CHAPTER IV.—THE TUBERCULOSIS OF NATIVE MINE-WORKERS ON THE WITWATERSRAND.

SECTION A.—TUBERCULIN TESTS.

1. PRELIMINARY STATEMENT OF OBJECTS OF ENQUIRY.

In this section of the enquiry undertaken by the Tuberculosis Research Committee the use and behaviour of tuberculin has been considered in the main from a rather novel standpoint. In most of the work in this field, tuberculin, apart from its use as a criterion of invasion by the virus of tuberculosis, has been studied either from the point of view of its value as an aid to diagnosis in cases of suspected tuberculosis or from the point of view of its value in the treatment and prognosis of recognized tuberculosis.

All the Natives dealt with in this section had, before being accepted for work underground, undergone a fairly stringent medical examination and been passed as in good physical condition and free from recognizable tuberculosis. In so far as we have used the tuberculin test as a means of learning whether the Natives brought their tuberculosis with them or found it on the mines, we have used the test as it has been used elsewhere, while we were breaking fresh ground in so far as we used the test in an attempt to learn what relation, if any, the result of this test had to resistance to infection and to resistance against virulence* in the event of a subject, free from clinical evidence of tuberculosis, succumbing to infection.

We sought for information bearing on the following questions :—

(1) What proportion of the Natives engaged for work on the Witwatersrand gold mines arrive already invaded by the virus of tuberculosis as evidenced by a tuberculin test ? Are the Natives acquiring tuberculosis *de novo* on the mines or are they either lighting up unrecognized but pre-existing foci or being super-infected ?

(2) Under our conditions, is the Native mine-boy who yields a positive reaction to the tuberculin test *more* or *less* likely to develop tuberculosis than is the Native mine boy yielding a negative tuberculin reaction ?

(3) Under our conditions, will a Native mine boy yielding a *positive* tuberculin reaction—should he develop tuberculosis—usually present the " modified "† as opposed to the " natural "† type ?

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* The term "virulence " as used in this section of the Report implies the capacity of the micro-organism to produce extensive, rapid and grave development of the tuberculous infection.

† The terms "natural " and " modified " were adopted from Professor Lyle Cummins. By " natural tuberculosis " is to be understood a generalized disease running a more or less acute course, while by " modified tuberculosis " is to be understood a local disease running a more or less chronic course.

(4) Under our conditions, will a Native mine boy yielding a *negative* reaction to tuberculin—should he develop tuberculosis—usually present the " natural " as opposed to the " modified " type ?

(5) In the case of positive reactors, is there any *quantitative* relation between the degree of the reaction and liability to tuberculosis or to type of an after-coming tuberculosis ?

It was assumed that a positive reaction signified that invasion by the virus of tuberculosis had taken place, while a negative reaction signified that the subject was virgin from the tuberculosis point of view.

It was recognized that, under experimental conditions, animals that have been inoculated with the virus of tuberculosis react to tuberculous infection after a manner different from animals that are virgin from the tuberculosis point of view.

It was supposed, on the strength of data acquired from the study of tuberculosis in the European, that tuberculosis in the virgin subject tends to take the natural, general and acute form, while the tuberculosis of the subject already invaded tends to take the modified, local and chronic form.

From the standpoint of infectivity, it was further supposed, also on the strength of data acquired from the study of tuberculosis in the European, that given conditions favourable to invasion, the subject that was virgin from the tuberculosis point of view was more likely to develop tuberculosis than was the subject already invaded by the virus of tuberculosis.

2. Summary Statement of Outcome of Enquiry.

The results of these investigations show that over 72 per cent. of the Native labour force apply for engagement already invaded by the virus of tuberculosis as judged from their response to a single intradermal test with one-tenth of 1 c.c. of 1/5,000 old tuberculin. Repeated tests with stronger solutions of tuberculin would probably show that 90 per cent. of the boys applying for engagement are bringing their tuberculosis with them to the extent of giving a positive response to the tuberculin test.

Boys yielding a positive reaction to this test are more likely to develop a recognizable tuberculosis than are boys yielding no response to the test. The possession of tuberculo-allergy is associated with lowered resistance against infection and the greater the tuberculo-allergy the less the resistance against infection.

The common form of tuberculosis is a generalized or " natural " tuberculosis, whether the response to the test was originally positive or negative. The septicæmic type of tuberculosis arises most frequently in the negative reactors, so the possession of tuberculo-allergy is associated with some resistance to virulence but not, as a rule, with sufficient resistance to localize tuberculosis. Such localized tuberculosis as does occur is most common in subjects showing tuberculo-allergy.

The possession of tuberculo-allergy while associated with lowered resistance against infection is not associated to any useful extent with the ability to modify an after-coming tuberculosis. While there is definite evidence of a quantitative relation between degree of reaction and liability to infection, there is no very definite relation between degree of reaction and type of an after-coming tuberculosis. Chronic localized tuberculosis occurs in a minority of cases and is met with in two forms. The one is chronic pulmonary tuberculosis; this state is, in mine-boys, practically always associated with silicosis and presents no relation to degree of tuberculo-allergy as far as our evidence goes. The other is local glandular tuberculosis, *e.g.*, glands of neck; this type is slightly more common in subjects presenting a strongly positive reaction. The common type of tuberculosis is the generalized or "cancer-type"* and its occurrence seems to be independent of the degree of tuberculo-allergy presented.

3. PREPARATORY WORK.

The satisfactory conduct of this enquiry entailed decisions on the following points :—

(*a*) The tuberculin to be used.

(*b*) The method of performing the inoculation.

(*c*) The strength of tuberculin to be used.

(*d*) Arrangements for the making of the test and for the recording of the results secured.

(*e*) Arrangements for the "follow-up" of subjects in the tuberculin-test group and recording date of recognition of tuberculosis in the event of its occurrence, with, as far as possible, the type of tuberculosis that had arisen.

(*a*) *The Tuberculin to be Used.*—There are various tuberculins on the market and, since it was desirable that the same preparation should be used throughout, a test was made of the various "makes" available. The trial took the form of carrying out the ordinary Von Pirquet test by scarification on various subjects. Both Europeans and Natives were submitted to this procedure. Many of the preparations were unsatisfactory, and it was learnt as the result of enquiry overseas that this was a familiar experience. At length, on the advice of Dr. Peter Allan, trial was made of the tuberculin of Messrs. Lucius and Brüning, and it was found to be satisfactory. Later on, Professor Lyle Cummins supplied the Sub-Committee with tuberculin prepared by Dr. R. A. O'Brien, of Messrs. Burroughs and Wellcome's laboratories. This tuberculin was perfectly satisfactory in use and behaved as did the preparation already adopted. As work had already been started with the Lucius and Brüning tuberculin, it was decided to continue to use it.

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* By "cancer-type" is implied the type of generalized tuberculosis with implication of lymphatic glands and caseating granulomata in the abdominal organs in addition to the pulmonary lesions. It is the same as Aschoff's "Metastasizing tuberculosis."

(*b*) *The Method of Performing the Inoculation.*—After consultation with Professor Lyle Cummins and witnessing his demonstrations, it was decided to adopt the intra-dermal method as practised by Mendel, Mantoux, and others. In our opinion, this method gave the most clear-cut response and lent itself best to uniformity of procedure when tests had to be performed by various different workers. Moreover, the mine-boys would be going straight to underground work, and even trivial open wounds had to be avoided.

(*c*) *The Strength of Tuberculin to be Used.*—Several matters had to be considered in arriving at a decision on this point. Many different men were to be employed in the performance of these inoculations, the majority of them hospital assistants, medically unqualified. In the case of the staff of the depôt at Ressano Garcia, they were asked, on occasions, to carry out as many as a thousand inoculations in a day over and above their regular work. The risk of general reactions had to be reduced to a minimum and, when intra-dermal inoculations are being carried out against time, there is a risk of an occasional subcutaneous dose. While we were, of course, anxious to use such a strength of tuberculin as would yield a fair distribution into " positives " and " negatives " considering that our figures had to be based on single inoculations, other considerations compelled us to keep down the strength. In the end it was decided to make the dose one-tenth of 1c.c. of 1/5,000 old tuberculin to be injected into the skin of the forearm, the diluent being 0·5 per cent. phenol in normal saline. This is the initial procedure of Engel,[44] though this authority, in the event of a negative reaction, repeats inoculations of one-tenth of 1c.c with strengths increasing to a dilution of one in ten before he is prepared to assert that a subject is definitely negative. The above decision as to dosage was arrived at after more than 300 separate tests, the Sub-Committee having formed the opinion—an opinion which turned out to be erroneous by the light of subsequent experience—that if a positive reaction were not yielded to 1/5,000, it would not be yielded to 1/1,000. On the other hand, it was thought that positive reactions to 1/5,000 might be associated with negative reactions to 1/10,000, and this to a misleading extent. There is no doubt that, had a stronger solution been used, there would have been a higher proportion of " positives " than was actually secured. Other observers using full-strength tuberculin and the Von Pirquet scarification method have obtained up to 90 per cent. of positive reactors in a series. Furthermore, as will be seen from Dr. F. J. Allen's work at Witbank (see Appendix 4), a certain proportion of negative reactors, even with our procedure, will yield a positive response to a second test. This is, of course, quite in keeping with familiar experience of these tests. We do not think that our conclusions regarding the relationship of the tuberculo-allergy to infection by and resistance against the tubercle bacillus are vitiated to any serious extent by this admitted fallacy in distribution as between negatives and positives. While the group of negative reactors is too large and therefore gives too low a prevalence rate for tuberculosis arising therein, this is compensated to a considerable extent by the consequent crediting

of cases of tuberculosis to the negative group that would have gone to the positive group had we been able to carry out the test in a more rigorous manner. In this context note the increasing proportion of cases credited to the negative group with reduction in the strength of tuberculin used for the test.

As it was convenient to send out the tuberculin diluted ready for use, tests were made with a view to learning how long tuberculin diluted to 1/5,000 maintained full reactivity. A tuberculin diluted on a known date was tested from day to day against freshly-made dilutions. As a result of this investigation the Sub-Committee recommended that all preparations should be dated and that no preparation should be used that had been diluted for more than fourteen days. When a higher degree of dilution was decided upon these tests were repeated on each occasion. The very dilute solutions used at the end of the enquiry (1/100,000, 1/1,000,000 and 1/10,000,000) were issued once a week and, at Ressano Garcia, used within four days. Attention was called to the need for keeping diluted tuberculin in a cool, dark place.

It has been suggested that the diluting medium, 0·5 per cent. phenol in normal saline, might give pseudo-reactions on its own account. We did numerous controls to test this possibility, with negative result, and would add that in the course of this enquiry we secured nearly 33,000 definite negative reactions. In our opinion, as far as Native mine-boys are concerned, the diluting medium does not give misleading pseudo-reactions.

(*d*) *Arrangements for the Performance of the Test and for the Recording of the Results Secured.*—After consultation with Dr. Bostock, manager for the Witwatersrand Native Labour Association at Lourenço Marques, and with Dr. Pinto Coelho, their senior medical officer, it was decided that all East Coast boys passing through Ressano Garcia should have the intra-dermal test performed on them by the staff of the hospital there. The procedure was under the control of Dr. Gama Rodrigues, resident medical officer. All boys who received the test-inoculation had their passes marked with a rubber stamp. These boys reached the Witwatersrand Native Labour Association depôt at Johannesburg within, at most, 60 hours of receiving their intra-dermal inoculation. All boys inoculated were seen there and the nature of the response recorded in the space provided on the mark stamped on the pass at Ressano Garcia (over 90 per cent. of this group were recorded by one observer). The staff at Ressano Garcia performed 74,987 separate inoculations and it is a great testimonial to their skill and care that not a single case arrived at Johannesburg presenting a definite general reaction. Over 38,000 of these boys received 0·1c.c. of the 1/5,000 dilution or 0·02c.mm. of old tuberculin, a dose sufficient to set up a general reaction in a susceptible subject if given subcutaneously. Some boys were found to be feverish on arrival at the Witwatersrand Native Labour Association depôt 24 hours to 48 hours after their inoculation, but these febrile attacks were no more common in positive reactors than in negative reactors, and no more common in the tuberculin-test group than in boys who had not been subjected to the tuberculin test at all.

In addition to this group of East Coast boys, the mine medical officers were good enough to perform the test on B.S.A. boys admitted to the mine hospitals for minor surgical injuries. A further 18,652 subjects were secured from this source.

As an attempt was being made to learn whether there might be any quantitative relation between degree of response and after-history, it was recommended that reactions should be recorded as " PP," " P," " P— " and " N " (positive plus, positive, weakly positive and negative). It was recognized that, with a variety of observers, uniformity of assay could not be secured, but the Sub-Committee could not arrive at an objective standard. A positive as opposed to a negative reaction takes the form of a definite plaque, but it may present variations in certain directions. There may be vesiculation, there may be efflorescence though a definite reddening of the skin over the plaque does not, in the case of the Native, occur in the majority of cases. The area involved varies. The thickness of the plaque varies and a thick plaque is not necessarily of excess area nor is a plaque of excess area necessarily thick. When all inoculations and records are being made by the same observer, it is possible that an area-standard might serve, but the Sub-Committee could not recommend such a standard in our circumstances. After some experience, the conviction grew that the determination of a " weakly positive " group was an unnecessary refinement, and in the subsequent Tables these weakly positive reactions (" P— ") are included amongst the positives (" P "). Later on it was hoped that it would be possible to pick out " PP " reactions by using such weak solutions that only strongly positive subjects would yield a definite response at all. This expectation was not realized ; the matter will be discussed later in this Report.

(*e*) *Arrangements for the Follow-up of Subjects in the Tuberculin-test Group and for Recording the Date of Recognition of Tuberculosis in the event of its Occurrence, with, as far as possible, the Type of Tuberculosis that had arisen.*—This part of the work was undertaken by the mine medical officers. Each mine was supplied with forms, of which a specimen is given in Appendix 2, and a form was filled in and returned once a quarter. On the form the medical officer noted further the date of inoculation and the resulting reaction, also the date on which he recognized tuberculosis and his diagnosis of the type presented. It must be remembered that these diagnoses are in many cases no more than preliminary diagnoses. A Native mine-boy recognized as suffering from tuberculosis is repatriated at once if well enough to travel, and the diagnosis is only final when the boy has died at a mine hospital or at the Witwatersrand Native Labour Association's hospital. In these cases an autopsy is performed and the return may be accepted as complete. The case-mortality *on the mines* is from 17 to 18 per cent., but the disease usually generalizes fairly promptly and the additional deaths occurring subsequent to repatriation bring the actual case-mortality to probably over 70 per cent. within eighteen months.

4. DISTRIBUTION OF TUBERCULOUS INFECTION IN MINE NATIVES.

The inoculations started on January 1st, 1928, with single intradermal injections of 0·1c.c. of 1/5,000 old tuberculin; in the course of the test the dose was reduced on several occasions and details will be discussed directly, but the crude return for the whole enquiry is given in Table 7, and will serve as a basis for a preliminary examination.

TABLE 7.

TOTAL RETURN, showing Reactions to Tuberculin and the Cases of Tuberculosis, all Forms, arising in the Whole Group from April 1st, 1928, to September 30th, 1930.

Total Number of Boys Tested		93,979
Total Number of "Positive Reactions"		61,115
Total Number of "Negative Reactions"		32,864
"Positives"	65 per cent.	
"Negatives"	35 per cent.	
Total Number of Cases of Tuberculosis, all Forms, arising in this Group		566

In Boys yielding a Positive Reaction, 452, or 738 per 100,000

In Boys yielding a Negative Reaction, 114, or 347 per 100,000.

3,879 Boys were returned as "PP." 60 Cases of tuberculosis arose in this Group, or 1,547 per 100,000.

57,236 Boys were returned as "P." 391 Cases of tuberculosis arose in this Group, or 683 per 100,000.

The salient facts appear to be these :—

(1) With the strengths of tuberculin used only 65 per cent. of the subjects yielded a positive reaction.

(2) Despite a probable under-estimate of the true numerical strength of the positive group, the incidence rate per 100,000 of tuberculosis was more than twice as high in the positive group as it was in the negative group.

(3) The more positive the reaction the greater the liability to tuberculosis.

It will be seen that two of the questions we asked ourselves are here answered : A Native mine-boy yielding a positive reaction has, under our conditions, a greater liability to tuberculosis than has a Native mine-boy yielding a negative reaction ; there is a quantitative relation between degree of reaction and liability to tuberculosis. The query as to the proportion of boys already invaded by the virus of tuberculosis as evidence by a tuberculin test is answered in part ; 65 per cent. of the boys passed as clinically free from tuberculosis show evidence of invasion by the virus. The answer is only partial because the figure of 65 per cent. is certainly too low ; even in this test, when the stronger solutions were used, the proportion of positives was 72 per cent. (see Table 8 below).

The first year's work having shown that negative reactors, so far from being in any special danger had the highest resistance to infection, it was decided to attempt a concentration of the positive group by diminishing the strength of tuberculin used. To begin with, a reduction

was made of from 1/5,000 to 1/10,000. This degree of reduction produced no difference either in the character of the reactions or in the proportion as between positive and negative reactors; actually the proportion of positive reactors was fractionally higher with 1/10,000 than with 1/5,000. It was decided to treat these two groups as one and the information secured is summarized in Table 8.

TABLE 8.

REACTIONS TO DILUTIONS 1/5,000 and 1/10,000, January 1st, 1928, to June 11th, 1929, with Cases of Tuberculosis, all Forms, arising in this Group.

Total Number of Boys Tested		57,659
Total Number of "Positive Reactions"		41,844
Total Number of "Negative Reactions"		15,815
"Positives"	72·5 per cent.	
"Negatives"	27·5 per cent.	
Total Number of Cases of Tuberculosis, all Forms, arising in this Group		422

In Boys yielding a Positive Reaction, 358, or 855 per 100,000.

In Boys yielding a Negative Reaction, 64, or 405 per 100,000.

3,105 Boys were returned as "PP." 49 cases of tuberculosis arose in this Group, or 1,578 per 100,000.

38,739 Boys were returned as "P." 309 cases of tuberculosis arose in this Group, or 798 per 100,000.

Although this particular series of inoculations ceased on June 11th, 1929, the cases of tuberculosis are drawn from a more or less complete "follow-up" carried to September 30th, 1930. This latter date is the latest to which cases have been followed so far and it is clear that the later in the series a boy has been inoculated the less time he has had to develop tuberculosis; hence the fall in the tuberculosis rate with the later series.

The cases dealt with in Table 8 represent nearly 62 per cent. of all the cases dealt with, and Table 8 brings out the same points as Table 7.

The strength of tuberculin used for inoculation was then reduced to 1/100,000, and the figures are given in Table 9.

TABLE 9.

REACTIONS TO DILUTION 1/100,000, June 12th, 1929, to November 22nd, 1929, with Cases of Tuberculosis, all Forms, arising in this Group.

Total Number of Boys Tested		20,810
Total Number of "Positive Reactions"		11,472
Total Number of "Negative Reactions"		9,338
"Positives"	55 per cent.	
"Negatives"	45 per cent.	
Total Number of Cases of Tuberculosis, all Forms, arising in this Group		94

In Boys yielding a Positive Reaction, 63, or 540 per 100,000.

In Boys yielding a Negative Reaction, 31, or 332 per 100,000.

338 Boys were returned as "PP." 4 cases of tuberculosis arose in this Group, or 1,183 per 100,000.

11,134 Boys were returned as "P." 59 cases of tuberculosis arose in this Group, or 530 per 100,000.

This section of the enquiry yielded interesting if rather sterile conclusions. To begin with, there was a considerable shift from the positive to the negative group ; some such shift was, of course, expected, and we should have been not at all surprised had the shift been greater. It will be seen that of nearly 21,000 boys tested well over half gave a positive reaction to this dilution of 1/100,000. We were impressed by the fact that, even with this dilution, very definite positive reactions continued to be secured. The tuberculosis-rate of the group is lower than the rate in the previous series owing to the shortened period of "follow-up." This dilution was used from June 12th to November 22nd, 1929, so less than a year had elapsed between the close of the test and the close of the "follow-up." The positive reactors still show a higher rate than do the negative reactors though the difference is less marked than in the "bulk test." The positive plus cases, as far as the figures go, stand out even more distinctly, but the numbers are too small to be significant.

As with the 1/100,000 dilution there were no signs of a small but highly susceptible group being isolated, the strength of tuberculin was next reduced to 1/1,000,000. This dilution was used from November 23rd, 1929, to March 23rd, 1930, and the figures are given in Table 10.

TABLE 10.

REACTIONS TO DILUTION 1/1,000,000, November 23rd, 1929, to March 23rd, 1930, with Cases of Tuberculosis, all Forms, arising in this Group.

Total Number of Boys Tested	9,007	
Total Number of "Positive Reactions"	4,640	
Total Number of "Negative Reactions"	4,367	
"Positives"	51·5 per cent.	
"Negatives"	48·5 per cent.	
Total Number of Cases of Tuberculosis, all Forms, arising in this Group	39	
In Boys yielding a Positive Reaction, 24, or 517 per 100,000.		
In Boys yielding a Negative Reaction, 15, or 343 per 100,000.		
217 Boys were returned as "PP." 5 cases of tuberculosis arose in this Group, or 2,304 per 100,000.		
4,423 Boys were returned as "P." 19 cases of tuberculosis arose in this Group, or 430 per 100,000.		

Once more the conclusions were rather of interest than importance. To begin with, more than half the boys still gave a positive reaction, though there had been a trifling further shift from the positives to the negatives. As will be seen, the differential tuberculosis rates are very similar to those secured with the 1/100,000 dilution with the positive plus cases standing out more definitely than ever though, of course, the figures are too small for serious conclusions to be drawn. This time there was a change in the character of the reactions ; while the grading into strong, ordinary, weak and nil could still be made, the whole scale had shrunk and there was not seen a single vesicular reaction. Considering how brief is the "follow-up" the rates are rather high.

For the concluding stage of the test the dilution used was 1/10,000,000 and the figures secured are given in Table 11.

TABLE 11.

REACTIONS TO DILUTION, 1/10,000,000, March 24th, 1930, to June 30th, 1930, with Cases of Tuberculosis, all Forms, arising in this Group.

Total Number of Boys Tested	6,503	
Total Number of " Positive " Reactions	3,159	
Total Number of " Negative " Reactions	3,344	
" Positives "	48·6 per cent.	
" Negatives "	51·4 per cent.	
Total Number of Cases of Tuberculosis, all Forms, arising in this Group		11

In Boys yielding a Positive Reaction, 7, or 221 per 100,000.

In Boys yielding a Negative Reaction, 4, or 120 per 100,000.

219 Boys were returned as " PP." 2 cases of tuberculosis arose in this Group, or 913 per 100,000.

2,940 Boys were returned as " P." 5 cases of tuberculosis arose in this Group, or 170 per 100,000.

At last the negative group exceeds the positive group, but, as Pharaoh said " . . . apart from that I observe no change." The " follow-up " is altogether too brief for anything to be expected and it is a little surprising to find the differential tuberculosis-rates coming out in the same order as with the 1/5,000 strength and long " follow-up." It is perhaps worth repeating that the inoculations, as far as concerned the seventy thousand odd East Coast boys, were performed at Ressano Garcia, while the recording of the reaction secured was done over two hundred miles away by an entirely different staff at the Witwatersrand Native Labour Association depôt, Johannesburg (about 90 per cent. were recorded by one observer). The boys were then scattered to over 30 different mines along 70 miles of the Witwatersrand, where the tuberculosis, when it arose, was recognized and recorded by over 30 different medical officers not one of whom had either performed the inoculation or recorded the result. Whatever may be said of this enquiry, it is evident that the " personal equation " factor was reduced to a minimum.

The positive reactors were for a time (see p. 96) recorded in three groups : Positive plus or " PP " ; ordinary positive or " P " ; weakly positive or " P—." The tuberculosis rate in the P— group was intermediate between the rate in the " ordinary positives " and the rate in the " negatives." The figures were as follows :—Tuberculosis incidence on the positive plus, 10·3 per 1,000 ; tuberculosis incidence on the ordinary positive, 6·5 per 1,000 ; tuberculosis incidence on the weakly positive, 4·5 per 1,000 ; tuberculosis incidence on the negative, 2·9 per 1,000. This is in keeping with the statement—the more positive his reaction the greater is the likelihood of the Native mine-boy to develop tuberculosis in the course of his engagement on the gold mines of the Witwatersrand.

5. TYPE OF REACTION AND TYPE OF AFTER-COMING TUBERCULOSIS.

Any attempt to answer the further question as to relation, if any, between type of reaction and type of after-coming tuberculosis demands a more detailed examination of the series of cases of tuberculosis arising in the tuberculin-test group. The data on which the following discussion is based are given in Table 12 and in Appendix 2. It may also again be mentioned that, except in fatal cases, the diagnoses are preliminary and provisional.

To begin with, let it be granted that different types of tuberculosis are dominant at different ages and that, for convenience, four such dominant types can be isolated :—

(1) Generalized septicæmic, or infantile.

"In infants tuberculosis is an acute, general infection, like typhoid or septicæmia . . ." (Fishberg[45]).

(2) Generalized lymphatic, or tuberculosis of school-age ("cancer-type").

"In children infection with tubercle bacilli, if it causes active disease at all, is usually followed by a generalized morbid process with implication of the lymphatic glands" (Fishberg [*l.c.*])

(3) During the latter half of the second decade, tuberculosis changes from being typically a general disease to being typically a local disease : Usually pulmonary tuberculosis of the caseating or exudative type and acute rather than chronic.

(4) In middle-life tuberculosis continues to be typically a local disease, usually pulmonary tuberculosis of the fibroid or productive type and chronic rather than acute.

It will be seen from data given elsewhere in this Report that the typical tuberculosis of the Native mine-boy is the tuberculosis of school-age (Group (2) above). That is to say, the generalized form of the disease, and, to this extent, "natural" rather than "modified."

In this series of cases from the tuberculin-test group a generalized tuberculosis was almost as much the rule in the positive reactors as it was in the negative reactors. Any cases that were diagnosed as chronic pulmonary tuberculosis did arise in the group of positive reactors, but, in nearly every case diagnosed as chronic pulmonary tuberculosis, this condition was associated with a silicosis and arose in boys of long underground service. The ability to raise barriers of fibrous tissue appears to be related in the mine-boy to invasion by silica dust rather than to invasion by the virus of tuberculosis or to age. However, a certain measure of distinction can be made. Out of the 471 cases of which details are available at date, the diagnosis of general tuberculosis was made in 41 subjects and confirmed by autopsy. In our classification general tuberculosis implies miliary and meningitis. Of these 41 cases of the infantile or septicæmic type 23 arose in the 95 negative reactors while 18 arose in the 376 positive reactors. To this extent, then,

invasion of the Native mine-boy by the virus of tuberculosis may confer on him a measure of resistance to virulence, even if it does lower his resistance to infection. The gain does not amount to much ; if compelled to choose between dying of tuberculosis in four weeks or in forty, most people would choose forty, but they would not be particularly grateful for this much of choice. One can take this question of resistance to virulence a little further. As one would expect with tuberculosis of school-age, local glandular tuberculosis is fairly common in the mine-boy. In the series of 471 cases the diagnosis " glandular," usually glands of the neck, was returned on 100 occasions. Of this 100, 85 arose in the 376 positive reactors, or over 22 per cent., while 15 arose in the 95 negative reactors, or just under 16 per cent. There were 15 in 49 " PP " reactors, or over 30 per cent. Here, again, is a suggestion of resistance to virulence in association with tuberculo-allergy, but boys exhibiting tuberculous glands are promptly repatriated, and we have but little direct evidence as to their after-history.

While we have no direct evidence such as that afforded by a rigid " follow-up " of a group, we have a good deal of indirect evidence as to the behaviour of local glandular tuberculosis in the South African Native. Dr. Neil Macvicar, superintendent of the Victoria Hospital, Lovedale, Transkei, has had a very wide experience with diseases of Natives. In response to enquiry he has been so good as to consult with his daughter, Mrs. Ross and her husband, Dr. R. C. Ross, both qualified physicians with wide experience of Natives. Their combined opinion is as follows : " . . . In some cases the infection seems to spread to other organs, but in the majority of cases tuberculous disease remains limited to the glands and most make a good ultimate recovery. We see many people in good health with the scars of old tuberculous gland abscesses."

Dr. Peter Allan, superintendent of the Tuberculosis Sanatorium at Nelspoort, has carried out several " tuberculosis-surveys " of Native territories, and he writes :—" In the Transkei I saw many Natives with tuberculous glands of neck. They did not appear to be generalizing, in fact, I saw several old gentlemen of 70 years of age with well-marked typical cicatrices who told me that they had had swollen glands which had broken down 40 years previously. After discharging for some time, the glands healed up. One might reasonably compare these cases with the European child, except that the Native seems to develop the condition in early adult life."

Dr. A. I. Girdwood, Chief Medical Officer of the Witwatersrand Native Labour Association Native Hospital, has had an unrivalled experience of the diseases of the South African Native, having been born in the Territories and having practised there before joining the Witwatersrand Native Labour Association organization. In Dr. Girdwood's experience Natives with primary tuberculous glands of the neck do not do well on the gold mines. The glands invariably get bigger and eventually break down and suppurate in spite of treatment. These cases do not, as a rule, develop pulmonary or generalized tuberculosis. On the other hand, Natives with old healed tuberculous scars

of the neck do remarkably well. It is exceptional for the disease to recur or for tuberculosis of the lungs to develop during their period of contract underground.

In the light of experience of great numbers spread over a generation, Natives with old healed tuberculous scars of the neck are being accepted for work on the goldfields. Despite the absence of statistical proof, one feels justified in saying that the mine Native reacts to local glandular tuberculosis as does the European child.

6. TYPE OF REACTION AND SPECIAL SUSCEPTIBILITY TO INFECTION.

Inspection of Tables 8 to 11 suggests that the tuberculosis incidence is less influenced by the progressive shortening of the "follow-up" in the positive plus group and in the negative group than in the ordinary positive group. It seemed worth going a little further into the matter with a view to learning whether there might be evidence associating the strongly positive and negative groups with a section that, under our conditions, were particularly readily infected and included the majority of those who went down early in a contract. Table 12 gives the necessary data.

TABLE 12.

INTERVAL BETWEEN PASSING PHYSICAL EXAMINATION AND RECOGNITION OF TUBERCULOSIS IN 471 BOYS WHO HAD EXPERIENCED THE TUBERCULIN-TEST.

Under Three Months.	Over Three Months and under Six Months.	Over Six Months and under Nine Months.	Over Nine Months and under Twelve Months.	Over Twelve Months.
"PP" 16 or 34% of this Group.	"PP" 6 or 13% of this Group.	"PP" 11 or 23% of this Group	"PP" 8 or 17% of this Group.	"PP" 6 or 13% of this Group.
"P" 71 or 21·25% of this Group.	"P" 61 or 18% of this Group.	"P" 71 or 21·25% of this Group.	"P" 55 or 16·5% of this Group.	"P" 76 or 23% of this Group.
"N" 32 or 34% of this Group. 119 or 25%	"N" 15 or 16% of this Group. 82 or 17·3%	"N" 16 or 17% of this Group. 98 or 20·6%	"N" 15 or 16% of this Group. 78 or 16·4%	"N" 16 or 17% of this Group. 98 or 20·6%

Further details of these 471 cases are given in Appendix 2.

It will be seen that an examination in some detail bears out the conclusion drawn from inspection, but only up to a point. Of the comparatively small number of cases arising in the positive plus and negative groups, over one-third develop tuberculosis within three months of having been passed as free from recognizable tuberculosis. There is not, however, very much in it, as over one-fifth of the cases arising amongst the ordinary positives also go down within three months of having been passed.

The positive plus group is fairly straightforward ; one can say that in the Native mine-boy high tuberculo-allergy goes with poor resistance to infection. The negative group is not so easy ; while the group as a whole has the best resistance to infection, it includes a section with as poor a resistance as has the positive plus group (see Table 12, col. 1).

Apparently there is some factor—not always present, however—in the subject virgin from the tuberculosis point of view that confers a measure of resistance against effective infection. This factor, even when present, becomes attenuated following invasion by the virus of tuberculosis. One is none the wiser for conjuring with such terms as "natural resistance."

It is generally held that a community, virgin from the tuberculosis point of view, has poor resistance to infection ; this is certainly not the case taking as a whole our group of mine-boys who give no reaction to tuberculin, and they are over 30,000 strong. In so far as invasion by the virus confers any benefit it is in the direction of resistance to virulence and not in the direction of resistance to infection. The fact that in tuberculosis, as in other diseases, resistance to infection and resistance to virulence do not go together is a commonplace ; we have only illustrated a form of the expression of this fact. After all, we are dealing with the European's tuberculosis of childhood-age and this type of tuberculosis, if virulent in the sense that it is typically general, is typically associated with low infectivity. The above considerations lead to two conclusions of importance to us. The first is that inoculation with some form of the virus of tuberculosis is unlikely to raise the mine-boy's resistance against infection and the second is that the mine-boy is not likely to spread in his kraal a type of tuberculosis that European children do not spread among their contemporaries. In both Europe and the United States of America mortality credited to childhood-tuberculosis is unimportant from the national point of view. It is by protection from and exposure to physiological stress that this type of tuberculosis is dominated. When the Factory Acts and the Education Acts became effective in England the incidence of this type of tuberculosis fell to a notable extent. Throughout most of the first half of the nineteenth century the mortality from childhood tuberculosis was a very serious matter, but it has ceased to be of national importance for nearly two generations. The Native in his kraal is as much "protected" as is the average European child in the home, while the Native on the mines is much in the position of the European child in the days of child-labour.

Table 12 raises a point that has no direct connexion with a tuberculin test. Several enquiries[46 47 48] have taught us that of the Natives who go down to tuberculosis a considerable proportion go down in the first three months of a contract. The data collected in Table 12 come into line with other experience in this respect, and in the respect that incidence falls for the rest of the first year. We also know that the prevalence of tuberculosis is high again in Natives known to be of five years' continuous service and upwards. There appear to be two antagonistic factors at play—acclimatization to conditions on the mines,

which acts beneficially and reduces the incidence of tuberculosis, and increasing duration of exposure to conditions on the mines, which acts harmfully and is associated with high tuberculosis incidence. It is clear that the harmful factor is dominating the situation by the close of the fifth year, and we are always asking ourselves at what period does the harm of duration of exposure begin to beat the good of acclimatization. In this Report we are dealing with a group of over 90,000 boys and the tuberculosis returns are to be kept up until the end of December, 1931. By this time we shall have a minimum "follow-up" of 18 months, *i.e.*, in the case of boys inoculated during June, 1930, and a maximum "follow-up" of nearly four years, *i.e.*, in the case of boys inoculated during January, 1928. The maintenance of incidence in boys of over 12 months' service as shown in Table 12 suggests that useful information may be forthcoming by the end of 1931.

NOTE.—The significance of some of the matters dealt with in the previous Section may be rendered clearer by a brief reference to conditions of service on the Witwatersrand gold mines.

Mr. W. Gemmill, General Manager of the Chamber of Mines, has been so good as to supply the following information :—

"The original contracts of the East Coast Natives have provided in every case for the Natives working for 313 shifts, *i.e.*, one year. The conditions of renewal of service have, however, varied in the last few years. East Coast Natives recruited prior to the 3rd May, 1927, were allowed to remain as long as they chose. Those recruited between 3rd May, 1927, and 10th October, 1928, were allowed to remain for two years, plus a further maximum period of 18 months. Those recruited after 10th October, 1928, were allowed to remain for 18 months only. The average actual period served is no longer, in the case of East Coast boys, a matter of statistical importance, as the number who are allowed to remain is getting steadily less, whilst all Natives recruited under the conditions of the new Convention serve for at least 313 shifts in ordinary circumstances and not more than 18 calendar months.

"In regard to British South African Natives, the average period of service when last the figure was calculated proved to be about 11 months, but this figure is at the moment in process of re-calculation."

It should also be added that the Portuguese Natives recruited under the new Convention are not renewing their contracts in large numbers, so that the total average period of service must be considerably nearer one year than 18 months.

7. INVASION BY THE VIRUS AND TYPES OF TUBERCULOSIS.

Of the four types of tuberculosis given in the arbitrary classification adopted on p. 101 by far the rarest to be met with in the South African Native is Class (3), or acute pulmonary tuberculosis : the "young adult phthisis" of Brownlee.[49] As this type of tuberculosis is so common and so important in the European the matter seems worth a reference. Of course, typical acute pulmonary tuberculosis—caseating, broncho-pneumonic and pneumonic—is almost the rule in the fatal cases,

but the disease is hardly ever confined to the chest. Almost invariably the abdomen is involved, and grossly involved, into the bargain. If the Native has sufficient resistance to localize his tuberculosis, he usually has enough to send it along a chronic course and present Brownlee's "phthisis of middle age." This condition is uncommon, particularly apart from silicosis, but typical cases of the European type are to be met with. While the old Native generalizes his tuberculosis far more commonly than does the old European, if one meets chronic phthisis at all it is in the old people. Dr. Brownlee writes[50] of "young adult phthisis":—

"It is less common in those districts in which there is a large number of deaths from tuberculosis in children.

"It is also less common in those districts in which there is much phthisis in middle age."

For the Native of South Africa "tuberculosis of school-age" takes the place of "young adult phthisis" and covers much the same age-incidence though prolonged into later life with subjects exposed to physiological stress, such as the old mine-boys who have avoided silicosis. One would rather have expected that, in the Native, "young adult phthisis" would take the place of "phthisis of middle age," as childhood tuberculosis takes the place of "young adult phthisis." The Native appears to skip this step and one wonders why. Dr. Brownlee's note to the effect that childhood tuberculosis and young adult phthisis do not go together is of interest in this context, also a further observation asserting that phthisis of middle age is more common in those districts in which there is a large number of deaths from tuberculosis in children.[51] It appears that Natives who have resistance to virulence at all have a fair amount; on the one hand, there is the considerable proportion of cases of local glandular tuberculosis in subjects with tuberculo-allergy, and, on the other hand, there is this tendency to dodge the betwixt and between stage of acute pulmonary tuberculosis. As said before, useful resistance to virulence is the exception.

After giving due weight to the above considerations one remains impressed by the comparative lack of ability to localize his tuberculosis shown by the positively-reacting adult Native mine-boy. Is it going too far to say that in these Natives a tuberculin-test is no more than a measure of the presence or absence of tuberculo-allergy, and that a positive reaction implies no gain in resistance to infection and but little gain in resistance to epidemiological virulence? Useful secondary immunity in so far as it is conferred by sub-inoculations of the virus of tuberculosis may only be arrived at *via* tuberculo-allergy, but the presence of this allergy is not evidence of the presence of useful resistance. Wingfield writes,[52] "High tissue allergy or hyper-sensitiveness is a dangerous condition (in moderation it may be protective)." In our experience with mine Natives, resistance to infection and resistance to virulence present a certain degree of independence. From the point of view of resistance to infection, any allergy at all puts the Native