the coastal areas there was a fair amount of endemic tuberculosis, some of it "chronic"; whereas in the high-altitude group tuberculosis was uncommon and the cases seen were of a mild type.

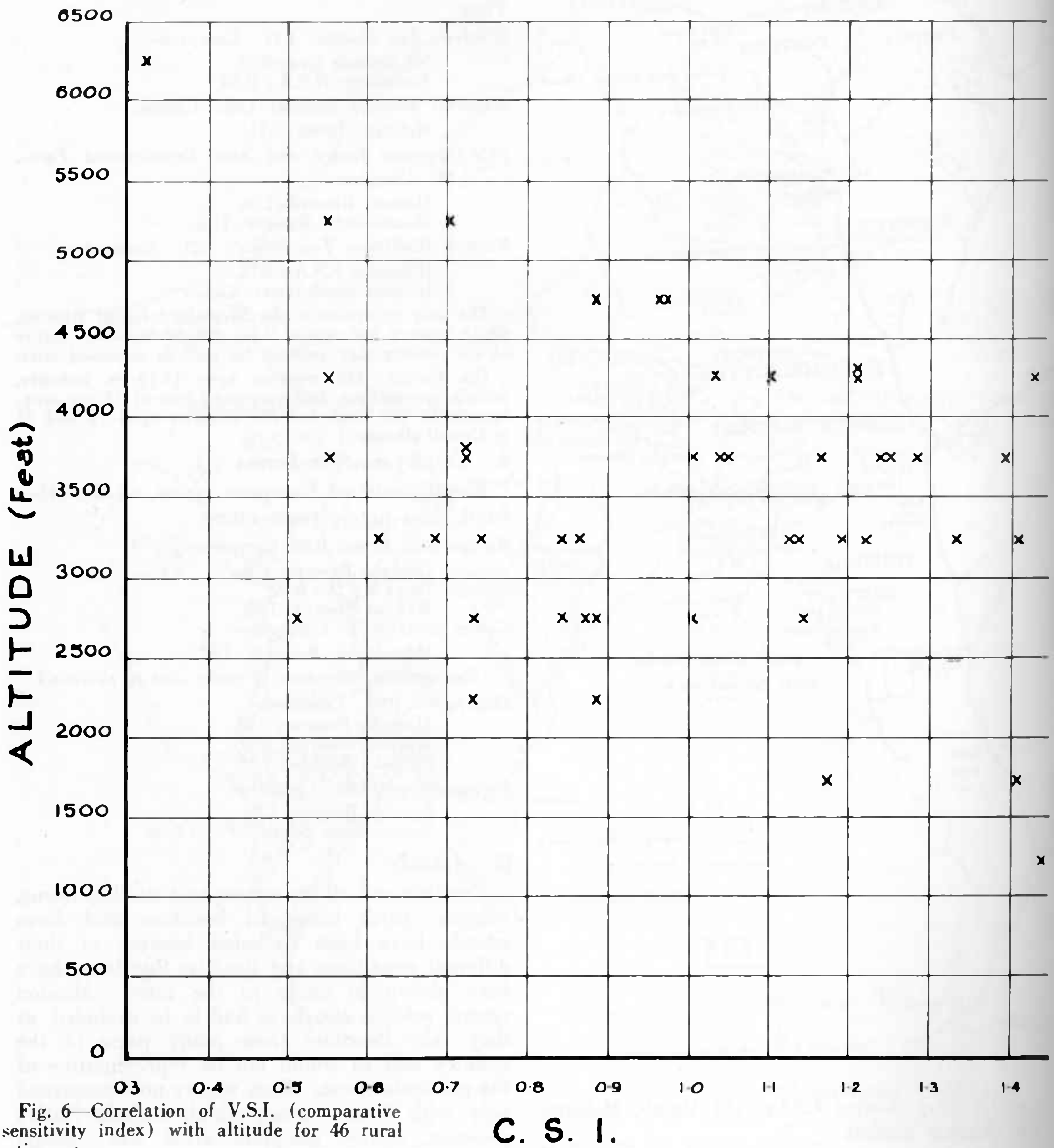


Fig. 6—Correlation of V.S.I. (comparative sensitivity index) with altitude for 46 rural native areas.

In the present investigation 46 areas were defined, each covering a 500-ft. altitude bracket and each comprising a group of schools with similar geographical conditions. The C.S.I. and altitude for each of the 46 areas are given in Appendix II. Figure VI shows the correlation between C.S.I. and altitude. At the lowest and highest altitudes a strong negative correlation is seen, whereas between 2,500 ft. and 4,500 ft. this does not exist and is even in fact slightly reversed. The overall correlation coefficient is —.330, a significant result (the 1/20 significance level is —.263).

The effect at the highest and lowest levels is probably due to the lowering of resistance at low altitudes due to the oppressive heat and the prevalence of parasitic diseases. The high infection rates are then due to the large number of infectious cases arising from within the community. In the very highest area (upper Nyamaropa Reserve) the low rate may be due to the remoteness of this part of the country, but this does not apply to the next two areas (at 5,000 to 5,500 ft.), which are Bannockburn South S.N.A. and the northern part of Makoni Reserve, both close to the Rusape-Inyanga main road.

At intermediate levels the picture is obscured, possibly by the factors which remain to be considered.

6. *Population Density*

The same 46 areas were used and the approximate population densities derived from the Native Department's figures for population and area of each Native reserve, Native purchase area and special Native area (Appendix II). The method is, unfortunately, fraught with inaccuracies. There is the difficulty of making satisfactory estimates of populations, the possibility of different results for a population differently arranged, such as in a Native purchase area, and the fact that many of the 46 areas overlapped two of the defined Native areas, making it necessary to estimate an average population density over the two. Lastly, and probably the greatest difficulty of all, is the likelihood that the actual mode of life, sleeping habits, ventilation and hygiene, are more likely to affect the infection rate than the number of persons per acre. This is borne out by the comparatively low rates found in the towns.

Under the circumstances it is perhaps not surprising that the correlation coefficient was only +.115 against a significance level of +.291, i.e., this could easily have happened by chance.

The Sabi Valley irrigation projects are more densely populated than the reserves in general, but they do not show high C.S.I.s compared with ordinary adjacent areas:

Altitude (Feet)	Irrigation Project Areas	Adjacent Non-Irrigation Areas
1,000-1,500	Chibuwe: 1.44	—
1,500-2,000	Mutema: 1.06	Sabi N.P.A. North: 1.41
	Devuli: 1.19	—
	Nyanyadzi: 1.20	—
2,000-2,500	—	—
2,500-3,000	—	Odzi Valley East: 1.14

It is probable that the high population densities on the projects are compensated by improved conditions of housing and more hygienic habits.

7. *Remoteness*

Certain parts of Manicaland have had comparatively little contact with the outside world. This fact is well reflected in the reactor rates. In the extreme north of Makoni district is the low-lying Chikore Reserve, where the C.S.I. was only 0.56, and in Tanda N.P.A. just south of this it was 0.72. In Upper Nyamaropa Reserve, as mentioned before, the lowest rate (0.32) was found; on the slopes below this, 0.55, and in Lower Nyamaropa Reserve, which has recently been opened up, 0.72. All these rates are lower than would be expected from the general rates for similar climatic conditions.

Unfortunately one of the most interesting remote areas, the lower Sabi river, was tested only by the Heaf method. This was done using old tuberculin in a dilution of 1/15 instead of pure O.T., as with the conventional Heaf test. The method has been extensively tested against the Mantoux 5 T.U., and although there is not complete agreement in individual cases, the overall rates obtained are approximately the same. It is therefore significant that the Heaf 1/15 test gave a C.S.I. of only 0.75 in this area, whose altitude is 500-1,000 feet. In the immediately adjacent areas, the northern part of the Sabi N.P.A. and Musikavanhu Reserve the C.S.I.s were 1.41 and 1.45 respectively. It is clear then that with all other conditions predisposing to a high reactor rate, this area has a low rate because it has not yet been well infected with tuberculosis.

One other area of Manicaland is somewhat remote; this is Inyanga North Reserve in the extreme north of the province. Its C.S.I. of 0.82 is therefore higher than one would expect. However, altitudes vary here from 1.500 to 3,000 feet, so that the rate of infection, once introduced, is likely to be high.

An attempt was made to assess numerically the effect of remoteness on the C.S.I. While doing the tests it was observed that in the most primitive places there were very few girls at school. Hence for the 46 areas the C.S.I.s were plotted against the boy/girl ratios, which are also given in Appendix II. The results were disappointing, giving an insignificant correlation coefficient of —.077. There was a moderate relationship up to a boy/girl ratio of 1.9, but the three boy/girl ratios which fell above this (2.3, 2.5 and 3.6) erred very badly on the side of a high C.S.I.

Combined Influence of Altitude, Population Density and Remoteness (Boy/Girl Ratio)

A multiple correlation coefficient was calculated, plotting the C.S.I. against the combined effect of altitude, population density and the boy/girl ratio. The combined coefficient is .460, which is significant, as would be expected ($F = 3.77$; at 1/20 level of significance $F = 2.9$).

The combined effect of the three factors on the C.S.I. can be plotted out roughly on a graph by measuring each variable in "standard deviation units" and finding the mean, for each of the 46 C.S.I.s, of the three points. The C.S.I. is then plotted against the number of "S.D. units" which represent the combined effect of the three variables. This method is not accurate statistically, but it has the advantage that it pinpoints those of the 46 areas which deviate greatly from the regression line. The graph formed is shown in Fig. VII.

Other Factors Which Have Not Been Allowed For

If we were able to consider every influence affecting the tuberculin reactor rate we should obtain a multiple correlation coefficient of 1 and the 46 points would all lie on a straight line. The degree of scatter remaining shows the extent to which we have failed to allow for certain factors.

(1) *Influence of Population Density and Remoteness Does Not Extend Above Certain Levels.*—There are six points scattered round the very periphery of the combined chart (Fig. VII) which represent the three highest population density levels and the three highest boy/girl ratios. If we had assumed that boy/girl ratios above 2.0 cause no further decrease in the C.S.I., and that similarly population densities above 0.15 persons per acre cause no further increase (as is suggested by the correlation of these, respectively, with C.S.I.), all these points would fall reasonably near the regression line.

(2) *Hilliness.*—It appears that if the countryside is hilly, as opposed to being of high altitude, the infection rate tends to be reduced.

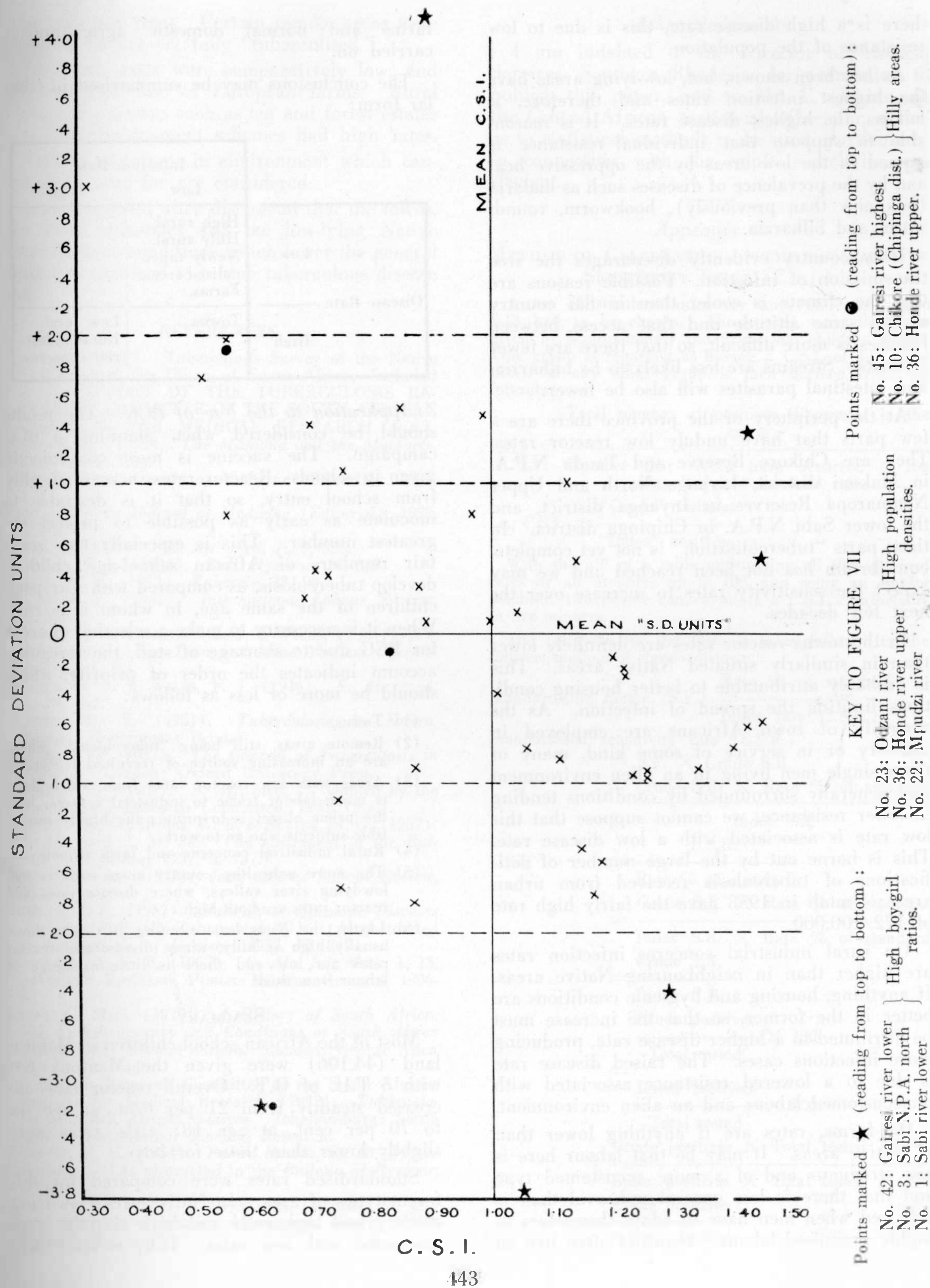
Thus Manga Reserve, in the upper Honde valley, has a rate of 0.61; Chikore (Chipinga district), overlooking the Sabi valley, gives 0.84; the eastern slopes of Upper Nyamaropa Reserve 0.55. The first two of these rates are lower than would be expected from the combined correlation graph (Fig. VII). In the eastern mountainous part of Manyika Reserve the C.S.I. is 1.01 as compared with adjacent areas of similar altitude; Manyika Reserve as a whole 1.22, Tsonzo N.P.A. 1.23, and Umtasa South Reserve 1.21. The eastern very mountainous part of Stapleford Forest Reserve is set aside for employees and their families; conditions are thus more like a Native reserve than on other forest estates. Although this is an industrial concern, it has a very low C.S.I. of 0.55, which may well be associated with the mountainous nature of the country.

(3) *Moving of Populations.*—There is constant resettlement of Africans from one area to another. For instance, the southern part of Inyanga North Reserve about four years ago received an influx of people from the area of Bonda Mission, Inyanga, which has been made European land. Under-populated areas, such as eastern Holdenby on the lower Honde river and parts of Maranke Reserve, are being filled with people from over-populated parts; this is a likely explanation of the unexpectedly low C.S.I. for eastern Holdenby, whose altitude is 2,000 to 2,500 feet (Fig. VII).

(4) *Mode of Living.*—Probably the most important factor not considered is the number of persons per hut, proximity of beds, ventilation, eating habits and hygiene-consciousness of the people. These imponderables must have a considerable influence on the rate of spread of infection.

Discussion and Conclusions

It is evident that in most of Manicaland tuberculous infection has been thoroughly introduced and has reached a state of equilibrium with the population. In the country areas, therefore, a high infection rate, in general, is an indication of a high disease rate, since it means there are more infectious cases in the community. (This generalisation is subject to the limitation that we do not know in what areas poor housing conditions, bad sleeping habits and lack of hygiene are most prevalent; these would increase the infection rate without necessarily affecting the disease rate.) Where


MEAN C.S.I.
MEAN "S.D. UNITS"
STANDARD DEVIATION UNITS
C.S.I.
KEY TO FIGURE VII
Points marked ● (reading from top to bottom):
No. 15: Gairesi river highest
No. 10: Chikore (Chipinga dist.)
No. 36: Honde river upper.
Hilly areas.
No. 23: Odzani river
No. 36: Honde river upper
No. 22: Mudzi river
High population densities.
Points marked ★ (reading from top to bottom):
No. 42: Gairesi river lower
No. 3: Sabi N.P.A. north
No. 1: Sabi river lower
High boy-girl ratios.

there is a high disease rate, this is due to low resistance of the population.

As has been shown, hot, low-lying areas have the highest infection rates and therefore, it follows, the highest disease rates. It is reasonable to suppose that individual resistance is sapped in the low areas by the oppressive heat and by the prevalence of diseases such as malaria (less now than previously), hookworm, roundworm and bilharzia.

Hilly country evidently discourages the free transmission of infection. Possible reasons are that the climate is cooler than in flat country of the same altitude and that access between families is more difficult, so that there are fewer contacts. Streams are less likely to be bilharzial and intestinal parasites will also be fewer.

At the periphery of the province there are a few parts that have unduly low reactor rates. They are Chikore Reserve and Tanda N.P.A. in Makoni district, Inyanga North and Upper Nyamaropa Reserves in Inyanga district, and the lower Sabi N.P.A. in Chipinga district. In these parts "tuberculisation" is not yet complete, equilibrium has not been reached and we may expect the sensitivity rates to increase over the next few decades.

In the towns reactor rates are definitely lower than in similarly situated Native areas. This is probably attributable to better housing conditions limiting the spread of infection. As the majority of town Africans are employed in industry or in service of some kind, many of them single men living in an alien environment and generally surrounded by conditions tending to lower resistance, we cannot suppose that this low rate is associated with a low disease rate. This is borne out by the large number of notifications of tuberculosis received from urban areas; Umtali in 1958 gave the fairly high rate of 172/100,000.

On rural industrial concerns infection rates are higher than in neighbouring Native areas. If anything, housing and hygienic conditions are better in the former, so that the increase must be attributed to a higher disease rate, producing more infectious cases. The raised disease rate is due to a lowered resistance associated with unaccustomed labour and an alien environment.

On farms, rates are if anything lower than in Native areas. It may be that labour here is less strenuous and of a more accustomed type and that there is less general upheaval than is required when men have to adapt themselves to highly organised labour. Families often live on farms and normal domestic agriculture is carried on.

The conclusions may be summarised in tabular form:

		Infection Rate	
		Low	High
Disease Rate	Low	High rural. Hilly rural. Newly tuberculised areas. Farms.	
	High	Towns.	Low rural. Rural industrial concerns.

Application to the Use of BCG.—The results should be considered when planning a BCG campaign. The vaccine is most conveniently given in schools. Reactor rates increase steadily from school entry, so that it is desirable to inoculate as early as possible to protect the greatest number. This is especially true since fair numbers of African school-age children develop tuberculosis, as compared with European children of the same age, in whom it is rare. When it is necessary to make a selection of areas for BCG due to shortage of staff, the foregoing account indicates the order of priority, which should be more or less as follows:

(1) Towns.

(2) Remote areas, still being "tuberculised," which are an increasing source of recruited labour.

(3) Areas with low reactor rates from which there is much labour traffic to industrial centres; here the prime object is to protect the highly susceptible subjects who go to work.

(4) Rural industrial concerns and farm schools.

(5) The more unhealthy country areas such as hot, low-lying river valleys, where disease rates and reactor rates are both high.

(6) Lastly, the parts least needing BCG are those, usually high or hilly, where disease and reactor rates are low and there is little exchange of labour from them.

Summary

Most of the African school children in Manicaland (44,106) were given the Mantoux test with 5 T.U. of O.T. Overall reactor rates increased steadily from 21 per cent. at age six to 70 per cent. at age 18; girls' rates were slightly lower than those for boys.

Standardised rates were compared for different types of area. In Native areas low-lying country had high rates and high altitudes were associated with low rates. Hilly country like-

wise gave low rates. Certain remote areas were found to be not yet fully "tuberculised."

In towns, rates were comparatively low, and this was true also of European farms. Rural industrial concerns such as tea and forest estates and Sabi development schemes had high rates.

Certain variations in environment which cannot be allowed for are considered.

It is concluded after discussion that the towns, the rural industries and the low-lying Native areas all have conditions which lower the general resistance and lead to a high tuberculous disease rate.

REFERENCES

Allen, P. (1932). Tuberculosis Survey of the Native Territories of the Union of South Africa. Included in the REPORT OF THE TUBERCULOSIS RESEARCH COMMITTEE OF THE SOUTH AFRICAN INSTITUTE FOR MEDICAL RESEARCH (*q.v.*).

Bullock, C. (1950). *The Mashona and the Matabele.* Cape Town: Juta.

Central African Journal of Medicine (Editorial), 1955, 1, 5.

Central African Journal of Medicine (Editorial), 1957, 5, 199.

Clark, M. (1951). *E. Afr. med. J.*, 9, 355.

Cummins, S. L. (1944). *Bull. Hygiene*, 11, 837.

Davies, H. N. (1952). *Tubercle*, 33, 98.

De Briey, P. (1945). *International Labour Review*, 52, 335.

Dormer, B. A., Friedlander, J. & Wiles, F. J. (1943). *Proceedings of the Transvaal Mine Medical Officers' Association*, 23, 71.

Dormer, B. A. & Wiles, F. J. (1946). *S. Afr. med. J.*, 20, 262.

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

Kayne, G. G. (1937). *The Control of Tuberculosis in England.* London: Oxford University Press.

MacVicar, N. (1907). *S. Afr. med. J.* Quoted by the Tuberculosis Research Committee, 1932 (*q.v.*).

Martingalia, G., Hobbs, W. B. & Blaine, M. G. (1957). *S. Afr. med. J.* 31, 339. (As abstracted in the *Bulletin of Hygiene*, 1957, 8, 737.)

Read, Margaret (1942). *International Labour Review*, 45, 605.

Rumeau, J. G. (1957). *Bulletin of Epizootic Diseases of Africa*, 1, 69 (English version, 21). (As abstracted in the *Bulletin of Hygiene*, 1957, 32, 842).

Singleton, A. C. B. (1957). *C. Afr. Jnl. Med.*, 1, 13.

Southern Rhodesia Public Health Reports, 1906-57.

Theal, G. McC. (1919). *A History of South Africa.* Vol. I: *Ethnography and Conditions of South Africa Before 1505.* Second edition. London: George Allen and Unwin, Ltd.

Tuberculosis Research Committee of the South African Institute for Medical Research (1932). *Tuberculosis in South African Natives.* Johannesburg: South African Institute for Medical Research.

Webster, M. H. (1954). *Public Health*, 18, 30 (Johannesburg). (As abstracted in the *Bulletin of Hygiene*, 6, 599).

Wilcocks, C. (1953). *J. Royal San. Institute*, 73, 480.

World Health Organisation Monograph No. 12, 1953. Geneva: W.H.O.

Acknowledgments

I am indebted to the Director of Medical Services, Southern Rhodesia, for permission to publish this paper, and to Mr. E. Osborn, of the Central African Statistical Office, for advice as to statistical methods to be used, particularly in connection with the triple correlation coefficient.

Appendix I

Method of Calculation of the Comparative Sensitivity Index (C.S.I.)

A set of standard rates for boys and girls aged 5-18 had to be chosen. Those used were the rates given by approximately the first 6,000 children tested. This group is regarded as having a C.S.I. of 1.0. The C.S.I. of any other group is then derived from the formula:

$$\text{C.S.I.} = \frac{\text{Total number of positives discovered in the group}}{\text{Number that would have occurred if the group had had standard rates}}$$

$$\text{i.e., C.S.I.} = \frac{\text{"Crude" positives}}{\text{"Index" positives.}}$$

With the aid of a table multiplying all the standard rates by all numbers up to 100, and using an adding machine, two people can calculate a C.S.I. comfortably in five minutes.

The rationale for the formula is as follows: in the indirect method of standardising:

$$\text{Standardising factor (S.F.)} = \frac{\text{Rate \% of standard}}{\text{Index rate (I.S.R.)}}$$

Standardised sensitivity rate (S.S.R.)

$$= \text{S.F.} \times \text{Crude S.R.}$$

$$= \frac{\text{Crude S.R.} \times \text{Rate \% of standard}}{\text{Index S.R.}}$$

$$\text{C.S.I.} = \frac{\text{S.S.R.}}{\text{Rate \% of standard}}$$

$$= \frac{\text{Crude S.R.} \times \text{Rate \% of standard}}{\text{Index S.R.} \times \text{Rate \% of standard}}$$

$$= \frac{\text{Crude S.R.}}{\text{Index S.R.}}$$

$$= \frac{\dfrac{\text{Crude positives}}{\text{Total tested}} \times 100}{\dfrac{\text{Index positives}}{\text{Total tested}} \times 100}$$

$$= \frac{\text{Crude positives} \times \text{Total tested} \times 100}{\text{Index positives} \times \text{Total tested} \times 100}$$

$$= \frac{\text{Crude positives.}}{\text{Index positives.}}$$

Appendix II

C.S.I., Altitude, Population Density, Boy-Girl Ratio and Numbers of Children Tested in 46 Rural Native Areas

Area	Serial No.	No. of Children Tested	C.S.I.	Altitude (1,000's of feet)	Boy-Girl Ratio	Population Density per Acre
Sabi river lower	1	871	1.44	1.0-1.5	2.5	0.08
Sabi river middle	2	1,310	1.17	1.5-2.0	1.2	0.07
Sabi N.P.A. north	3	445	1.41	1.5-2.0	2.3	0.04
Sabi river upper	4	326	0.87	2.5-3.0	1.4	0.05
Mukuni river lower	5	577	0.98	2.5-3.0	1.2	0.04
Mukuni river upper	6	660	1.19	3.0-3.5	1.0	0.06
Mroti river	7	467	1.41	3.0-3.5	0.9	0.06
Sabi valley east	8	455	1.13	3.0-3.5	1.3	0.06
Mount Selinda	9	544	0.74	3.0-3.5	1.6	0.06
Chikore (Chipinga area)	10	705	0.84	3.0-3.5	1.4	0.10
Macheke river lower	11	592	0.86	3.0-3.5	1.2	0.12
Macheke river upper	12	917	1.16	3.5-4.0	1.0	0.12
Mazi river	13	566	1.03	4.0-4.5	1.2	0.12
Inyamapamberi river	14	582	1.21	4.0-4.5	1.0	0.12
Inyazura river	15	726	1.25	3.5-4.0	0.9	0.12
Nyamidzi river	16	979	1.33	3.0-3.5	1.2	0.12
Odzi river lower (west)	17	589	0.73	2.5-3.0	1.0	0.06
Odzi river upper (west)	18	901	0.68	3.0-3.5	1.2	0.06
Odzi river lower (east)	19	1,053	1.14	2.5-3.0	1.1	0.11
Odzi river upper (east)	20	1,397	1.22	3.0-3.5	1.0	0.10
Odzi river intermediate	21	313	1.00	3.5-4.0	1.0	0.10
Mpudzi river	22	887	1.04	3.5-4.0	1.1	0.29
Odzani river	23	782	1.28	3.5-4.0	1.2	0.23
Inyamajura river lower	24	576	1.05	3.5-4.0	1.1	0.13
Nyatandi river lower (west)	25	491	1.25	3.5-4.0	1.1	0.14
Nyatandi river lower (east)	26	379	1.39	3.5-4.0	1.0	0.12
Inyamajura river upper	27	144	1.44	4.0-4.5	1.0	0.14
Nyatandi river upper (west)	28	582	1.10	4.0-4.5	0.9	0.14
Nyatandi river upper (east)	29	593	1.21	4.0-4.5	1.0	0.12
Makoni Reserve north lower	30	227	0.88	4.5-5.0	1.1	0.14
Makoni Reserve north upper	31	450	0.70	5.0-5.5	1.0	0.14
Odzi river higher	32	241	0.96	4.5-5.0	0.9	0.08
Odzi river highest	33	372	0.55	5.0-5.5	1.2	0.08
Honde river lower	34	299	0.73	2.0-2.5	1.5	0.11
Honde river upper	35	696	0.88	2.5-3.0	1.1	0.13
Honde river highest	36	432	0.61	3.0-3.5	1.1	0.23
Mwarazi river lower	37	306	0.51	2.5-3.0	1.9	0.03
Mwarazi river upper	38	540	0.72	3.5-4.0	1.4	0.05
Inyangombi river lower	39	346	1.12	3.0-3.5	1.3	0.03
Inyangombi river upper	40	489	0.55	3.5-4.0	1.2	0.06
Inyangombi river highest	41	373	0.97	4.5-5.0	1.3	0.09
Gairesi river lower	42	321	0.88	2.0-2.5	3.6	0.03
Gairesi river upper	43	507	0.84	2.5-3.0	1.8	0.03
Gairesi river higher	44	616	0.72	3.5-4.0	1.2	0.08
Gairesi river highest	45	183	0.55	4.0-4.5	1.7	0.08
Bende uplands	46	247	0.32	6.0-6.5	1.2	0.08