PREVALENCE AND INCIDENCE OF TUBERUCULOUS INFECTION AND DISEASE IN INDIA:

A Comprehensive Review

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CONTENTS

SUMMARY

The data available on tuberculosis morbidity and mortality from various surveys in India are summarised in this review, with a consideration of their socio-economic aspects. A brief interpretation of the epidemiological situation in India, along with the use of the information on epedemiology in designing the tuberculosis programme in India (NTP) is given in Appendix (vi).

1.1. Tuberculosis problem is more or less spread all over the country. Differences in prevalence rates of disease as observed between area to area did not appear to be statistically significant (barring a few exceptions e.g., Tamil Nadu, Raichur and urban slums as in Calcutta).

Prevalence rate of disease was observed to be the same for the rural and urban areas (Fig.5).

1.2. Of persons in all ages both sexes about 38% were infected. In males, almost 70% of persons above 40 years of age were infected. About 2% had pulmonary tuberculosis, but only 0.4% could be the average prevalence rate of bacillary cases (in 5+ age group). Mortality rate was observed for the last time in a population survey way back in 1966. It was reported to be about 90 per 100,000 (could be half of that, as hypothesised in recent times).

1.3. Prevalence rates of infection, disease and mortality were more in males than in females: a third of the cases in all ages could be females. However, of cases in females, about half could be in the child-bearing age.

1.4. In a rural area in Bangalore, there was a marginally decreasing trend in the infection rate: about 2% per year over a long period of observation ranging from 5 to 25 years, among children (Fig 3). But the same was not seen in the adjoining areas of Tumkur, Doddaballapur and in the neighbouring state of Tamil Nadu (the last, over a 15 year period).

1.5. Pulmonary tuberculosis is an adult disease. Population in 0-19 years (comprising about 50% of total population) could be estimated to contain only 7% of total prevalence cases. Remaining 93% of cases could be distributed in population aged 20 years over (Fig.6). Relatively higher and higher concentration of cases in higher age groups was observed in later surveys as compared to earlier surveys in Bangalore rural area. In later surveys conducted in 1984 in Bangalore rural areas, about 80% of cases were detected among those in 40+ age group as compared to about 50% in earlier surveys (Fig.8).

1.6. Prevalence rates of cases had shown almost no change over a period of over 20 years from different surveys in different areas (Table 9 & 10).

1.7. The incidence of cases was observed to be a third of the prevalence, on the average, which could be interpreted to be due to failure of intervention and pooling up of previous cases. The incidence of smear-positive cases was estimated to have dwindled in 23 years in Bangalore rural area from around 0.65 to 0.23 per 1000 (Table 15). No such observation was made elsewhere.

1.8. Nearly 10% of all causes crude mortality in the community was contributed by death due to tuberculosis (tuberculosis mortality rate: about 90 per 100,000). The highest proportional mortality in women in the reproductive age could be attributed to be due to tuberculosis, higher than even that due to peri-natal causes. Nearly 40% of female population being in the age group of 20-44 years, this could amount to be the highest single cause of death in women in this vulnerable population group.

1.9. Mortality rate due to tuberculosis was observed to be considerably lower than case rate, and was decreasing with time from survey to survey. The case rates were considerably lower than the infection rates (mortality rate: case rate: infection rate ::90:400:38,000 per 100,000). The observed wide gap between the rates has significance with respect to the age of the epidemic (Fig.15). The survival rate of cases diagnosed in later surveys were better, compared to that in earlier rounds of longitudinal surveys.

1.10. Paediatricians were generally seeing less of miliary, meningeal and fulminant forms of tuberculosis. Occurrence of pulmonary tuberculosis in paediatric age-group was minimal (Table 17). However, children in 0-4 year age group was found to be highly vulnerable in a Madras slum, having conspiculously high mortality to tuberculosis.

1.11. There was a higher prevalence in 'Kutcha' houses than 'Pucca' houses, the former inhabitated by the poor. There was an observed association of pulmonary tuberculosis with lack of education, lack of regular source of income as well as per capita income. Of the workers with tuberculosis, it is recently estimated that about 52% are in the 15-44 years age group (Table 18). In this age group, the proportion of women among the urban workers with tuberculosis (40.0%) was estimated to be higher than among the rural (17.9%).

1.12. The rates observed in the various surveys conducted in India, have been used to estimate the approximate average number of cases and deaths etc., in the country, to serve as a guide for planning for the resources for a programme at the National level (Table 19). The numbers presented in brackets in the table are estimates, revised in the light of more recent observations. The likely estimate of disease in India could be on average; Bacteriologically (culture) positive cases 4.4 million (0.6%), Radiologically active bacteriologically negative 2.3 million (0.3%), and annual tuberculosis mortality 0.42 million (45/100,000).

I. INTRODUCTION

In line with the current scientific development and WHO policy[1], Govt. of India, had in the recent years, re-examined the strategy hitherto followed under the National Tuberculosis Programme (NTP). A revised NTP is currently being formulated with assistance from the World Bank and the WHO[2]. While re-defining the strategy and deciding on the priorities/emphasis on programme activities as well as their scope, the epidemiological aspects of the disease, peculiar to this country, have to be kept in mind. For instance, because of its recognised predilection for affecting the relatively underprivileged segments of the society[3], a control programme addressed to the needs of the country, requires also to evaluate the relevant data with particular reference to the socio-economic and gender differentials, if any. The current report is prepared in this context, reviewing the tuberculosis situation in India. The data could be made use of not only for planning but also evaluation purposes, generating fresh thinking in respect of epidemiologic dimensions of control programmes, especially keeping the circumspection of some of the noted programme managers in view[4].

Considering the infectiousness of the pulmonary forms of the disease, the present report confines itself to the data on pulmonary tuberculosis and tuberculosis infection only. Available data, both published as well as unpublished to the extent available, are relied upon to present:

1. **Prevalence and incidence** of tuberculosis **infection** as well as of **sputum positive and sputum negative pulmonary tuberculosis,** by age and sex.

2. Prevalence of tuberculosis infection and disease by **socio-economic status of population.**

II. MATERIAL

The review mainly derives its material from the published sources, originating from some of the leading tuberculosis research institutions of the country. However, wherever required, unpublished work from these institutions have also been freely referred to. Apart from the main papers originating from some of these studies, a considerable number of subsidiary papers were published as well. These have been referred to in the text, as and when required.

Other lesser known organisations have, especially in comparatively recent times, carried out some significant research; a few of them still to be published. These have been duly evaluated and referred to, if found authentic enough! The major research efforts in epidemiology of tuberculosis are described briefly in Table 1, giving the name of the study, reference, year of study, population represented, the design and methodology (age group studied, population-screening and diagnostic methods used).

III. CRITERIA FOR DEFINING INFECTION AND DISEASE

(A) PREVALENCE OF INFECTION

The estimate of prevalence of tuberculous infection in the community is based on the interpretation of the results of tuberculin testing of persons without BCG scar. The indurations, measured ideally, between 48 and 96 hours of the tests, are distributed in the form of a histogram (FIGURE-1). From these distributions, it is possible to demarcate the positive reactors from those who are negative to the test dose, since the indurations tend to lie around two discernible modes separated by a dip, called the antimode. The nature of distribution of the indurations however differ to an extent from study to study, depending on the tuberculin (or antigen) used, their dosages, testing and reading variations, as well as on cross-reactions on account of the non-specific sensitisations that may be present in a given area due to environmental factors (including non-tuberculous mycobacterial sensitisations). In fact the dip between the two modes is sometimes less recognisable due to a high prevalence of non-specific reactions in India, especially south India[6),23,32]. Due to these problems, it is not possible to have a uniform size of test reaction identified with tuberculin test positivity in every survey.

Besides the type of tuberculin and their dosages used form survey to survey not being the same, the problem of defining the infected is compounded by the changing levels of demarcation between the infected and uninfected from one survey to the other[10,12]. The problem of changing demarcation levels from survey to survey had no doubt engaged the attention of researchers[12,33]. It is suggested after a field study that the demarcation line between the infected and non-infected persons would require to be shifted from survey to survey to take care of the observer variations or the rising proportions of BCG scars in the population being wrongly classified as unvaccinated from one survey to the next, thereby affecting the classification between the infected and uninfected[33]. It is not intended to go into more detailed analysis here owing to space-constraint.

For this review, persons are considered as infected, if the indurations to tuberculin test are observed to lie to the right of the demarcation line as decided on the basis of the distribution of the indurations, for the given study.

Non-specific sensitivity: Frimodt Moller had recognised that there could be two kinds of infection in south India ('specific' and 'non-specific') and that it could have serious implications in understanding infection risks[6]. The prevalence of the non-specific infections were hypothetically considered to be due to other mycobacterial infection. Chakraborty et al had shown that the non-specific infection increased with age, so much as to leave only a small proportion of the population in the age group 15-24 years without any kind of sensitivity to tuberculin[32]. Figure 2 shows that in the age group 15-24 years, where the proportion infected with Mycobacterium tuberculosis was 33.2%, of the uninfected 93.4% were showing evidence of other Mycobacterial infection. Raj Narain had shown its prevalence to be widespread in some areas[23].

Thus the interpretation of the tuberculin test results in older age groups could be unreliable owing to a high prevalence of non-specific sensitivity.

(B) INCIDENCE OF INFECTION

'The results of tuberculin testing surveys are usually presented only in the form of prevalence figures for past tuberculous infection. Prevalence figures do not indicate, when in the past the first infections had occurred[34]. **Incidence of infection, which gives the most recent tuberculosis transmission situation in the community, is defined as the number of fresh infections occurring in the community between two points in time, among those uninfected initially.** It calls for direct measurement of the conversions of uninfected persons to infected status, in the intervening period between two succeeding surveys, say a year or so apart. Information on incidence from some of the surveys in India are reviewed here [6,10,15,35].

Apart from the operational constraints in carrying out the incidence surveys on tuberculous infection again and again, there were inherent problems in interpreting the repeat test results[35]. The latter was proposed to be solved by distributing the differences between the two tests in each individual. In younger age group, where the situation was not likely to be complicated by high non-specific sensitivity etc., the distribution was found to be bimodal, the antimode separating the 'new infected' (occurring to the right of the antimode), from those who were 'not newly infected' (to the left of the antimode). In the BCG TRIAL, for instance, the antimode was at 12 and 10mm, between the initial test and at retests at 2½ years and 4 years respectively[15]. Thus persons showing more than 12 and 10 mm increases over the first test induration size, when retested after 2½ and 4 year period respectively, were identified as freshly infected in BCG.Trial. Somewhat similar method was adopted for NTI.LS[10].

Annual Risk of Infection (ARI): The problem of obtaining data on incidence of infection could be obviated by computing these from one or more prevalence figures, if these are obtained by similar testing methods and if the prevalence surveys 'cover a range of ages'[34]. The computed estimates of the incidence, called the 'Annual Risk of Infection'(ARI), give the risk of tuberculous infection in successive calendar years. These estimates may be regarded as an alternative method of presentation of the tuberculin surveys. **ARI could be defined as the proportion of the population which will be primarily infected or re-infected (in those previously infected) with tubercle bacilli in the course of 1 year, and is usually expressed as a percentage or as a rate.** A tuberculin survey carried out in a representative sample or a succession of them could be converted into the estimated risks (ARI). The ARI at a particular time indicates the current magnitude of the incidence and prevalence of infectious cases as well. An observed decline in the ARI would be the earliest indicator of a decline in the epidemic cycle of tuberculosis and would therefore be a suitable indicator for evaluating tuberculosis control programme. A rising risk on the other hand could be the portent for a change to the other direction consequent on adverse epidemiological situation e.g., HIV supervening.

The ARI could generally be worked out on the basis of the method described in TSRU Report[34,22]. By this method, the ARI (R) for a group of average age (A) was derived from the prevalence (P) by $R = 1 - (1-P)\ 1/A$

Incidentally, the corroboration that ARI represents annual incidence of infection is available from the study by Chakraborty et al in the LS-Follow up[13](Figure 3).

(C) TUBERCULOUS DISEASE

(i) Screening for bacteriological examination: In the classical epidemiological surveys for estimating the case-load, the population is x-rayed at first, mostly using a mobile mass miniature radiography (MMR) unit. Only the persons with shadows on MMR of chest assessed as abnormal, usually by two readers independently, are subjected to sputum test (x-ray-screening). Alternatively, the persons in the community are questioned for presence of chest symptoms (cardinal chest symptoms being cough, pain chest and fever of one or two weeks duration and haemoptysis); those having symptoms (symptomatics) are subjected to sputum examination (symptoms-screening). In the MS, NSS, TUMKUR STUDIES, NTI-LS, BCG-TRIAL and NEW DELHI STUDY, the x-ray screening procedure was adopted[6,7,8,9,10,15,21](Table 1). On the other hand, in the WARDHA, RAICHUR, TRC-TRIBAL and CARNICOBAR Studies, symptoms-screening procedure was followed[25,26,27,28]. In the NTI.PERI URBAN STUDY and LS-FOLLOW UP, again, the population was screened for their eligibility to undergo sputum examination, using a criteria, different from the above mentioned two, and casting a wider net[14,24].

Varying screening procedures from survey to survey affect the observed prevalence rates and therefore the comparability of results between one survey and the other[36,37].

(ii) Definition of a bacteriological case: It was shown that cases positive by smear alone, detected in an epidemiological survey, were hardly the real cases of tuberculosis, the reproducibility by a second smear or by way of radiological confirmation as active TB in these cases being very poor[15,38]. In the BCG-TRIAL, of the 567 persons positive on smear but negative on culture, 76% had only 1-3 bacilli on both smears examined. The x-ray confirmation in these persons having actively tuberculous pulmonary shadows was a mere 13%[15]. Cases with positivity on culture only, without radiological abnormality at the corresponding survey, were also a group whose tuberculous etiology was not acceptable in the NTI-LS[11]. In most of the epidemiological surveys carried out at the NTI using the classical survey method, **a case of tuberculosis was defined as a culture positive person, with a radiological abnormality at the current survey**[11]**. Persons not confirmed on culture (i.e., smear alone positive) were not defined as bacteriologically positive cases, even if they had an x-ray-abnormality, (they were however eligible to be defined as x-ray positive cases, if shadows on their chest-radiography were classified as actively tuberculosis).**

Three categories of bacteriologically positive cases were presented in the BCG-TRIAL: (i) positive on two cultures (ii) positive on one culture (iii) smear-positive, excluding those showing 1-3 bacilli. There was, of course, the additional group of radiologically positive bacteriologically negative group[15]. In the NSS, the sputum was collected contingent on an abnormal shadow being present on chest x-ray. It appears that the definition of a bacteriological case, under NSS and NTI classical surveys were, essentially similar. In the Madanapalle study, on the other hand, there was too much stress on radiological examination, bacteriological results being comparatively of less prominence[6].

(iii) Variation in screening prodecure and diagnostic test influencing prevalence rate: In some of the more recent prevalence surveys carried out in India, mobile MMR units were not employed to screen the population (MMR-screening). An alternative method of screening the population was followed in order to identify the population eligible for sputum tests, by questioning the persons on the presence of cardinal chest symptoms on a house to house basis, followed by sputum tests, either culture or smear microscopy[24,25,26,28,30].

A recent NTI-study, addressing itself to the problem of comparability of culture positive prevalence rates obtained by employing population-screening by MMR vs. symptoms questioning has shown that the efficiency of the above two screening procedures in diagnosing culture positive cases was different from the best estimate obtained of employing multiple screening (MMR and/or symptom question)[24] The correction factor to obtain the best estimate of culture positive cases

from that obtained on symptoms screening could be between 1.30-1.63 (approximately 1.5). **However, the significant finding from this study, which to an extent seemed to extenuate the problems of estimating cases based on variable screening procedures, was that the prevalence rates of the culture positive cases in the community were the same, irrespective of whether symptoms or MMR screening was the procedure of choice in screening the population for identifying the eligibles for sputum test. The same was found to be good even for the estimates of smear positive cases.** Moreover, it was observed that there were no age-sex wise differences in observed rates between the two procedures. It was immaterial for the estimate on the basis of symptoms screening, whether the interviews of the population for identifying symptomatics was carried out by a qualified social investigator or a field health worker, as long as adequate training on the procedure was given prior to the deployment for the investigation. The above could be utilised in evaluating and drawing inferences from some of the latest studies on prevalence.

(iv) No.of bacteriological specimens examined and prevalence of cases: The number of specimens of sputum collected from among the eligibles after screening were variable from survey to survey, which would affect the estimate of the bacteriologically positive cases in the community. The extent of difference in rates could be estimated from the finding, that instead of two sputum specimens, if four were examined in a survey, nearly 25% more number of cases could be added to the prevalence[39]. This was found to go as high as 39%, when eight specimens were examined[37]. **Needless to say that the findings from surveys with variable number of sputum specimens need to be suitably revised, before comparative assessment of the rates are made.**

(v) Definition of a radiologically positive bacteriologically negative case of tuberculosis: Apart from its use as a screening tool for the identification of persons eligible for bacteriological examination in a tuberculosis survey in the community, MMR-results are also relied upon to diagnose and label persons as radiologically positive cases of pulmonary tuberculosis ('persons with active and probably active shadows'-NSS). Estimates of the problems of tuberculosis on this basis has some serious limitations, principally owing to the inherent 'reader-variations' in interpretation of the x-ray shadows (as well as their identification) their tuberculous etiology as well as the activity. The procedure, usually followed, was to have two independent interpretations of the chest x-ray shadow on MMR (single picture) and to collect sputum from persons with a shadow ('x-ray-screening'). The disagreements between the two independent interpretations were then subjected to a third reader's assessment (or, an umpire reader's arbitration) regarding the nature and etiology of the shadow. However, despite the panel of readers, used in these surveys, being composed of highly experienced persons in their field, there was considerable disagreement in interpretations[15].

A five-year follow up of the persons, diagnosed to have active tuberculous shadows (as also other MMR abnormalities in their chest), was carried out by repeated x-ray of chest, smear exam for AFB and culture for M.tuberculosis (three examinations at 1½, 1½ and 2 years after the initial one)[40]. Based on an overall consideration of all the follow up investigation results, at one time, a panel of x-ray-readers had jointly re-evaluated the initial MMR-interpretations (Joint Parallel Reading-J.P.R.). Of the initial 385 sputum negative x-ray active persons identified initially, only 22.0% could really be classified to have sputum negative x-ray active tuberculosis at the first survey, when such a re-evaluation of the MMR-shadows was carried out by J.P.R.[40]. Unpublished information from the TRC Madras on the BCG.TRIAL FOLLOW UP studies recently corroborated this; not even a third of the radiologically positive cases were later assessed to be having active tuberculosis needing treatment[41].

It could be suggested that the generally accepted **prevalence rate of radiologically active bacteriologically negative pulmonary tuberculosis in India, largely estimated on the basis of data from the NSS and other similar studies (using a single MMR and the pulmonary shadows evaluated by 2 readers and umpire), could be nearly three times the likely estimate of the problem.**

IV. RESULTS

(A) TUBERCULOSIS INFECTION
(PREVALENCE AND INCIDENCE)

1. PREVALENCE OF INFECTION

1.1. Prevalence in different areas (Tables 2 & 3): That the tuberculosis infection was more or less spread throughout the country was hypothesised on the basis of studies done by Ukil and from information available from the mass BCG - Campaign results[42]. However, differences were observed from area to area, e.g., hilly areas. In later surveys carried out in parts of India, different epidemiological situations could be observed between areas in adjoining states (Tamil Nadu and Karnataka)[10,15], contiguous districts in the same state (Tumkur and Doddaballapur in Bangalore district)[8,22] and between areas within the same district (economically backward northern part of Tumkur compared to the southern part: infected, 46.0% and 30% respectively[8]), as also between two panchayat unions of Tiruvallur district in BCG.Trial: Infected 1-9 year old, Kodambathur 8.7, Thiruvalangadu 12.3 percent in 1979[16] (Not on Table). Prevalence by socio-economic criteria is presented separately under Section IV F (see infra).

1.2. Prevalence by age and sex (Tables 2 & 3): Between 25-38% of population in all ages both sexes were infected, as per data available from Tumkur Study (males 42.8, females 33.9 per cent) (Not on Table)[8], infection rising with age, more in males (Fig.4)[6,8,10]. Prevalence rates were almost similar in males and females upto about 14 years in age, after which males had higher prevalence. Whereas the peak in the males was observed at around the age of 30 years, it was so in females by about 40. Similar phenomenon was observed both in Tumkur, as well as in the BCG Trial area (Not presented)[16]. In the BCG.Trial overall prevalence was found to be 50% (males 54.0, females 46.0%)[16].

1.3. Situation over a period of time: There was a declining trend in prevalence with time in NTI.LS area (Appendix table i), not seen elsewhere.

2. INCIDENCE OF INFECTION

2.1. Incidence by age, sex and over time: The incidence of infection was found to be 1% per year and did not seem to vary age-wise in 0-4, 5-9 and 0-14 year age group in the NTI.LS (Table 4)[10]. In rural areas of Bangalore there was a marginally declining trend observed over a period of 5 years (Fig.3)[10].

2.2. A.R.I.: ARI calculated from different parts of the country was found to be between 1 and 2% (Tables 5 & 6). The decline in Bangalore area at about 2% per year annually for over 23 years, as seen in Figure 3[13], was not seen elsewhere, including in BCG.Trial area over 15 years period of observation[15].

(B) PREVALENCE OF DISEASE

This report confines itself to pulmonary tuberculosis. No significant population-based study on extra-pulmonary TB is available, except study on glandular forms in small population groups of Nicobar island and Sheriff garden in Bangalore [28,54]. Being in specific and selected groups, data from them could not be representative.

1. RADIOLOGICALLY ACTIVE CASES:

1.1. Area-wise prevalence: Table 7 presents the prevalence of pulmonary tuberculosis, including bacillary cases, across the country from NSS data. Table 8 presents the bacteriologically negative radiologically active case prevalence, derived from it. Tables 9 and 10 present the rates from limited area surveys conducted after the NSS. Prevalence rates of disease **did not appear to be significantly different from area to area, whether rural, semi-urban or city. There were however pockets of high prevalence, possibly related to economic situation.** For example, the prevalence rate of 58 and 50 per thousand in Block No.39 and 8 Calcutta city (slum-dominated) was higher than 2.48 per thousand in Block No.34. Similar was the case with Delhi city.

1.2. Age-Sex-wise rate: The rates were seen to be rising with increasing age in both sexes, irrespective of areas of study (Fig.5).

1.3. Radiologically active abacillary case-rate: The bacteriologically negative radiologically active case prevalence rate varied from 10-19 per thousand. These could be over-estimates to the extent of about 75% (See section III C.V.),[40]. The rates, after correcting for possible over-estimates, is presented in the last column of Table 8. The NTI-rural study which had followed the JPR method of interpretation of MMR and the Madanapalle study, also following a similar method, had reported prevalence rate of 5.40 and 4.23 respectively (Table 9)[6,40,43].

2. BACTERIOLOGICALLY ACTIVE CASES:

2.1. The prevalence rates are presented in Table.7 (for NSS), Table.9 (for, limited area studies using MRR-screening) and Table 10 (for, limited area studies with symptom-screening). **There was no difference between the rates, either from area to area or with time, provided the same method and criteria were followed.** It should be appreciated that large sample sizes of population are required to be followed up, so as to be able to discriminate small differences in the already low case-prevalence rate of about 4.0 per thousand[46,47] (Appendix Table ii).

2.2. Age-sex distribution: Figure 5 shows age, sex distribution by areas. The rates rose with age in both sexes, more in males. Based on the age-distribution of the cases, it could be estimated that the population in 0-19 years age (comprising 50% of total) could contain only about 7% of total prevalence cases (Fig 6). **Remaining 93% of the cases could be found distributed in the population aged 20 years and over** (i.e., in remaining 50% of population). On the other hand, of the total cases, nearly 50 per cent could be distributed among the population aged 40 years and over, constituting about 20 per cent of the total population.

Prevalence of bacteriological cases in each of the age and sex groups studied, is presented in Table 11, as computed on the basis of BCG.Trial. Prevalence in each of the age groups was much less in females. Of the total bacillary cases 79.0% could be in males and 21% in females in BCG.Trial,[15]. **Whereas males in 20-54 years age group i.e., the wage-earners, had constituted 39% of total male population, nearly 70% of all male cases were in this age-group. For females, on the other hand, the population in the reproductive age group of say 20-44 years, had constituted nearly 40% of the total female population, with about 56% of all the female bacillary cases distributed in this age group.**

2.3. Prevalence by age-sex and categories of case: Figure 7 presents the distribution of cases by criteria of diagnosis and by age/sex. The prevalence of cases was lower among females than among males and increased with advancing age in males. Whereas prevalence of bacillary cases had more or less reached its peak in females by about 40-49 years, it had continued to rise for radiologically positive cases in both sexes in BCG.Trial.

2.4. Change in distribution with time: The observed age-sex distribution of cases with time in the NTI.LS area was seen to reflect a change in situation as shown in Figure 8[47]. In the first of the longitudinal surveys in Bangalore rural area, about 50% of cases was found in the population above 40 years in age, constituting about 20% of total population. About 43% of the cases were distributed in 20-39 year age group, constituting about 39% of population. In later surveys in the same area, about 70-80% of cases were found among those in 40+ age group. **Relatively higher and higher concentration of cases was observed to take place in higher ages in later surveys.**

2.5. Bacteriological case prevalence and socio-economic dimensions: Table 12 along with Appendix Table (iii) and (iv) present the various socio-economic categories in the population and prevalence rates in them along with the proportion of cases contributed by each to the total prevalence cases in the community[25]. These aspects are dealt with separately under Chapter F (see infra) of this Section.

The Wardha study[25] and the NTI.peri -urban study[24] had shown, that as different from other studies, the rural areas had higher prevalence rates. The respective rates per thousand were:- Wardha study: Urban 1.62, Rural 1.98, NTI.Peri-urban: 3.4 (interval estimate 2.7 to 4.2) as compared to Bangalore rural 5.7 (interval estimate 5.4 to 5.9). Whether the differences were due to urban-peri-urban and rural divide or had represented a favourable trend in favour of the urban group is a matter for discussion.

2.6. Culture: Smear positivity proportion: Table 13 shows the data from NTI.LS[14].Inspite of the fact that there was no difference in the age standardised case-prevalence rates from survey to survey in the area for a 23 year period, the smear positivity among the prevalence cases had come down to 16% at the survey in 1984, from the initial proportion of 47.0% observed in 1961. More importantly, notwithstanding a very comprehensive screening method in the 1984 survey, the smear positive case prevalence rate had also come down to 68 from 189 per 100,000, observed in 1961 survey. It is debatable, whether this could be attributed to the National Programme, implemented in the area after the Survey 4, in 1970. The trend may be the result of a low-efficiency programme running over a long term in the area[14]. In other surveys conducted elsewhere in India, **the smear positivity proportions were more or less similar to NTI.LS first to fourth surveys (e.g., Bangalore Peri-urban area 44.9 to 46.7%[24], survey 1 of BCG.Trial 57.4%[16]).**

2.7. Bacterial drug-resistance: Table 15 and Figure 9 shows the bacterial drug resistance in the community. **Unpublished information from New Delhi TB centre, Bangalore Peri-urban area and rural area in Raichur (Karnataka) shows high initial resistance to INH in recent times.**

(C) INCIDENCE OF DISEASE

1. INCIDENCE OF RADIOLOGICALLY ACTIVE CASES

1.1. Definition: Sputum negative persons with a normal MMR of chest or those with non-tuberculous or inactive tuberculous shadows at the initial survey, who had a radiologically active tuberculous shadow at a later survey, but sputum was negative, were classified as incidence of radiologically active bacteriologically negative cases (also called "suspect cases").

1.2. Incidence rate: In the NTI rural area study, of 35,876 persons aged 5 years and over, incidence was found to be 2.24 per thousand between two points of observations in 3 months on JPR[43] (not on table). The incidence rates, as calculated for 3 months, was not different from that estimated for one year[44].

2. INCIDENCE OF BACTERIOLOGICAL CASES:

2.1. Definition: Culture negative persons or those without a radiological opacity in a previous survey, who were detected to have culture positive disease at a later survey, were termed as "bacillary case incidence" between the two surveys[40]. The respective incindence rates expressed as an annual average between two surveys are available from New Delhi, NTI.LS and BCG.Trial areas[20,21,10,18]. On the other hand, new cases detected in the community following continued surveillance are reported from Nicobar and CMC-Vellore studies [28,45] (Direct observation of incidence).

2.2. Incidence of cases and age-sex distribution: Table 15 shows the incidence from various surveys in India. Age-Sex distribution of incidence cases over a 5 year period is shown in Figure 10. The incidence in BCG.Trial area was higher than elsewhere, as it was for prevalence also. On an average, **incidence of cases between two points of observation however, was a third of the prevalence** at the initial point of observation, similar to that in NTI.LS. In the NTI.LS about 50% of total incidence was observed to be in males aged 35 years and over. In females the contribution was 15%[10,11].

2.3. Incidence of cases with time: In the NTI.LS, **among the younger population in the age group 5-4 and 15-34 years, a decrease with time was observed, with corresponding rise in those aged 35+ years**[10,11].

2.4. Proportion of smear positivity in incidence cases: The proportion in incidence cases, positive on culture alone (negative or smear), in relation to culture and smear positive cases in the NTI.LS was **75.0% and 55.8%** for surveys 2 to 3 and 3 to 4 respectively (not on table)[10,11]. The incidence of smear positive cases was estimated to have declined in 23 years in the NTI.LS area from 0.65 to 0.23 per 1000 (not to table)[14]. No such observation was made elsewhere.

2.5. Incidence of infection in relation to that of cases:Table 4 shows, that the relationship of annual **incidence of infection of 1%** as observed in various age groups upto 14 years, **corresponded to smear positive case incidence of 45/100,000 in survey 1 of NTI.LS**[10,11], and in line with observations made elsewhere[49]. However, the relationship was not stable in later surveys of NTI.LS (not presented).

2.6. Conclusion: The considerably higher prevalence of cases as compared to incidence (3:1) could be interpreted to be due to failure of intervention and consequent pooling of previous cases in the community.

3. INCIDENCE OF CASES BY EPIDEMIOLOGICAL GROUPS:

3.1. Case incidence by infection: Figure 11 depicts a higher rate of case incidence among the infected, rising with age, especially in males.

3.2. Case incidence by radiological abnormality: Bacteriologically negative persons having radiologically active tuberculous shadows had the highest incidence rate of bacillary cases (2.6% per year), on a five year observation, more so if they were tuberculin positive[11].

3.3. Incidence of cases by epidemiological groups: Various population groups, classified by some epidemiological attributes, and incidence of cases in them, are presented in Figure 12[50]. **The two highest risk groups had constituted only 5.6% of the population** size, but still **contributed 46% to the total new cases arising in the population in a year.** However, one must also balance it with the observation that 48% of the new cases would arise from amongst those who had no shadow in their chest x-ray, *albeit*, with a much lower rate, and was attributable to the relatively larger

group size (89% of population). **It could be concluded that surveillance of the two highest risk groups could be useful, if they were action-taking[50].**

(D) PROGNOSIS OF CASES

1. PROGNOSIS OF PREVALENCE CASES:

1.1. Fate: Fate of cases in a situation without active intervention is presented in Figure 13. Based on 1 1/2 year period observation, 20%, 18% and 62% of the cases were dead, became sputum negative and remained sputum positive respectively, in a year's time, subject to the hypothesis that the dynamics within the 1½ year period, had remained uniform.

1.2. Natural dynamics: Figure 14 is a stylised presentation of the dynamics of tuberculosis in the community without active intervention, utilising the information available from NTI.LS[47]. The proportion excluded annually from the existing pool of cases by reasons of death and cure, was rounded up to be nearly a third of the initial pool (d:20%, c:18% of pool, total: say, 1/3 of pool). The exclusions would get balanced with the estimated addition by way of annual incidence (i: to the extent of about 1/3 of size of initial pool). **Thus, year to year, the size of the pool would remain unaltered, and 2/3 of it would be formed by the continuing cases (the so-called "left overs"[51]).**

2. PROGNOSIS OF INCIDENCE CASES:

Of the incidence cases in the NTI.LS between surveys 1 and 2, the proportion of dead, cured and remained positive were 14%, 52%, 33% respectively, thus having a better prognosis than that in prevalence cases[11] (not on table).

3. TUBERCULOSIS MORTALITY:

3.1. Proportional mortality due to tuberculosis: Nearly 10% of all causes crude mortality in the community was shown to be due to tuberculosis in the NTI. LS area (Table 17)[52].

3.2. Mortality rate due to tuberculosis in the community: Mortality rate in the NTI.LS area was reported to be 95/100,000, not changing with time in 5 years (1961-68)[52] (Table 17). In the New Delhi area, between 1972-76, the rates were about 40 per 100,000, consequent on a well organised programme[20,21]. In the Madanapalle area, the mortality was reported to have declined from 253 (in 1949) to 64 (1952-53) and then to about 21 per 100,000 (in 1954-55), the latter hypothetically attributed to be due to a well-organised programme[6]. Murray C.J.L., in his draft trip report (Geneva WHO CDS 1992) estimated that **women in their reproductive age (15-44 years) had about 70,000 deaths from tuberculosis, every year, higher than that attributed to peri-natal causes related to pregnancy and child-birth (un-published).** Further, unpublished report derived from the Sample Registration System (SRS), and available with the TB section, Government of India, estimates around 400,000 annual deaths from tuberculosis in India. The currently estimated mortality due to tubercuolosis could be in the range of 50-80 per 100,000 i.e., between 0.3 to 0.5 millions annually (say 0.4 millions).The above projection agrees with that by Dholakia [53].

(E) TUBERCULOSIS IN PAEDIATRIC AGE GROUP

1. PREVALENCE:

Pulmonary tuberculosis in children was reported to be less of a problem in the paediatric population as compared to those aged 15 years and over[54,55]. Table 17 presents prevalence and incidence of cases from NTI.LS, upto the age 14 years. Average rate of incidence of bacteriologically positive cases among children was $^1/_5$ of prevalence, whereas it was $^1/_3$ in those

aged 15 years and over. In the Nicobar study the best estimate of all forms of tuberculosis in children was 0.6%, including histo-pathology confirmed glandular tuberculosis (smear positive case prevalence 0.4%)[56].

2. MORTALITY:

In a study by Rajnarain and Diwakara, **considerably higher annual mortality rate was reported from a Madras urban population group aged 1-4** years old (239 per 100,000) as compared to between 52-55 in the rural areas under BCG-Tiral and NTI.LS[57]. Of the total causes deaths in that age group, nearly 50% were estimated due to tuberculosis, as against between 4 and 5% in the rural areas in the same age group. The study had concluded that the special risk pertained only upto 4 year of age and not beyond.

(F) MORBIDITY AND MORTALITY: SOCIO ECONOMIC CONSIDERATIONS

1. STUDIES NOT SPECIFICALLY DESIGNED FOR ECONOMIC INFORMATION ON POPULATION:

1.1. Information prior to NSS: Not much reliable information on infection by socio-economic criteria are available in general. It was however known from BCG vaccination campaign results, upto early 1950s, that the infection rates were higher in industrial towns than elsewhere - 50 per cent of those aged 10 years and more and 75 per cent of those 15 years and more were infected[7].

1.2. NSS: In the NSS the only information collected on the economic strata of the population was place of residence (urban/rural) by type of dwelling houses ("Kutcha"/ "Pucca" houses)[7]. In the cities, there was higher prevalence of disease (x-ray active as well as bacillary) among persons living in the "Kutcha" houses than in the "Pucca" houses. The differential in prevalence rates by type of houses did not exist in rural areas. It was taken to indicate the possible effect of economic and sanitary conditions. The NSS had also shown that there were areas within a city (as in Calcutta), where the prevalence of tuberculosis was as high as 40 or 50 per thousand. These areas were invariably inhabitated by the poorest segment of the population. For example, Block 39 and 8 of Calcutta city had prevalence of 58 and 50 per thousand respectively, against 2.48 per thousand in Block 34 (comparatively affluent) as being the lowest estimate. Delhi city also had several blocks with prevalence between 30 and 50 per thousand, and so had other cities too in every zone.

Even though, generally speaking, the bacillary case prevalence rates in urban and rural areas were similar within each zone, Bangalore city, forming part of the Madanapalle zone, had a lower prevalence (2.40 per thousand; confidence limit 1.64 - 3.16) than the rural areas of the zone (6.11 per thousand; confidence limit 5.02 - 7.20). In all likelihood, Bangalore being one of the economically betterof cities, with considerably less slum problem within its environs, had something to do with it. The information is further substantiated by the observation in recent times that a sample population of Bangalore peri-urban area had a lower case prevalence rate than found in the sample survey conducted in the Bangalore rural areas[24].

1.3. Tumkur Survey: The tuberculosis prevalence study in Tumkur district, which had immediately followed the NSS had, as one of its objectives, to investigate the area-wise difference in tuberculosis case-rates[8]. It had made the significant observation, that the southern half of the district, consisting of six subdivisions (talukas), had "strikingly" large differences in the tuberculosis situation over the southern four talukas. (Tuberculous infection rate all ages: Nothern half 46, Southern half 30%. Prevalence of x-ray active cases: North 2.3, South 1.4% and Prevalence of bacillary cases: North 0.58, South 0.24%). Moreover, there was a preponderance of male bacillary cases in the north than in the south. It is well known that the northern part of Tumkur district is comparatively backward than the sourthern areas studied. There was no difference of course due to coverage by age, sex or due to size of villages between the two zones in the study, to which the differences could be attributed.

1.4. BCG Trial: In the Chingleput study of BCG.TRIAL, there is the consistent finding, that in terms of prevalence of infection, the problem of tuberculosis was higher in Thiruvalangadu area as compared to Kadambathur area, the annual risk of infection in the 1-9 year old children in the former being 1.6 times higher (prevalence of infection 10.9 and 7.6% respectively)[16].

1.5. Other Studies: In the study conducted in the tribal area in Madhya Pradesh [30], the tribal population had a significantly higher prevalence rate of bacteriologically positive cases (15.0 per thousand) compared to the non-tribal residents of the same area (9.7 per thousand). This was the nearest approximation to a study of the bacillary case rates by economic stratification, as one could have, without consciously designing for it, provided the hypothesis is true that the tribals were economically weaker in the area than the non-tribals. In the isolated Andaman Nicobar islands territory, the prevalence of smear positive cases among the primitive tribal population of Nicobar island, was found to be 4.1 per thousand, higher than that seen in CMC Vellore study (Table 10) and NTI.LS (Table 13).

1.6. Mortality: Apart from these studies, one could consider Rajnarain's finding[57], that there was a considerably higher annual tuberculosis mortality rate in children aged 1-4 years old in the Choolai area in Madras city, dominated by slums (239 per 100,000), as compared to the rural areas of BCG.TRIAL or in NTI.LS in Bangalore district (between 52-55 per 100,000).

2. SPECIALLY DESIGNED BY SOCIO-ECONOMIC CRITERIA:

2.1. Wardha Study: The survey carried out in Wardha district is the only tuberculosis prevalence study, specifically designed to observe the socio-economic aspects of population, as related to tuberculosis prevalence rate[25]. It gives information on various socio-economic strata, re: place of residence (urban/ rural); type of dwelling house (kutcha/ pucca), education, occupation and income strata. (Table 12 and Appendix Tables iii & iv). Of all the socio-economic groups studied, the highest prevalence rate was found to be among the urban female professionals (8.49 per thousand) as shown in Appendix Table iv. The rural women service group (5.20 per thousand) and women cultivators (6.80 per thousand) were also particularly vulnerable.

Other salient features of the study are summarised as under:

2.1.1. By Age and sex: The prevalence in males was higher than in females (2.39 vs. 1.32 per thousand population), both in urban and rural areas (Not on Table).

In rural areas, the prevalence was higher than in urban areas. The males had twice the prevalence than among females.

The age group 55-59 and 60+ years had the highest prevalence, rising with age in males. In females the rise was upto 39 years, falling after the age of 50-55 years.

2.1.2. By Literacy standard: The tuberculosis prevalence per thousand population was the highest among the illiterates (2.49) and lowest among the graduates (0.74) (Table 12). However in the rural population, the high school group (1.79) had higher prevalence than those educated only upto primary level (1.42). This has been interpreted to be due to the hardship that a rural student has to go through, leaving rural environs in pursuit of higher education.

For calculation of the respective prevalence rates by education levels, the eligible population group in the denominator were considered (Narang P, Personal Communication).

2.1.3. By employment: Prevalence per thousand (Table 12) was the highest among the professionals (including the petty shop keepers) (4.08) followed by cultivators (3.12) and agricultural labour (2.45). The housewives had a comparatively low prevalence rate, but had

contributed a high proportion to the total prevalence of cases, owing to the group-size being relatively larger. Of all cases in both sexes, about 70% were among those either classified as non-worker (24.9%), cultivators (24.8%) or agricultural labour (21.4%). All these could be persons without a regular source of income. Of the total cases in females, about 48% was among those unemployed (called "non-worker" which included housewives), followed by agricultural labour 23.9% and cultivators 15.2% (Not on Table).

2.1.4. By income-group: The prevalence of pulmonary tuberculosis showed inverse relationship with increase in per capita income from 2.04 per thousand in <Rs.100 group to 1.09 in ⟩, Rs.300 group (Table 12). The inverse relationship had held good both for urban and rural population (Appendix Table iv).

In urban areas, prevalence in ⟩, Rs.300 group was fairly high (2.18 per thousand).

The grouping by income, used in the survey was decided after a preliminary socio-economic study in the rural areas of Wardha. The economic scenario, reflected by per capita income, is different from India as a whole and gives a grim picture (Narang P, Personal Communication).

2.1.5. By area and living standard: The prevalence (2.4 per thousand) as found in those living in "Kutcha" houses in urban areas was the highest. In rural areas, there was no difference in rates between "Kutcha" - "Pucca" houses (Appendix Table iii). It was probably due to small number of pucca houses and also to the almost similar quality of life and the level of health consciousness among rural population, affluent or otherwise.

3. TUBERCULOSIS AMONG THE WORK FORCE

Dholakia[53] contends that the proportion of workers among the tuberculosis cases is likely to be more than among total population. This may have more to do with the distribution by age-sex in the population than anything else, i.e., more among males than in females and among adults than in children. Evidence, according to him, is lacking to assume a differential prevalence of tuberculosis among workers and non-workers. His estimate of workers with tuberculosis in the base-year 1993-94, among population aged 15 years and over is presented in Table 18. Of the workers estimated to have tuberculosis in India, about 52% were in the age group 15-44 years. In this age group, about 40% of the workers with tuberculosis were estimated to be women in the urban areas. The proportion, however, was only 17.9% in rural areas. There was much lower proportion of women among workers with tuberculosis in higher ages, especially in urban areas.

V. DISCUSSION

1. SUMMARY OF TUBERCULOSIS PROBLEM:

The average rates of tuberculous morbidity and mortality, hypothetically considered to be relevant to the country as a whole, are utilised to estimate the problem in absolute numbers, so as to serve as a guide for planning for resources at the national level (Table 19). **However, it is recommended that the estimates be considered in the light of the comments made in para 2 (vide infra).**

A brief interpretation of the epidemiological situation in India, along with the use of the epidemiology in designing the tuberculosis programme in India (NTP) is given in Appendix (vi).

2. RELIABILITY OF DATA AND PROBLEM OF EXTRAPOLATION:

2.1. Problem in Sampling and identification of strata: The near continental dimension of India and the variability in the socio-economic situation from area to area and even within as small an area as a district, raises the question of representativeness of the data and the wisdom of extrapolation of the findings obtained from epidemiological studies carried out in limited areas to other areas or groups. While some of the surveys had taken samples for ensuring a degree of representativeness, others had arbitrarily selected the population. Even in the sample surveys, owing to lack of hypothesis, an appropriate stratification by relevant variables could not be carried out, thereby rendering the study population less representative for the area, to that extent. Examples of both NSS and Tumkur surveys could be cited in this respect[8,10]. No doubt suggestions were available from the results of these studies that the prevalence rates could vary by the socio-economic strata in society, yet the information could not be reliable for lack of representativeness of samples. The data from the Wardha study[25] as well as Dholakia's study[53], however, could now be useful in this regard. Hypothesis on socio-economic aspects, gender differentials and areawise distributions of cases besides the pressing problem of tuberculosis among the workforce could now be formulated for designing representative sample surveys in other areas of the country, apart form putting it to use in programme planning. Priorities may have to be redefined, keeping in view the relatively deprived sections of the society. **It appears that tribal or urban slum dwelling population groups, living on the fringes of the society, could need specially monitored programme**, may be on the lines of that followed in the Nicobar or North Arcot tribal population groups[28,29,45]. The higher prevalence in the urban slums, as observed in the NSS, needs to be viewed now in the light of the projection that the proportion of urban slum-dwellers, already high at about 37%, is likely to escalate, to be about 50%, by the turn of the century.

2.2. Reconsideration on average prevalence rates: The review has highlighted the need for re-consideration of the average prevalence rates for the country.

2.2.1. Infection: The question of considering the infection rate in the country to be 60-70%, in both sexes of all ages needs to be reviewed. Given the inappropriateness of tuberculin testing for discriminating the population as infected and uninfected in the age group beyond 10 years (or say 15+ years) in age, makes the estimates on infection rates beyond this age inaccurate. From Figure 2 it could be seen that the proportion of positive reactors to tuberculin could be a phenomenon related to age. In the age group of 15-24 years, 93% of those who were negative reactors to 1 TU, were still positive reactors to a higher dose, i.e., its only a small proportion who would be negative reactors to any dose of tuberculin. Because of this problem, **the estimates of infection could only be made in younger age group, with any degree of accuracy.**

2.2.2. Radiological cases: The revised estimates of radiologically positive bacteriologically negative tuberculosis prevalence as per NSS are presented in Table 8 along with their revised estimates, correcting them as suggested on JPR[40] (see section III.C.V.). As per the corrected rates, the **bacteriologically negative but radiologically positive cases prevalence in the community would vary from 2.6 to 4.7 (say, 3.0 per 1000, as average), instead of 10.3 to 18.6 (say, 16 per 1000) without correction (Table 8).**

2.2.3. Bacteriologically positive cases: The above information, taken together with the finding, that the estimate of bacteriological case rate (culture positive) should be corrected to be 39% more than the rate obtained from surveys examining only two specimens of sputum[37], would mean that the proportion between bacteriologically positive cases and radiologically active and bacteriologically negative cases should be revised. **The bacteriologically positive case rate in the NSS, taken to be between 2 and 8 per thousand (say, 4.0 on an average)** varying from area to area, **should be corrected to be approximately between 3 and 11 per thousand (say, 6.0). The ratio between bacillary cases and radiologically active bacteriologically negative cases would then no longer be 1:4 (i.e., 4.0 vs 16.0 per 1000) as currently estimated for India, but as 2:1 (i.e, 6.0 vs 3.0 per thousand on an average). The use of the revised rates (given in bracket in Table 19), in preference to the oft-quoted NSS rates hitherto followed in respect of radiologically positive cases in the community, has over-riding implications for the planning process of NTP as well as in respect of resources-management under it.**

2.2.4. Current estimates on pulmonary tubercusis:

2.2.4.1. Estimates for Andhra Pradesh, South India: In a recent report, the prevalence rates of bacteriologically as well as total problem of positive tuberculosis in Andhra Pradesh is estimated, based on two studies of comparatively recent vintage, rural area in Medak (1992) and tribal area in Khammam (1982)[60]. The smear positive prevalence among those aged 15 years and over in the former was 1.62 per thousand. It was 5.13 in the latter. The coverage of sputum exam of eligibles in Medhak study was only 70.8% and radiolograpic coverage, a mere 55%. To what extent the rates obtained from low coverage of population could be taken to be representative is questionable[15]. In most studies presented in the current review, the coverages were of the order of 90% or more[7,10,12,14,15].

In the Andhra Pradesh estimate, presented by Ramana, the above rates were adjusted (Total prevalence in the state 890 per 1000 in 15+ age), using the correction factors for varying methods of screening and sputum tests, based on unpublished data from North Arcot study (TRC, unpublished)[61]. This was to make the estimates comparable to NSS, NTI.LS and BCG Trial data[7,10,15]. However, whether these correction factors were seeking to correct rates, falling within 95% confidence limit, as was done in an earlier study[62,63], could not be ascertained, owing to unpublished and brief nature of the material under reference [61]. Correction factors for prevalence rates based on statistically discriminated rates were provided in a later NTI study, revising the earlier correction factors[24,62]. The adjusted rates provided in Ramanna's report are recalculated, adjusting for age-difference, screening method and bacteriological specimens examined. Accordingly, the prevalence rates for culture positive cases are found to be 300.0 per 100,000 for 5+ age group in Andhra Pradesh (270.0 to 330.0 per 100,000). These are similar to rates found in NSS[7]. The prevalence of smear positive cases could be 130, 370 and 150 for Medak, Khammam and Andhra Pradesh respectively, for the population aged 5+.

2.2.4.2. Estimate on patients on treatment: Based on data from secondary sources, as well as qualitative study in 26 villages spread over 13 selected states in India, the National Council of Applied Economic Research New Delhi has estimated the point prevalence of tuberculosis (all forms) to be 4.23 per thousand, with an estimated total number of 3.8 million tuberculosis patients on treatment in the country[64]. Since information on method, population, coverage and diagnostic criteria are not readily available in the report, (as already discussed in Section IIIC, these have vital

bearing on the results), the above should be viewed more as an estimate of the load on the health services than epidemiological estimate of the problem in the population at large.

2.2.4.3. Estimate on morbidity and mortality from SEARO workshop 1996: In the workshop on country-specific estimates of tuberculosis morbidity and mortality, organised by the WHO SEARO at New Delhi in November '96, all available country-specific data were used to estimate the problem, by using four models, namely Notification Method, ARI Method, Incidence Study Method and Triangulation Method (DISMOD). The current estimate on mortality for India, as arrived at, is shown in bracket in Table 19. The disease rates are being further developed and not presently included herein.

2.2.4.4. Use of estimates: The average rates, as estimated and presented above, could be of great use in the planning for provision and utilisation of resources, as well as for monitoring of programme output in terms of the problem in the population at large. It should be realised, however, that these estimates, owing to the nature of their computation and large range, could be of limited purpose in effect-evaluation of intervention. This is especially so, since in tuberculosis control, one is called upon to discriminate between low initial prevalence rates with small amount of change consequent on intervention (say between 5-7%) (see para 3.1, intra).

3. CHANGES IN TUBERCULOSIS WITH TIME: ITS MEASUREMENT:

3.1 Indices for measurement: Starting from the NSS in 1955-58, several surveys were conducted in different areas in India at different times (Table 1). It was observed that the comparatively low prevalence rate of cases between 2-8 per thousand, (say, 4 per thousand) had more or less, remained unchanged over the years. The reason for this is clear from an understanding of the natural dynamics of tuberculosis (Figure 14). It could be observed that the pool of cases remained unchanged over short period of time, without active intervention. On account of the relatively low initial case prevalence rates (Table 9 and 10) and the expectation of a very small change in it, if at all, the population sample size had to be considerably large to identify a statistically valid change (Appendix Table ii)[46,48]. Even mortality rates in tuberculosis did not present itself to be a sensitive index of actual epidemiological time trend. However, on interpreting the above survey results on infection and disease by areas, especially their distribution by age and sex as well as over time, Indian epidemiologists had taken the viewpoint that the **disease could be in an endemic phase in India, on a slow declining trend,**taking their cue from Grigg's work[58,59] (see Fig.15 for the hypothetical secular epidemic curve).

It is to be noted in this connection, that the wide gap between mortality rate, case rate and infection rate in the community (90:400:38,000 per 100,000 respectively) is also considered significant with respect to the interpretation of the interpretation of the age of the epidemic in India (Fig.15). **While dwelling on the current epidemiological situation in India, one may not miss the rather disturbing recent findings on drug resistance as shown in Table 14**, even though information on this is still meagre.

3.2 A.R.I.: It needs to be recognised that bacteriological case-prevalence, in being the pool of cases leftover and carried over time, is more of an index of a failure of the anti-tuberculosis effort, than a representation of the secular epidemiological trend as such. Incidence of cases, on the other hand, represent the current risk of developing disease among the previously infected, and therefore give a cumulated risk over a long time, as it has to be observed in higher ages. As distinct from these, risk of infection is the index, which represents the direct and a near-immediate consequence of the presence of bacteriological cases in the community. Following extensive work on the epidemiology of tuberculosis in the western countries in the comparatively recent times, ARI has been recognised to reflect the current epidemiological situation in an area, in preference to the disease rates[34]. It is also possible to derive from it an estimate of the current rate of incidence of the infections cases, as suggested by Styblo[49], also shown in Table 4. In the Bangalore

rural area studied by NTI in a 23 year period, ARI was seen to have declined at 2.3% per year (Figure 3). The smear positive case incidence was 23 per 100,000 at the last survey, as estimated from the prevalence rate of cases in 1984. It could thus be interpreted as coming down during the period at a rate nearly corresponding to the fall in ARI. However, there was no other evidence of ARI declining in India, apart from Kashmir valley (Fig 16). Thus, **India could be identified as a country of high transmission and inadequate decline, a situation which it shares with the sub-Saharan countries (ARI 1-2.5%, annual decline 0-3%).**

4. CONTROL PROGRAMME AND EFFECT-EVALUATION:

4.1 Objective of a tuberculosis programme in the Indian context: One may wonder whether the epidemiologists are not over-zealous in expecting a control programme, like it is in India with a current efficiency at 33% or less, to bring in the epidemiological returns in a relatively short time. For countries like India, with the likely current average annual number of smear positive incidence of 750 cases in an average Indian district of 1.5 million population, the task of reducing it is altogether a different proposition, as compared to, say, a country like the Netherlands, with an incidence level of 12-15 smear positive cases in a million population (Table 20)[47,65].

The Indian situation should be viewed in the light of the fact **that already diagnosed cases continue to constitute a major proportion of the prevalence (2/3rd) year after year (Fig.14) i.e., it could be a sort "of an epidemic of the left-overs".**[51] This needs to be transformed through the operation of a highly efficient treatment programme, as experts globally contend, with a well-thought out case-finding network in place.

Some salient features of the epidemiological situation, as used for planning a relevant control programme for the country, together with their interpretation with regard to the trend, is given in Appendix Table vi.

4.2 Continued surveillance through ARI and effect-evaluation: In view of the large population size required (Appendix Table ii) for obtaining information on disease from the repeat surveys to be meaningful towards reviewing of the epidemiological situation from time to time, or effecting a comparison from area to area following a tuberculosis programme, the **alternative of carrying out infection surveys instead, could be considered. For this purpose, sub-district level samples of unvaccinated children could be selected (cluster samples).** Care should be taken to obtain socio-economic stratification, in view of differences in rates as seen even between contiguous areas. Study by Bleiker and unpublished information developed in association with the WHO Geneva and available with the reviewer, shows that the relevant sample sizes required for ARI-study in the population, could, infact, be a manageable activity[66]. The question of an adequate number of unvaccinated children available in the community was not found to be a problem, even if the proportion vaccinated was found to be as high as 80-90%[67]. It was also shown that the exclusion of variable proportions of vaccinated children from infection surveys would not affect the estimate[68]. Moreover, ordinary general health workers with simple training could carry out the field work[19,31]. The finding from the NTI as well as BCG.Trial that the prevalence of various grades of protein energy malnutrition among younger children had not influenced the estimates of the prevalence of tuberculous infection, could be of special significance, in this context, to the developing countries[62,63,64].

It is placed on record here that a study on ARI as related to some well-known health indices in the community (e.g., child mortality, infant mortality and tuberculosis case fatality rates etc.) was completed at the NTI Bangalore in 1993-94. (NTI, peri-urban follow up). When analysed, it could show the way towards developing the ARI as an index for general health as well, besides for tuberculosis.

4.3 Epidemetric Models: Over and above the direct measurement of the situation through ARI, it is also suggested that repeat surveys in some areas be carried out in order to provide inputs for construction of epidemiological models, feeding into them the data on operational efficiency of the programme also as a variable, as done by the present reviewer's group[48]. The trend obtained from such a model (Fig.17) had shown a marginal decline, relevant to the current programme efficiency over a period of 50 years or more, the decline almost getting arrested thereafter, corroborating the observation of epidemiologists on a slow decline[59,69]. It is suggested that the exercise of mathematical approximation could be perfected from the data obtained from longitudinal surveys in selected areas, of course with adequate provision for reflecting socio-economic changes with time.

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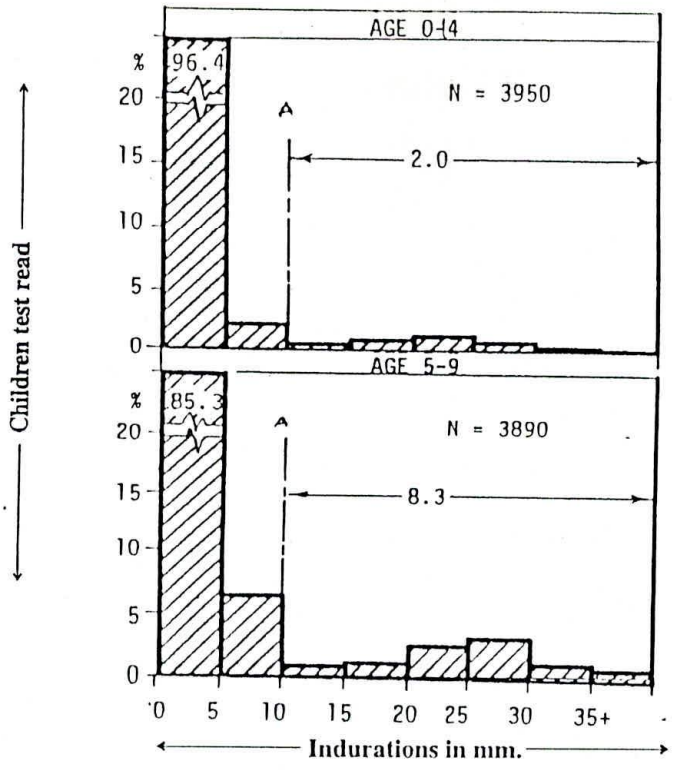
LIST OF FIGURES

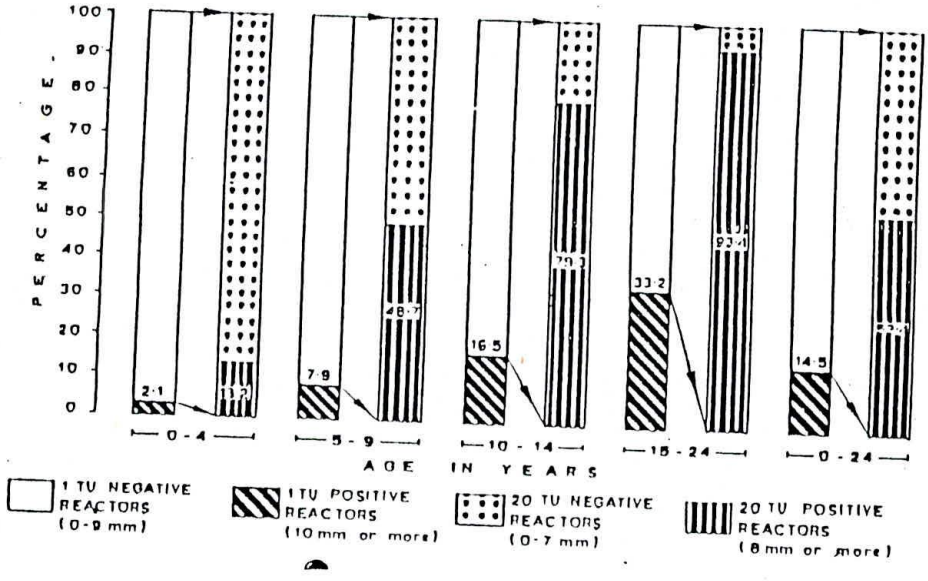
Fig. 1. DISTRIBUTION OF TUBERCULIN INDURATIONS IN A POPULATION AGED 0-9 YRS.



'A' - Antimode of distributions : Arrow to its right infected proportion

SOURCE : OLAKOWSKI[11]

Fig. 2. PROPORTIONS OF PERSONS INFECTED WITH M. TUBERCULOSIS* AND THOSE SHOWING NON - SPECIFIC SENSITIVTY** IN A RURAL POPULATION

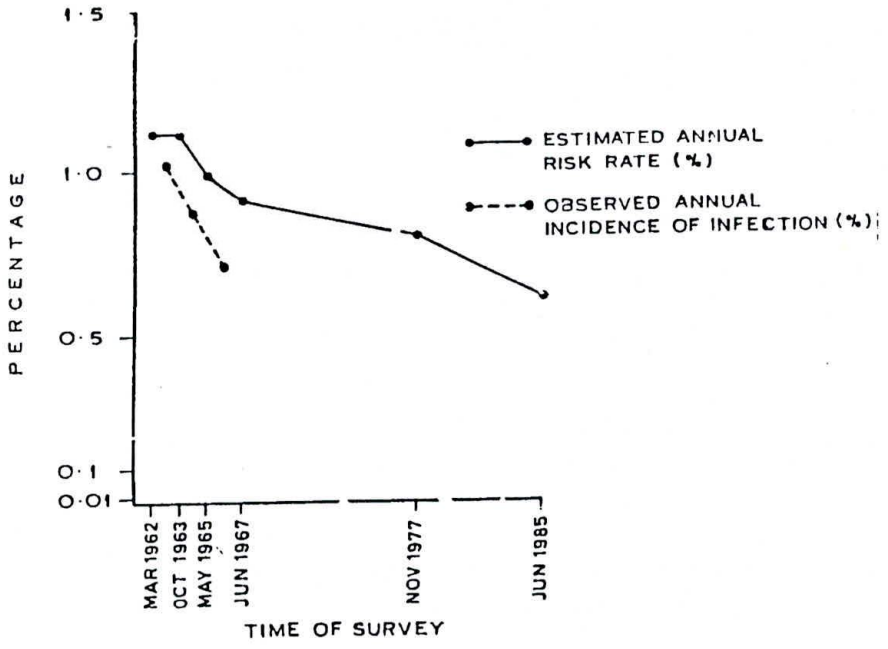


* Infected - Persons who are 1 TU positive reactors

** Non - Specfic sensitvity - Persons 20 TU positive reactors among those with negative reactions to 1 TU.

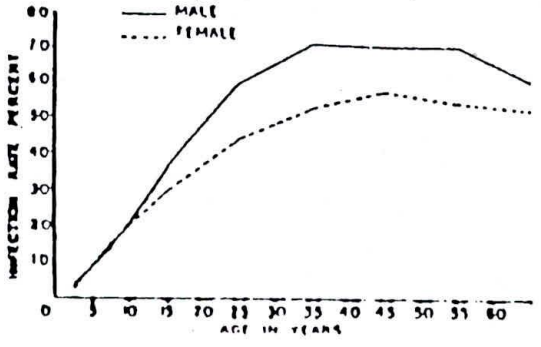
SOURCE : CHAKRABORTY et al[32]

Fig. 3. ANNUAL ESTIMATES OF RISK OF INFECTION (1962 - 1985) AND OBSERVED ANNUAL INCIDENCE OF INFECTION (1962 - 1967)



SOURCE : CHAKRABORTY, AK et al[13]

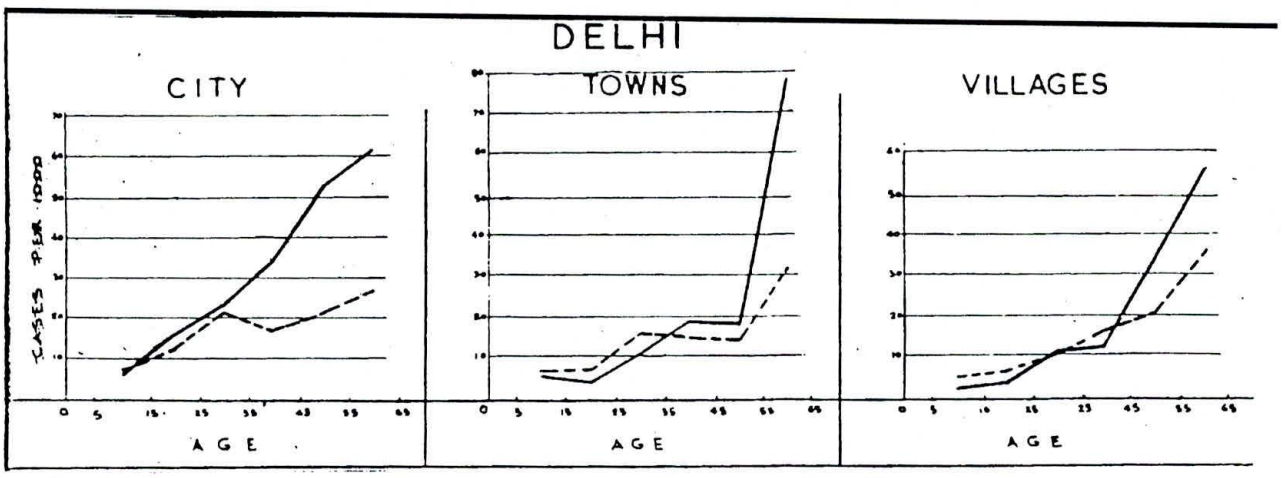
Fig. 4. PERCENTAGE OF REACTORS BY AGE AND SEX (TUMKUR DIST. 1960)



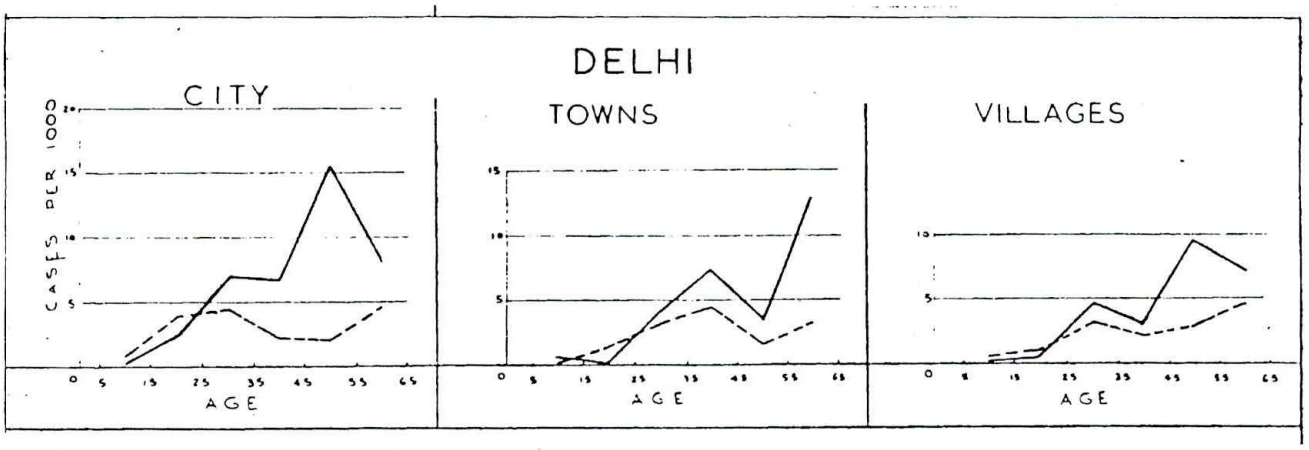
Reactor : 10mm and over SOURCE : RAJNARAIN et al[8]

FIG. 5. PREVALENCE OF DISEASE IN DELHI ZONE BY AGE & SEX

A . ACTIVE & PROBABLY ACTIVE CASES ON MMR



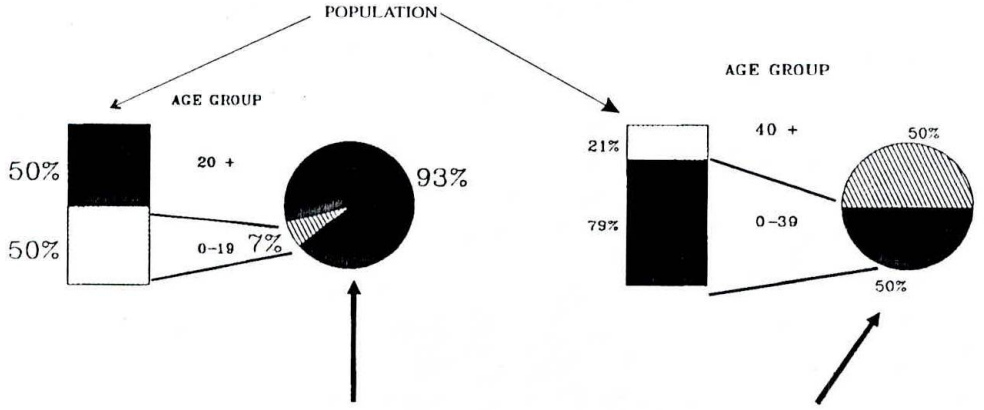
B. BACTERIOLOGICALLY POSITIVE CASES.



MALES _____ FEMALES---------- SOURCE : NSS (7)

FIG 6

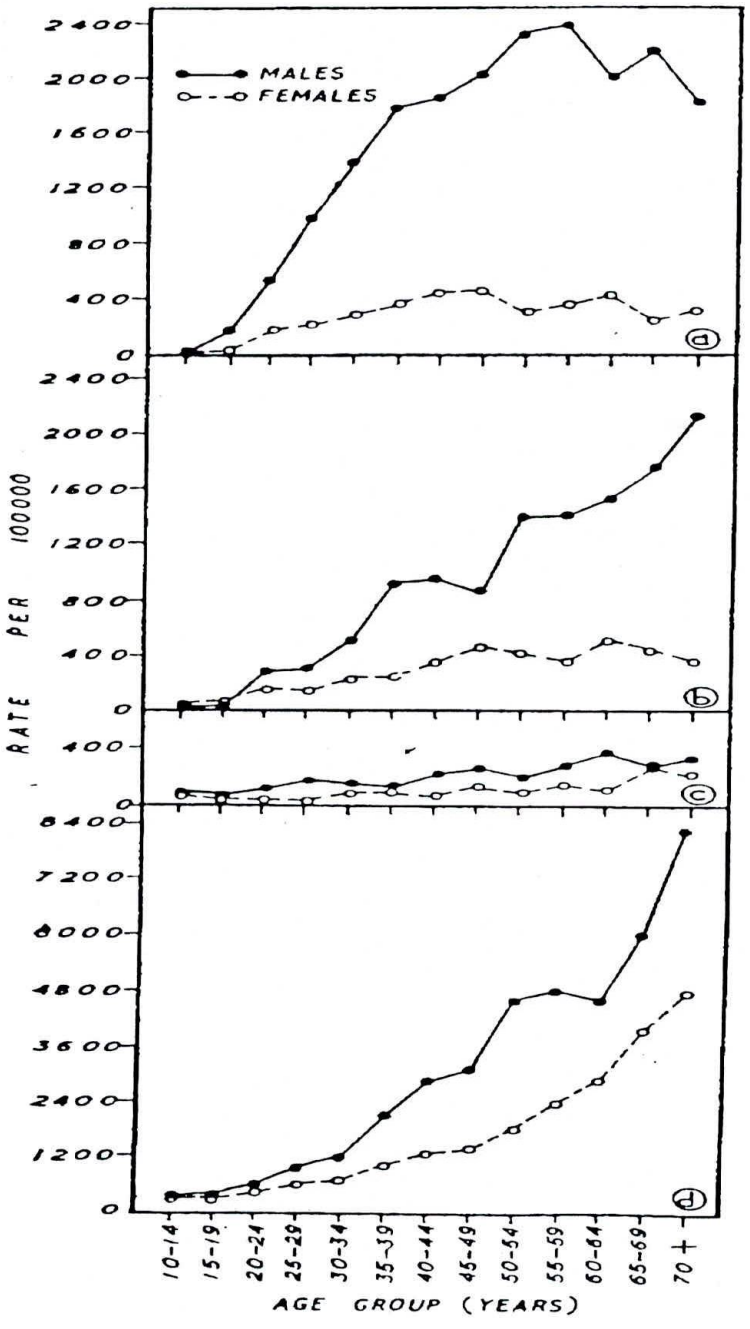
DISTRIBUTION OF AGE WISE PREVALENCE OF BACILLARY CASES IN THE COUMMUNITY



TB CASES IN THE POPULATION

Source: Author (Unpublished)

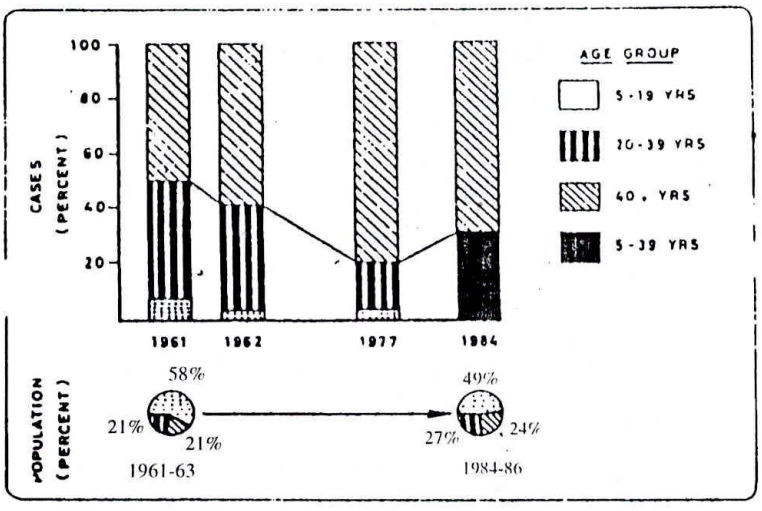
Fig. 7. PREVALENCE OF DISEASE BY AGE SEX AND METHOD OF DIAGNOSIS



Categories of cases :
a) Culture Pos. on 2 specimens
b) Culture Pos. on one specimen only
c) Culture Neg. smear Pos. (3 or more AFB)
d) Abacillary MMR - active (by 2 readers)

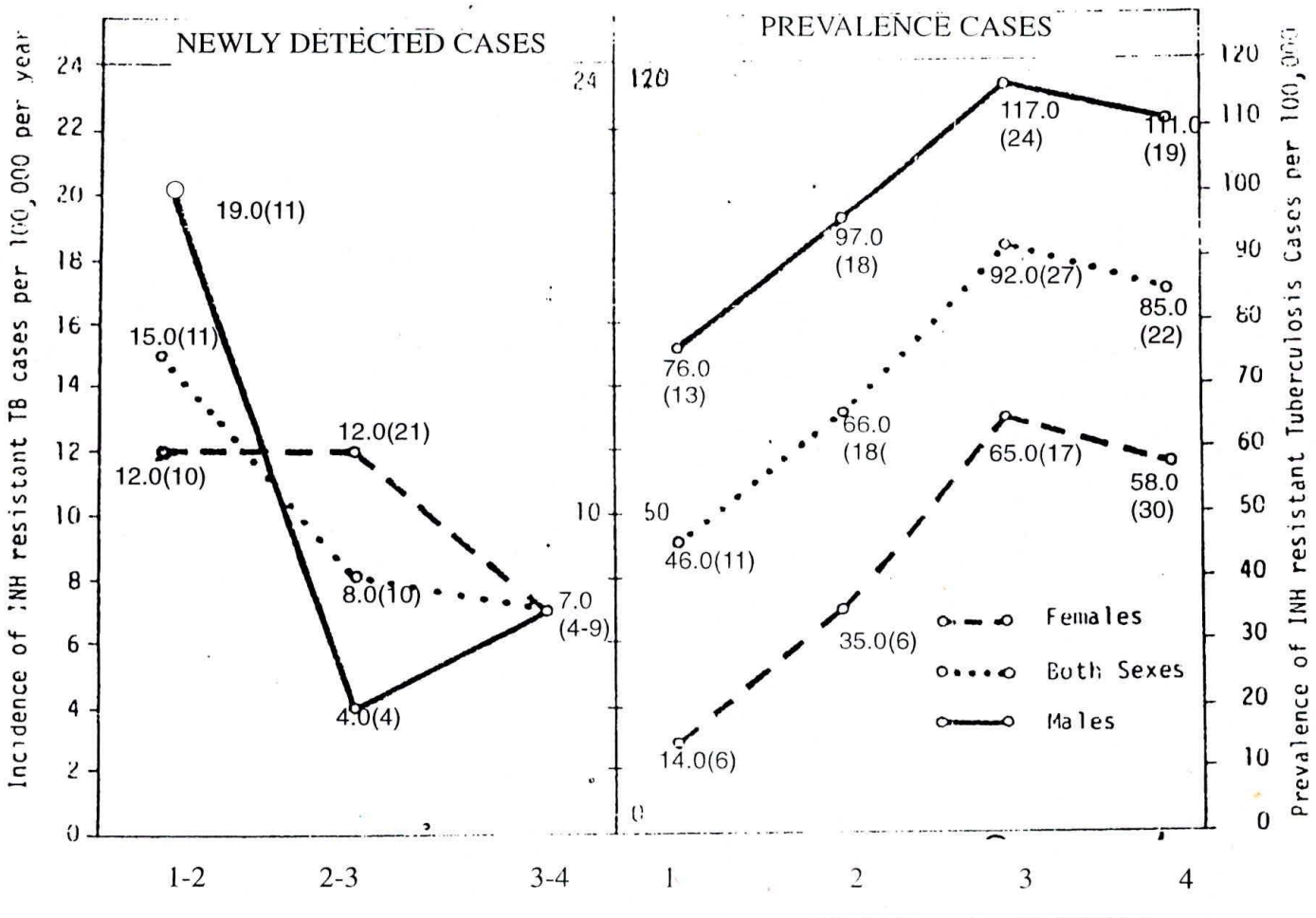
SOURCE : BCG. TRIAL[15]

Fig. 8. AGE-WISE PROPORTIONAL DISTRIBUTION OF CASES IN BANGALORE RURAL AREA WITH TIME (1981 - 84)



SOURCE : CHAKRABORTY AK[47]

Fig. 9. INCIDENCE AND PREVALENCE OF INH-RESISTANT TUBERCULOSIS CASES DURING 5 YEARS OF OBSERVATION (1961 - 68) IN BANGALORE RURAL AREA

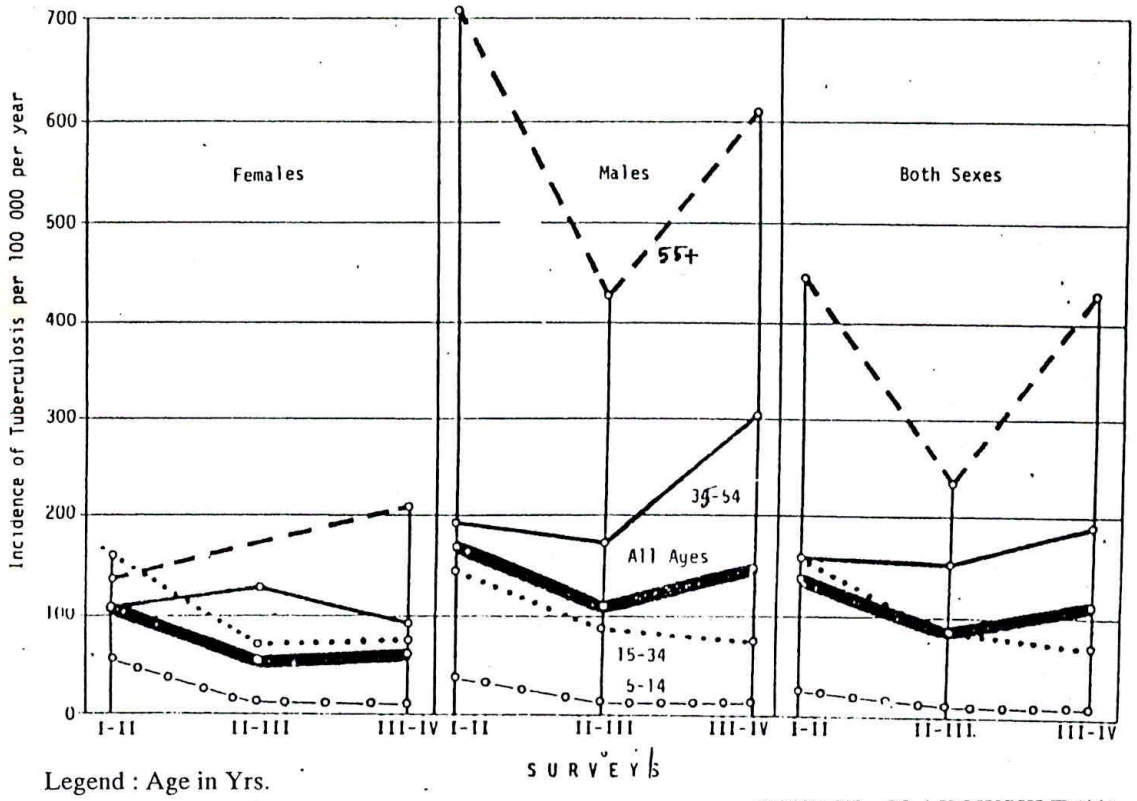


SOURCE : OLAKOWSKI.T (UNPUBLISHED)[11]

SURVEY 1- 1961
SURVEY 4 - 1966

(Percentage INH resistant out of total caes, in bracket)

Fig 10. INCIDENCE OF TUBERCULOSIS BY AGE AND SEX DURING 5 YEARS OF OBSERVATION

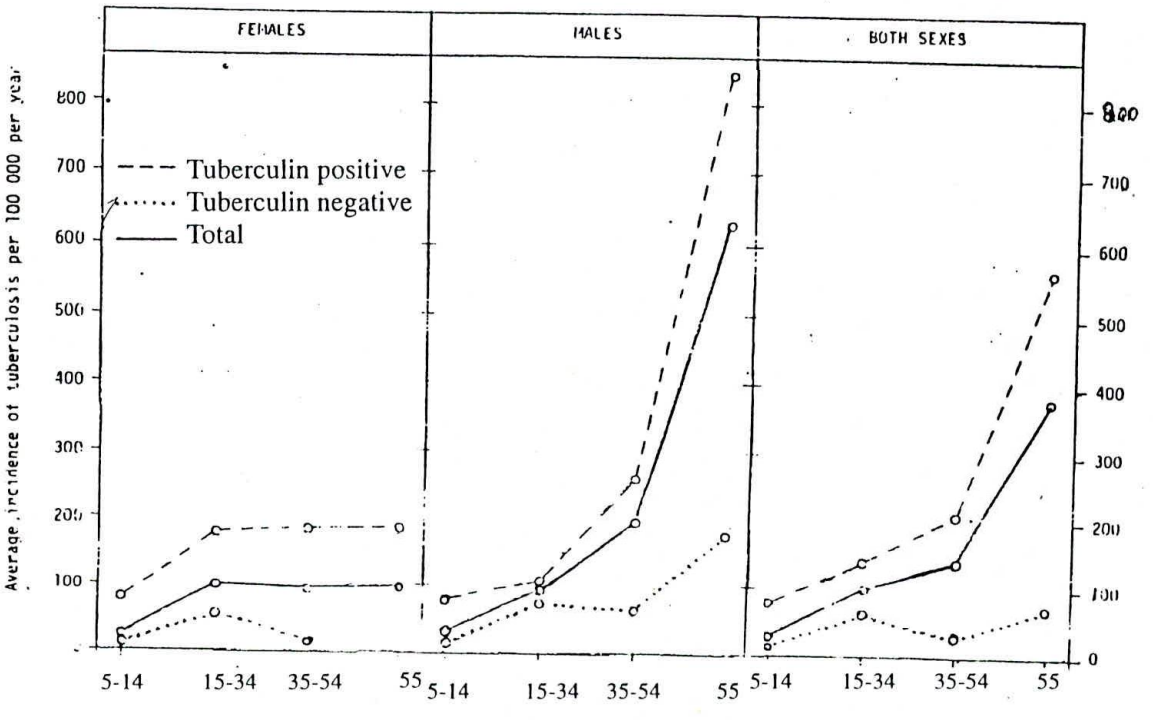


Legend : Age in Yrs.

5-14
15-34
35-54
55+
All ages

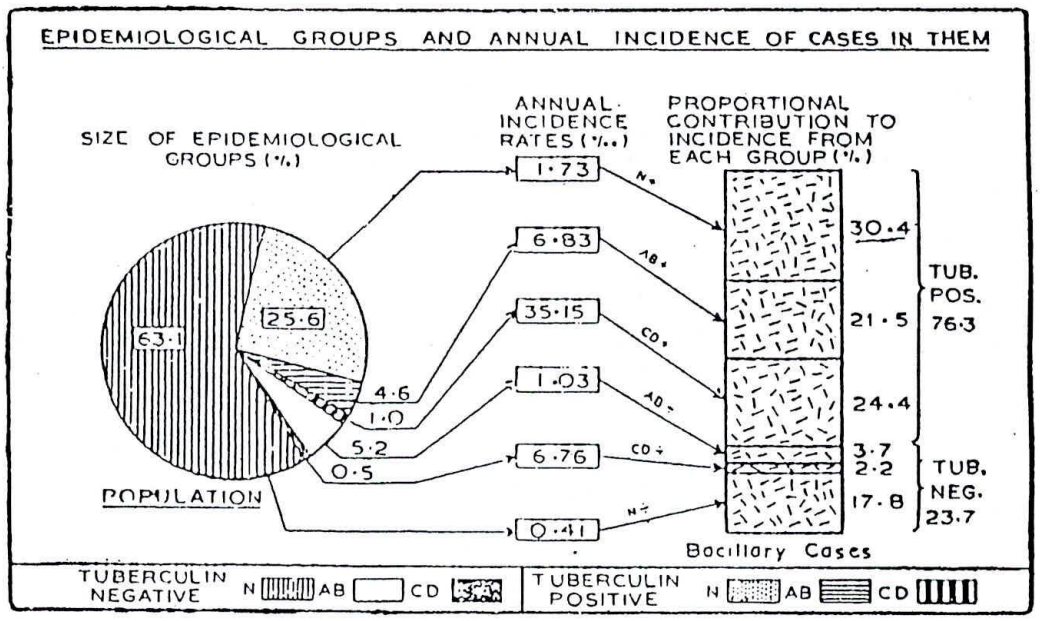
SOURCE : OLAKOWSKI T (11)
(Unpublished)

Fig 11. AVERAGAE INCIDENCE OF TUBERCULOSIS BY SEX AND AGE AMONG PREVIOUSLY NON- INFECTED AND INFECTED PERSONS



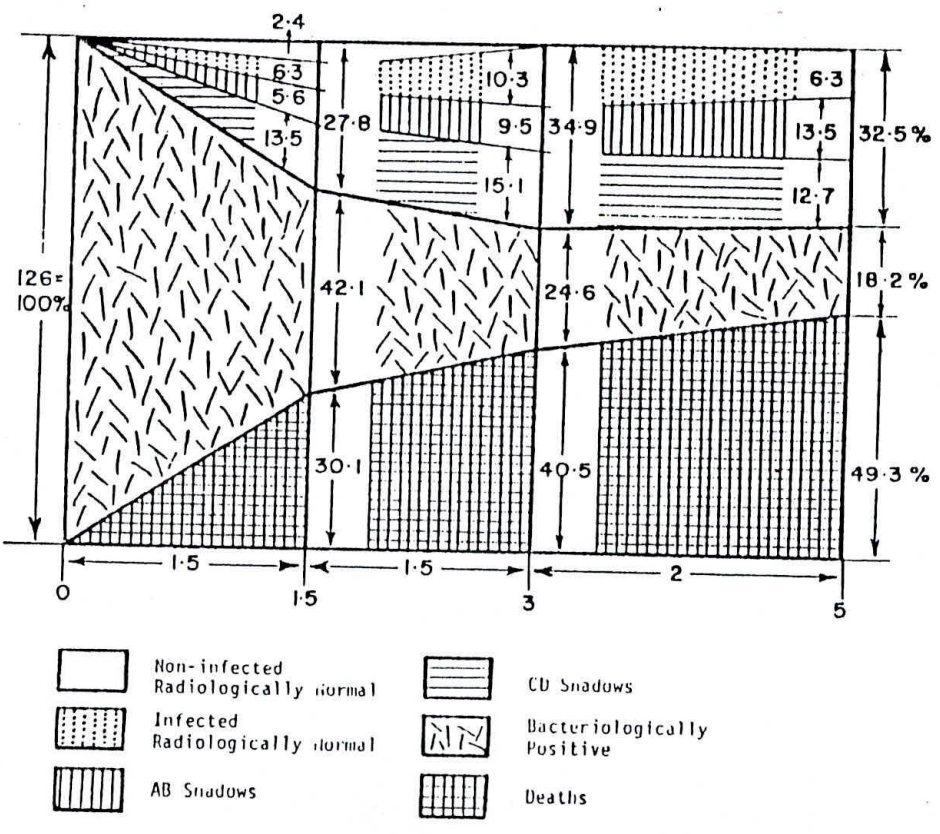
SOURCE: OLAKOWSKI T, UNPUBLISHED (11)

Fig. 12. INCIDENCE OF SPUTUM POSITIVE TUBERCULOSIS IN DIFFERENT EPIDEMIOLOGICAL GROUPS



N : X-ray normals, AB : inactive tuberculous lesion and non-tuberculous shadows.
CD : Probably active tuberculous shadows.
SOURCE : Gothi et al[50]

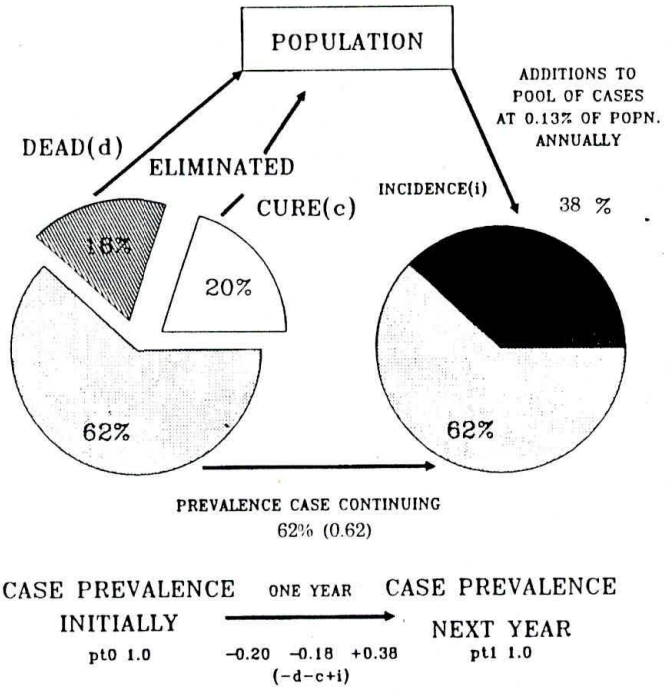
Fig. 13. PROGNOSIS OF TUBERCULOSIS CASES DURING 5 YEARS OF OBSERVATION, ALL AGES AND BOTH SEXES.



SOURCE : OLAKOWSKI T, UNPUBLISHED[11]

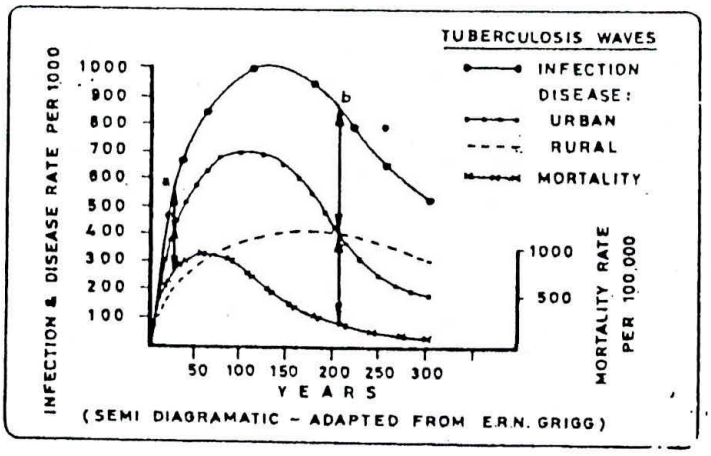
FIG 14

POOL OF TUBERCULOSIS CASES IN THE COMMUNITY
(NATURAL DYNAMICS)



Source Author (Unpublished)

Fig. 15. DEVELOPMENT OF THE WAVE OF TUBERCULOSIS EPIDEMIC THROUGH TIME



SOURCE : CHAKRABORTY AK [47]

The tuberculosis epidemic curve appears similar in form to those of other infectious diseases. However, the former develops through centuries. It has an ascending limb (phase of spread), a peak (phase of transition) and a descending limb (phase of decline), followed by endemicity. The essential proximity of infection, disease and mortality curves characterises the phase of spread (shown with arrow 'a'). Wide gaps between one and the other rate develop at the peak and descending limb (shown with arrow 'b'). In India, gaps similar to the latter, exist now. An inference that could be derived is obviously of an advanced epidemic curve, probably in declining phase. The urban - rural epidemic curves are different entities - but could cross at some point in the descending phase. The urban - rural distribution presently observed in India, may be viewed in this light.

FIG 16. ANNUAL RISK OF INFECTION (ACROSS INDIA)

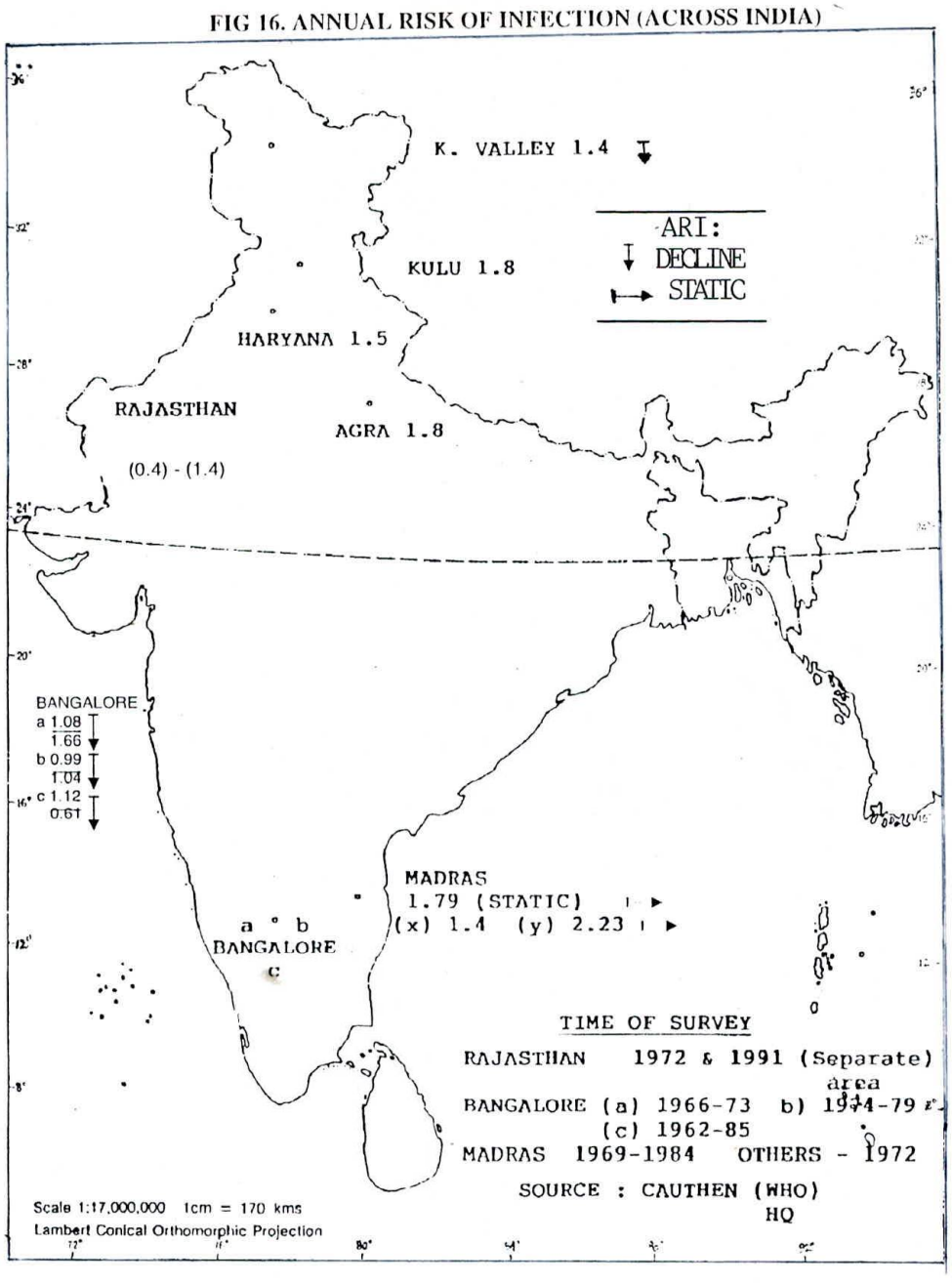
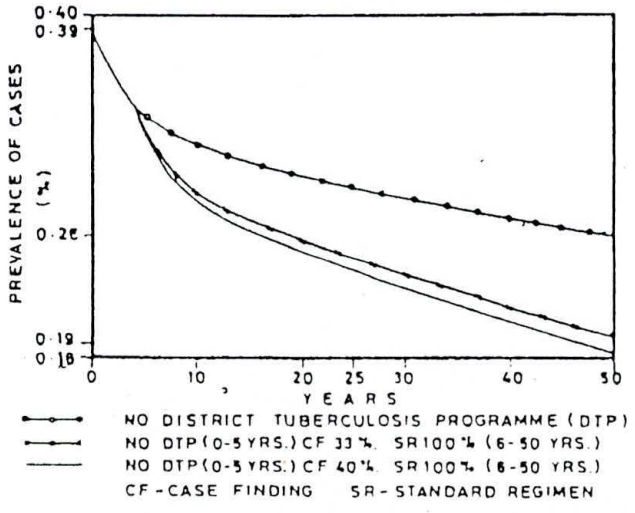


Fig. 17. MODEL DEPICTING HYPOTHETICAL TIME-TREND OF TUBERCULOSIS IN BANGALORE RURAL AREA.



SOURCE : CHAKRABORTY AK

LIST OF TABLES

Table 1: PROMINENT EPIDEMIOLOGICAL STUDIES IN INDIA REPORTED/UNREPORTED

Short Title	Refere nce	Year	Area	Design	Examined popn & age group	Method & investi- gations	Outcome
•Madanapalle Town study	5	1948 -49	Madanapalle town	Arbitrarily selected	Popn size 14,000	All ages-Tuberculin test PPD-S 1Tu-10 Tu-100 Tu MMR Sputum Culture	i)Infection rate ii)X-ray active case rate iii)Bacillary case rate
•Madanapalle study(M.S.)	6	1950 -55	Madanapalle town & rural area	Sample Survey	60,000 5+ in age	a)House to house census b)All ages-tuberculin test, PPD-S, 1Tu-10 Tu-100 Tu; c)5+ age MMR Sputum Culture	- Do -
•National Sample Survey(N.S.S.)	7	1955 -58	6 Zones: Hyderabad Madanapalle, Patna, Trivan drum, Delhi, Calcutta. Towns, villages & 1 city in each zone	Sample Survey representing 40% of Indian popn	Cities-131,319 Town-59,548 Villages-137,271 5+ in age	a)House to house census b)MMR 5+ in age FROM MMR-abnormals: c)Direct Smear of Sputum -2 Specimens d)Two laryngeal swab culture	i)X-ray active case ii)Culture positve case
•Tumkur Study	8	1960 -61	Tumkur district	Sample Survey	About 30,000 10+ age	a)House to house census; b)MMR 10+ age c)Tuberculin testing all 1Tu RT 23	i)Infection ii)Xray active case iii)Culture+ case
•Tumkur Resurvey	9	1972 -73	- Do -	- Do -	- Do -	- Do -	- Do -
•'Long'Survey (LS.NTI) Su 1 Survey 2 Survey 3 Survey 4 Survey 5	10,11 12	1961 -68 1961 -63 1962 -64 1964 -66 1966 -68 1977	3 sub-districts (taluks) of Bangalore dist	Sample Survey Sub-Sample	Popn 66,000 Age 5+ Popn about 14,500	a)House to house census b)Tuberculin test to all 1Tu RT 23 c)MMR-5+ age	- Do - Fate of infected, suspects, cases & other risk-groups
•LS:Followup	13, 14	1984 -86	Fresh Sample in 2 of the above 3 Taluks	Sample Survey	Popn. about 30,000 age 15+	Tuberculin 0-44 yrs 1Tu RT 23 Chest symptom questioning: 15+ yrs 2 specimens culture & smear exam from chest symptomatics/ tuberculin reactors	Infection & case rates

•BCG Trial (BCG.TL)	15	1968 Followup every 2½ for 7½ yrs	Chingleput district Tamil Nadu	Selected for study of BCG efficacy	All ages(1+) Ap-prox 360,000 in 209 contiguous villages and 1 town	a)House to house census b)All ages tuberculin test PPD-S c)MMR 10+ age, d)2 specimens of sputum from MMR abnormals - direct smear & culture	a)Infection rate b)Xray active cases c)Bacillary cases
•BCG Trial (Infection Trend)	16,17	1978 1983	- Do -	- Do -	Popn:1-9 yr. 10 yr trend: Survey 1, 8703 ▪15 yr trend: Survey 1, 4808	Tuberculin test PPD-S	Annual infection rate
•BCG Trial 6 resurveys	18	1968 -83	- Do -	- Do -	As in BCG trial with selected group for followup	MMR-5+ in follow up surveys	Incidence of cases
•Infection surveillance feasibility study	19	1983 -84	Anantpur dist AP Dharmapuri dist in TN	Arbitrary selected population	Aged:0-9 yrs Anantpur-4350 in 12 vils Dharmapuri-2077 in 6 vils	Tuberculin testing by general health workers 1Tu RT 23	Infection rate
•New Delhi study 6 surveys	20,21	1962 -75 (resurveys at 2½ yr intervals except Su6: after 4yrs from preceding)	New Delhi area under New Delhi TB centre	Population covered by Centre	Aged-5+ Approx 30,000	a)House to house census b)MMR c)MMR abnormals-culture of sputum & laryngeal swab d)Followup exam by xray, repeated sputum	Xray case, Bacillary case rate Prevalence & incidence of cases
•All India Tuberculin survey	23	1972	Villages in Kashmir, Kulu, Lohaghat Pithoragarh, Agra,Haryana, Rajasthan	Selected for altitude contrast	1-4 yrs Between 76-769 children in each	PPD-S, 5 Tu	a)Infection rate (ARI) b)Non-specific sensitivity
•Kashmir Survey	22	1978	Kashmir valley	Sample Survey	0-4 yrs popn 2448	Tuberculin testing PPD-S, 3Tu	Infection rate (ARI)
•Bangalore dist study on nutrition 2 surveys	22	1974 1979	Dodballapur subdist of Bangalore	Sample survey: repeated in same villages	Aged 0-4 yrs	a)Tubeculin testing 1 Tu RT 23 b)Nutrition assessment	Infection rate by nutrition grades
•Bangalore peri-urban study	24	1986 -89	Bangalore peri-urban area	Random Sample of villages in a 5 km radius 19 km from city centre	Aged 15+ 56,000 persons	a)House to house census b)Chest symptom screening c)MMR d)One specimen of sputum culture from eligibles by (b)/(c)	Symptom screened culture positive case rate
•Bangalore peri urban repeat study (under analysis)			- Do -	- do -	a)Aged 0-14 b)Old cases of previous survey	Tuberculin test 1 Tu RT 23	Infection rate (ARI) Fate of cases

Table P.No.2

•Wardha study	25	1981	Wardha dist in Maharashtra Central India	Purposive sample (whole dist)	Aged 5+ Popn 773,500	a)House to house census b)Socio-economic stratification c)Chest symptom questioning d)2specimens of sputum from symptomatics - culture & smear	Symptom-screened culture positive case rate
•Raichur study(Analysis not completed) by TRC Madras	26	early eighties	Raichur dist in Karnataka	Sample Survey	Aged 15+ Approx 70,000 in 56 villages and 21 town blocks	a)House to house census b)Chest symptom questioning c)2 specimens of sputum from symptomatic - culture & smear	- Do -
•Tribal study TRC	27	1980	Jawadhu hills of N.Arcot dist in TN	Sample Survey	Aged 15 + Tribal popn of 96,000 in 56 panchayats: 24 selected	a)Tuberculin test:1-9 yr (N-6702) 1TuRT 23 b)MMR 15+ age (N-12745) c)Chest symptom questioning 15+ age (N=15075) d)From symptomatics/MMR abnormals: 2 specimens of sputum-culture & smear	Culture positive case rate
•Nicobar study	28,29	1986	Car Nicobar island in Bay of Bengal	Entire island	Entire popn of 17,277 resident of 15 villages	a)Tuberculin test 0-14 (popn 5907) 1Tu RT 23 b)Chest symptom questioning 15+ age (popn 9514)	Infection rate, smear positive case rate
•Madhya Pradesh Tribal study by Regional Health office	30	1991	Morena dist in MP	Sample Survey	Aged 15+ Tuberculin test 1-9 yr (N-7642) Popn 23,000 in 37 villages	a)Tuberculin test 1Tu RT 23 - 1-9 yr age b)Chest symptom questioning 15+ age c)2 sputum specimens by culture/smear for chest symptomatics	Infection rate, smear positive case rate
•Rajasthan study by URMUL in Lunkaransar	31	1991 -93	Bikaner dist in Rajasthan	Arbitrary selection: 16 of 33 vil in Lunkaransar sub-dist	Popn 0-9 yr (N 2482)	Tuberculin test 1 Tu RT 23	ARI

NOTE: Other studies referred to in the text at respective places.

Table 2: PREVALENCE OF INFECTION IN DIFFERENT AREAS (with Tuberculin RT 23)

Study by:	Study Area	Time	Ref	Per cent infected●				
A) NTI	Age group (yrs):			0-4	5-9	10-14	0-9	0-14
	1. Tumkur,▪	1961	8	2.7	9.6	28.9	6.7	13.3
	2. Bangalore,	1961	10	2.1 (1.8-2.4)	7.9 (7.3-8.5)	16.5 (15.7-17.4)	4.9 --	8.6 (8.3-9.0)
	3. Bangalore	1984	13	1.2 (0.8-1.6)	5.3 (4.4-6.2)	9.2 (7.9-10.5)	--	5.4 (4.3-6.0)
B) LOCAL HEALTH STAFF/ TRAINING: NTI	1.Andaman & N	1986	28	3.7	12.0	19.6	--	10.0
	2. A.P.(Andhra)	1983	19	--	--	--	9.7	--
	3. Tamil Nadu,	1983	19	--	--	--	5.0-7.0	--
	4. Rajasthan Bikaner	1991	31	2.66 (1.54-3.78)	12.33 (9.98-14.68)	19.55 (16.44-22.66)	7.39 (6.08-8.70)	10.89 (9.58-12.20)
C) Local hlth staff/	Age group (yrs):				1-2	3-4	5-9	1-9
	Madhya Pradesh	1991	30		6.7(±1.8)	13.4(±2.8)	22.7(±1.7)	16.9

NOTE: ●Infected: Those showing an induration beyond antimode of its distribution; ▪Sample of whole district, urban & rural. Others only rural. (Figures in bracket give range for 95% Confidence limit, wherever given in original paper)

Table 3: PREVALENCE OF TUBERCULOSIS INFECTION* IN DIFFERENT AREAS BY AGE (with PPDS)(Percentage showing tuberculosis infection)

	Age Group(Yrs):- 1-4	5-9	10-14	15-19	20+
BCG.TRIAL 1979	4.9	14.9	30.4	48.1	74.4
Kashmir 1972	4.0	11.4	24.1	47.4	80.9
Kulu 1972	5.2	14.9	22.2	35.6	68.8
Lohaghat 1972	3.1	12.3	21.5	41.5	70.3
Pithoragarh 1972	4.1	13.2	31.1	49.4	71.4
Agra 1972	5.2	14.7	33.1	51.8	78.6
Haryana 1972	4.4	8.2	14.8	29.0	61.1
Rajasthan 1972	1.3	14.4	33.8	45.1	77.1

Source: Tuberculosis Prevention Trial[18] and Rajnarain et al[23]

NOTE: * Infected= Positve reactor to PPDS 12mm & over

Table 4: AVERAGE ANNUAL INCIDENCE OF TUBERCULOUS INFECTION AND SMEAR POSITIVE CASE INCIDENCE (BETWEEN SURVEY 1 & 2)

Age	Annual Incidence of Infection %		Annual Incidence of Sm+ cases in ages 5+(per 100,000)
0-4	0.8	0.93	45
5-9	1.07		
0-14	1.0		
All ages	1.63		

Source: 1) NTI[10], 2) Olakowski et al[11] NOTE: Sm+=Smear Positive

Table 5: ANNUAL RISK OF INFECTION (ARI) ESTIMATED OVER A PERIOD IN RURAL POPULATION GROUPS UNDER NTI.LS[13] & BCG.TRIAL[16]

Survey	NTI LS:Children 0-14 yr age[13]		BCG.TRIAL. Children aged 1-9 yrs[16]			
	Mid-Point of observation	ARI(%) on standard Prevalence rate□	Year	Panchayat area		
				ARI %:- Group 1	Group 2	All*
1	Mar 1962	1.12	1969	1.28	2.17	1.70
2	Oct 1963	1.12	1979	1.48	2.41	1.93
3	May 1965	0.99	1984	1.43	2.08	1.73
4	Jun 1967	0.92				
5	Nov 1977	0.80				
Follow up	Jun 1985	0.61				
Total	--	--	1969-84	1.40	2.23	1.79

NOTE: □ Annual decrease 2.3% per year; * No change over time in ARI

Table 6: ANNUAL RISK OF INFECTION ACROSS THE COUNTRY

Year	Area represented	Antigen used	Procedure of popn selection	Year Mid-point	Age(Yrs)	ARI (%)
1960-61	Tumkur dist in south India	RT23 1Tu	S.Survey	1960.9	0-4	1.66
1972-73	- do -	- do -	- do -	1973.0		1.08
1974-75	Dodballapur in Bangalore dist	- do -	- do -	1974.8	0-4	1.04
1979	- do -	- do -	- do -	1979.5		0.99
1978	Kashmir valley	PPD-S 3Tu	- do -	1978.7	0-4	0.92
1972	**Villages in:**					
	Kashmir	PPD-S 5Tu	Selected	1972.8	1-4	1.4
	Kulu Valley	- do -	- do -	- do -	- do -	1.8
	Lohaghat	- do -	- do -	- do -	- do -	1.0
	Pithoragarh	- do -	- do -	- do -	- do -	1.4
	Agra	- do -	- do -	- do -	- do -	1.8
	Haryana	- do -	- do -	- do-	- do -	1.5
	Rajasthan	- do -	- do -	- do -	- do -	0.4
1991▪	Rajasthan	1Tu RT23	Selected	1992.0	0-9	1.44

Source: ▪Siddique et al [31], others: Cauthen et al [22]

Table 7: PREVALENCE OF PULMONARY TUBERCULOSIS BY SEX ACROSS THE COUNTRY

Zone	Rad 'A' or probably 'A' case*/ `BA' (+) & (-)				BA cases*			95% confidence limit**
	Area	Male	Female	Total	Male	Female	Total	
Calcutta	City(Calcutta)	18.30	14.15	16.73	7.16	5.12	6.39	5.16-7.62
Delhi	City(Delhi)	24.46	15.61	20.56	4.99	2.88	4.06	3.23-4.89
	Town	14.13	12.69	13.47	2.09	1.83	2.45	1.54-3.36
	Villages	14.84	11.98	13.51	2.99	1.92	2.49	1.87-3.11
Hyderabad	City(Hyderabad)	17.71	13.09	15.44	5.31	3.03	4.18	3.44-4.92
	Towns	22.99	17.57	20.42	4.47	2.30	3.44	2.32-4.56
	Villages	23.33	18.33	20.88	2.93	1.62	2.29	1.70-2.88
Madanapalle	City(Bangalore)	21.55	17.79	19.75	2.33	2.48	2.40	1.64-3.16
	Towns	31.43	16.72	24.35	11.69	4.29	8.13	6.58-9.68
	Villages	21.71	10.67	16.39	8.46	3.57	6.11	5.02-7.20
Patna	City (Patna)	19.13	21.30	20.12	6.43	6.31	6.38	5.10-7.66
	Towns	21.84	18.12	20.22	6.22	3.98	5.25	3.83-6.67
	Villages	18.42	14.43	16.58	7.07	4.43	5.85	4.58-7.12
Trivandrum	City(Trivandrum)	17.19	15.53	16.31	3.70	2.30	2.96	2.14-3.78
	Towns	21.89	20.51	21.21	3.69	2.70	3.20	1.93-4.47
	Villages	16.41	12.86	14.64	3.68	1.49	2.59	2.08-3.10

Source: NSS[7]

Note: Rad- Radiologically; `A'= Active; `BA' = Bacteriologically; (+) = Positive; (-) = Negative;
* Rates per 1000 x-rayed in persons aged 5 years and over; ** Computed by author

Table 8: PREVALENCE OF RADIOLOGICALLY POSITIVE BACTERIOLOGICALLY NEGATIVE TUBERCULOSIS ACROSS THE COUNTRY

Zone	Area	Population x-rayed	Radiologically (+) Bacteriologically (-)		
			Estimated (#)	Rate/1000	Revised Rate/1000♦♦
Calcutta	City(Calcutta)	16,155	167	10.34	2.58
Delhi	City(Delhi)	22,780	376	16.50	4.13
	Town	11,215	124	11.05	2.76
	Villages	25,075	276	11.01	2.75
Hyderabad	City(Hyderabad)	29,240	329	11.25	2.81
	Towns	10,410	176	16.91	4.20
	Villages	25,590	475	18.56	4.65
Madanapalle	City(Bangalore)	15,986	277	17.32	4.31
	Towns	12,955	210	16.21	4.01
	Villages	19,622	202	10.29	2.55
Patna	City (Patna)	14,970	206	13.76	3.41
	Towns	9,880	148	14.98	3.75
	Villages	13,820	149	10.78	2.68
Trivandrum	City(Trivandrum)	16,665	222	13.32	3.30
	Towns	7,595	137	18.04	4.48
	Villages	38,800	468	12.06	3.01

Note: (+) = Positive; (-) = Negative; (#)No. estimated on the basis of population xrayed and the proportion bacteriologically positive (given in Table 7); ♦♦Revised after making allowance for 75% over-estimate[40]
Source: Based on NSS[7], derived on applying bacillary case rates to the corresponding population.

Table 9: PREVALENCE OF RADIOLOGICALLY ACTIVE AND BACTERIOLOGICALLY POSITIVE TUBERCULOSIS FROM LIMITED AREA STUDIES (ON MMR-SCREENING)

Study	Year & Reference	'P' of disease (per 1000)			Total 'A' (with/with out 'BA' positivity
		'RAD' 'A' & 'BA' (-) on 2 reader & on JPR		'BA' (+)	
1	2	3	4	5	6
1. Madanapalle study (in aged 5+ yrs)	1950-55[6]	--	--	4.1	4.23º (15.00■)
1. New Delhi(in aged 5+ yrs) Survey 1	1962[21]	13.20	--	4.00	17.2
Survey 3	1967	9.70	--	4.00	13.7
Survey 6	1976-77	9.90	--	3.20	13.7
2. Tumkur(in aged 10+) Survey 1	1960[8]	10.0*	4.0	4.10●	18.6(14.0*)
Survey 2	1972[9]	11.6*	4.64	4.40●	11.0(16.0*)
3. NTI.LS(in aged 5+) Survey 1	1961[10]	--	--	4.06(3.96●)	--
Survey 4	1968[10]	--	--	3.93(3.48●)	--
Survey 5	1977[12]	--	--	4.92(3.58●)	--
SPECIAL REPORT WITH JPR	[40]	10.5	4.03		--
4.BCG TRIAL (in aged 10+) Survey 1	1968[15]	14.30	--	10.70(10.55●)	25.0
Survey 3	1973[18]	--	--	-- (10.37●)	--
Survey 5	1978[18]	--	--	--(8.68●)	--
Survey 7	1983[18]	--	--	-- (7.75●)	--
5. NTI-Rural Study (in aged 5+ yrs)	1968[40,43,44]	--	5.40	3.10	
6. NTI Peri-Urban (in aged 15+ yrs)	1986-89[24]	--	--	2.50	
7. TRC.TRIBAL Area	[27]	--	--	4.30	

NOTE: 'P'=Prevalence; 'RAD'=Radiologically; 'BA'=Bacteriologically; 'A'=Active; JPR=Joint Parallel Reading[40]; ■RAD 'A'=Clinically significant x-ray cases[6]; ºWhen evaluated with all results; ●Standardised prevalence rates for comparability; (*)When x-rays of both surveys evaluated by the same set of readers for excluding reader-variation[9]

Table 10: PREVALENCE OF BACTERIOLOGICALLY POSITIVE TUBERCULOSIS FROM VARIOUS SURVEYS IN INDIA (WITH SYMPTOM-SCREENING AS A METHOD)

Sl. No.	Study	Year	Observed 'P' per 1000		
			Cu+	Cu &/ Sm+	Sm+
01	LS FOLLOW UP(14)(Aged 10+ yrs)	1986	4.38	--	--
02	NTI PERI-URBAN(24)(in 15+ yrs age)	1986-89	1.8-2.3	--	--
03	WARDHA STUDY(25) (in 5+ yrs age)	1982	1.73	1.9	--
04	CAR NICOBAR STUDY(28)	1986	--	--	4.1
05	RAICHUR STUDY(26)	--	3.3	10.9	--
06	M.P. TRIBAL STUDY(30)	1982	--	12.7*	--
07	CMC VELLORE STUDY(45) (in 10+ yrs age)	1981	--	--	2.41

Note: 'P'= Prevalence; 'Prop'= Proportion; Cu+= Culture positive; Sm+= Smear positive;
* (Tribals 15.0, Non-Tribals 9.7)

Table 11: PREVALENCE OF BACILLARY● CASES IN A COMMUNITY BY AGE AND SEX

Age group (yrs)	No. X-rayed		Proportion of case contributed by population proportion	
	Male	Female	Male[a]	Female[b]
10-14	19437	17412	0.36	0.35
15-19	11272	10170	1.69	0.79
20-24	10408	11654	7.20	3.09
25-29	10607	12505	11.41	3.20
30-34	9588	10300	16.69	4.76
35-39	9017	9576	20.07	5.64
40-44	7357	7865	25.01	7.54
45-49	7253	7134	26.20	8.41
50-54	5695	5609	33.71	6.60
55-59	4657	4434	34.79	6.54
60-64	3617	2981	32.35	8.39
65-69	2455	1964	36.67	6.11
70+	2265	1436	36.63	6.27
All	103629	102980	15.60	4.12

NOTE: ●Culture Positive

Total Population - (both sexes all ages): 259,291. (10+ in age + 26.65% being Regd population in 0-9 years age)

Population(10+ yrs) - 206609

Total cases(10+ yrs) - (both sexes) : 2,041 (Prev 9.88, Adjusted 10.7 / 1000)

Total cases(10+ yrs) - (Males) : 1,617 (Prev 15.60 / 1000)

Total cases(10+ yrs) - (Females) : 424 (Prev 4.12 / 1000)

Source: BCG.TRIAL[15]

Table 12: PREVALENCE OF TUBERCULOSIS AMONG POPULATION● IN A CENTRAL INDIAN DISTRICT (by selected socio-economic attributes)

Some selected attributes	Popn aged 5+ / Sex Ratio	Proportional contribution to total cases (%)	`P' cases/ 1000 (urban & rural)	Sex-Ratio in `P' cases (male /female)x100 (urban & rural)
SOCIAL				
PLACE OF RESIDENCE:				
Kutcha houses	108	66.85	2.09	189
Semi-pucca	109	25.64	1.73	175
Pucca houses	109	7.51	1.17	154
EDUCATION:				
Nil	67	51.20	2.49	189
Primary	124	29.07	1.51	252
High School	171	18.53	1.55	212
Graduate/above	310	1.2	0.74	193
RELIGION:				
Hindus(Cat `A')	109	45.21	1.76	170
Hindus(Cat `B')	107	30.11	1.93	200
Neo-Budhists	109	16.61	2.00	189
Muslim	109	5.35	2.72	176
Others	105	2.72	1.55	151
ECONOMIC				
INCOME(in Rs./month/capita):				
< 100	101	43.29	2.04	211
100-199	111	45.77	1.87	160
200-299	116	9.98	1.50	177
>300	175	0.96	1.09	--
OCCUPATION:				
Non-worker	34	24.92	1.74	170
Student	125	6.63	0.43	140
Professional	1219	4.39	4.08	105
Cultivator	245	24.84	3.12	157
Agri-Labour	85	21.41	2.45	194
Others	641	17.81	3.0	962
IN ALL	108	1252(100.00)	1.87	181

See Appendix Tables iv & v.
Source: S. Nayar et al[25]

● Total population aged 5 year and more : 687,401;
`P' cases - Culture positive prevalence

Table 13: PROPORTION SMEAR-POSITIVE IN A GIVEN RURAL COMMUNITY (1961-1984)

Inter-vention	Surveys	Time	Age grp	Popu-lation	Case (#)	Stdd case 'P' (per 1000)	Smear positive number(*)	'P' Sm+ cases (per 100000)
1	2	3	4	5	6	7	8	9
No organi-sed Inter-vention	'Long' Survey1	1961	5+	43889	178	420	83(47.0)	189
	- do -2		5+	40633	151	416	71(47.0)	175
	- do -3		5+	40405	136	412	61(44.8)	151
	- do -4	68-70	5+	41213	162	426	95(58.6)	230
NTP 1970	Follow-up Survey	1984	10+	21924	96	438	15(15.6)	68

NOTE: Stdd=Standardised; 'Long' = Longitudinal; 'P' = Prevalence;
'Sm+ = Positive; (*)Per cent in bracket 8/6x100
Source: Chakraborty et al[14]

Table 14: PROPORTION OF PATIENTS WITH DRUG-RESISTANT BACILLI FROM DIFFERENT STUDIES
[Bacillary Resistance to drugs (per cent)]

Survey		Year	INH	RFP	To any	INH & RFP Combined
NTI.LS:[10]	Survey 1	1961-63	11	--	11	--
	Survey 2	1962-64	18	--	--	--
	Survey 3	1964-66	27	--	--	--
	Survey 4	1966-68	22	--	--	--
LS Followup[a]		1984-86	17.7	--	31.25	--
Bangalore Peri-urban[a]		1986-89	27.9	8.1	33.70	6.97
NEW DELHI STUDY-6 surveys[21]		1962-77	8.1	--	24.40	--
NDTBC area[c]		1992	18	0.6	--	--
Raichur Study[26]		1980s	29.5	7.6	34.1	7.6

NOTE: (a) Author, unpublished information; (c) Jain NK, personal communication

Table 15: INCIDENCE OF PULMONARY TUBERCULOSIS IN INDIA

Study	Period of Study(yrs)	Urban/ Rural	Popn aged in yrs	Annual Incidence Rate		
				Cu/1000	'M' alone/ 1000	As a '%' of 'P'
A) Using MMR-Screening/Periodic Survey Method▪						
1. New Delhi Study [20][21]						
Survey 1-2	1962-65	Urban	5+	0.90	-	44.4
2-3	1965-67	Urban	5+	1.30	-	30.8
3-4	1967-70	Urban	5+	1.10	-	36.4
4-5	1970-73	Urban	5+	0.60	-	35.0
5-6	1970-77	Urban	5+	1.80	-	15.6
2. NTI.LS[10]						
Survey 1-2▫	¹1961-62	Rural	5+	1.36	[a][a]	30.8
2-3	1962-64	Rural	5+	0.80	-	47.1
3-4	1964-68	Rural	5+	1.04	-	34.0
3. BCG.TRIAL[18]▫						
Survey 1-2	1968-71	Rural	15+	3.83	-	27.5
4-5	1976-78	Rural	15+	2.30	-	41.4
6-7	1981-83	Rural	15+	3.00	-	33.4
B) Direct Observation of Incidence						
CMC-Vellore	81-83[45]	Rural	10+	--	1.10	46
Nicobar Study	1986[28]	Rural	15+	--	1.50	36

NOTE: 'Cu'=Culture; 'Popn'=Population; 'P'=Prevalence; 'M'=Microscopy; ▪Annual average incidence calculated between two surveys; ▫Rates on the basis of standardised population of survey 1 NTI.LS & BCG TL respectively; ¹For NTI.LS diagnosis by culture (with/without microscopy): for others microscopy and /or culture; [a][a]Microscopy positive among cases (culture positive):0.65 per thousand.

Table 16: ESTIMATED ANNUAL TUBERCULOSIS MORTALITY RATES IN THE BANGALORE RURAL AREA WITHOUT ACTIVE INTERVENTION OVER 5 YEARS

Age group (yrs)	Rate between two consecutive surveys/100000 popn			Average '%' mortality ☼
	1-2	2-3	3-4	(1-4 survey)
5-14	9.8	5.8	--	1.6
15-34	79.4	34.1	51.7	9.9
35-54	146.4	135.2	101.3	12.7
55+	394.1	324.3	580.3	9.8
Total	95.4	69.2	87.6	9.4

Source: CHAKRABORTY AK[52] **NOTE**: ☼Death due to tuberculosis as proportion of total death (per cent)

Table 17: PREVALENCE AND INCIDENCE OF TUBERCULOUS DISEASE IN PAEDIATRIC AGE GROUP (NTI.LS)

Age group (yrs)	No. X-ray ed	Prevalence (per 1000)		No. follow ed up	Incidence(per 1000/ year)	
		Bacillary cases	`RAD' active, `BA'(-)		Bacillary cases	`RAD' active `BA'(-)
5-9	4851	1.0	3.0	4833	0.2	0.3
10-14	3880	1.0	4.0	3860	0.4	0.7
5-14	8731	1.0	3.0	8693	0.2	0.5

Source: Gothi et al[54] **NOTE:** `RAD'=Radiologically; `BA'=Bacteriologically

Table 18: ESTIMATES OF WORKERS WITH TB OF LUNGS IN INDIA 1993-94
(in '000)

Age Group	Rural Areas		Urban Aeas	
	Male	Female	Male	Female
(1)	(2)	(3)	(4)	(5)
15-44	661.3	143.865	189.337	125.818
45-59	385.613	95.016	97.325	7.271
60+	360.276	34.379	60.721	0.639

Source: Dholakia, 1996 [53]

Table 19: PROBLEM OF TUBERCULOSIS IN INDIA (AVERAGE)
(estimated on 1991 population)

1.	Population: 844 million: 726 million in 5+ age (85%)	
2.	Prevalence of Infection	
	a) Rate - 38% (all ages)	b) more than 50% in 40+ age
3.	Prevalence of radiologically active abacillary pulmonary tuberculosis	
	a) Rate - 1.6% (0.3, 0.26 - 0.47%)	b) Number - 12 million (2.3 million)
4.	Prevalence of positive cases	
	a) Rate - 0.4% (0.6, 0.3 - 1.1%)	b) Number - 3 million (4.4 million)
5.	Prevalence of total cases	
	a) Rate - 2.0% (0.9, 0.56 - 1.57%)	b) Number - 15 million (6.5 million)
6.	New patients arising annually: 2.5 to 3 million	
7.	New bacillary cases arising annually: a) Rate - 0.13%	b) Number - 1 million
8.	Case fatality Rate: 14% in untreated bacillary cases	
9.	Mortality (annual): a) Rate - 50 - 80/ 100,000 population (45, 28-71 per 100,000)*	b) Number - 0.3 - 0.5 millions (0.42, 0.26 - 0.67 millions)*

NOTE: See under Discussion V. 2.2. for an update.
( ) Rates in bracket based on Appendix Table v
* Derived from WHOSEARO workshop on country specific tuberculosis etstimate, 1996 (unpublished)

Table 20: INDIAN SITUATION SET AGAINST THAT IN THE EPIDEMIOLOGICALLY ADVANCED COUNTRIES HEADING TOWARDS THE GOAL OF `ELIMINATION'

Country	Epidemiological Situation			
	Present		Qualification for `Close to Elimination' Status	
	Incidence of smear positive cases per million/year	Prevalence of infection all ages (%)	Incidence of smear positive cases per million/year	Prevalence of infection all ages (%)
Most Advanced*	12-15	15	10 (1.2)	1.0
India**	500(750)	40		

*Norway, Netherlands, etc.: (ARI 0.1 to 0.01%, 10% Annual Decline, `Close to Elimination Status' projected to be achieved by 2025 A.D.)[65];
NOTE: **Figures based on NTI Survey [10]; ( )Calculated for 1.5 million population i.e., an average Indian district.

APPENDIX TABLES

APPENDIX Table (i): PREVALENCE RATES (%) OF INFECTION

(23 years period) (With Confidence Intervals of Estimate)

Age	Survey	I(0) Mar '62	II(1.58)[A] Oct '63	III(3.17)[A] May '65	IV(5.25)[A] Jun '67	V(15.67)[A] Nov '77	Present[c] (22.83)[a] Jun '85
0-4	Rate	2.1	1.8	1.3		1.5	1.5
	Range	(1.8-2.4)	(1.5-2.1)	(1.1-1.6)	(0.8-1.2)	(0.9-2.1)	(0.8-1.6)
5-9	Rate	7.9	7.6	7.0	6.4	6.0	5.3
	Range	(7.3-8.5)	(7.0-8.2)	(6.4-7.6)	(5.8-7.0)	(4.4-7.6)	(4.4-6.2)
10-14	Rate	16.5	16.9	16.1	15.4	12.1	9.2
	Range	(15.7-17.4)	(16.0-17.8)	(15.2-17.0)	(14.5-16.3)	(9.2-15.0	(8.0-10.5)
0-14	Rate	8.6	8.6	7.7	7.1	4.7	4.8
	Range	(8.3-9.0)	(8.2-8.9)	(7.3-8.1)	(6.8-7.5)	(3.9-5.5)	(4.3-5.3)
0-14[b]	Rate	8.6	8.5	7.9	7.4	6.4	5.4
	Range	(8.3-9.0)	(8.0-9.1)	(7.4-8.5)	(6.8-7.9)	(4.9-8.3)	(4.3-6.0)

(Estimated limits of infection rate at 95% confidence intervals in brackets).
a) Interval from I survey in years; b) Based on standardised population of I survey;
c) Decline in infection rates for each age group statistically significant over 22.8 years.
Source: Chakraborty et al[13]

APPENDIX Table ii*: POPULATION REQUIRED FOR REPEAT SURVEYS TO VALIDATE CASE PREVALENCE RATES DERIVED FROM EPIDEMETRIC MODEL UNDER SOME INPUT VARIABLES OF INTERVENTION

(Given Initial Case Prevalence Rate 0.389%)
(For Confidence Level 95%, One Sided Test, Power 80%)

	Input Variables of Intervention					
	(a)		(b)		(c)	
Year of observation	Case `P'rate estimate from model (%)	Popn required in a survey for validation	Case `P'rate estimate from model (%)	Popn required in a survey for validation	Case `P'rate estimate from model (%)	Popn required in a survey for validation
10	0.312	89,748	0.281	43,609	0.281	43,609
25	0.286	48.302	0.239	21,194	0.238	20,881
50	0.255	27.232	0.190	11,104	0.175	9.354

Input Variable of Intervention: a) No intervention - 50 years; b) No intervention - 5 years; 33% case-finding efficiency (CF) and all cases on standard regimen (SR) for 6 - 50 years; c) No intervention - 5 years; 33% CF and all cases on SR for 6 -25 years; 33% CF - 20% cases on SCC; 80% on SR for 26-35; 40% CF - 40% on SCC and 60% on SR for 36 - 50 years.
* Calculated on declining prevalence rates of cases (initially by 3.8% per year) decelerating with time, as per model[48].
Source of Data: Balasangameshwara, Chakraborty, Chowdhury[48]. **NOTE:** `P'=Prevalence; `Popn'=Population;

Appendix Table (iii): PREVALENCE OF TUBERCULOSIS AMONG POPULATION⊡ IN CENTRAL INDIAN DISTRICT (by some social attributes in 1982)

Selected social attributes	Population(%)	Prevalence of culture positive tuberculosis / 1000 population							
		URBAN				RURAL			
		Male	Female	Total	Sex Ratio	Male	Female	Total	Sex Ratio
Place of Residence									
Kutcha Houses	60.04	3.11	1.64	2.40	190	2.63	1.40	2.01	188
Semi pucca	27.88	2.05	1.56	1.62	131	2.26	1.29	1.79	175
Pucca Houses	12.08	1.13	0.75	0.95	151	2.51	1.55	2.04	162
Education									
NIL	38.52	3.33	1.67	2.27	199	3.50	1.87	2.55	187
Primary	36.06	2.33	1.11	1.76	210	1.98	0.70	1.42	283
High School	22.41	1.60	1.03	1.24	155	2.16	1.08	1.79	200
Graduate & above	2.93	0.53	0.34	0.48	156	1.51	0.59	1.31	229
Others	0.08	--	--	--	--	--	--	--	--
Religion									
Hindus (Cat`A')	48.14	1.37	0.97	1.18	141	2.56	1.42	2.29	180
Hindus (Cat`B')	29.29	2.79	1.42	2.13	196	2.47	1.23	1.87	201
Neo- Budhists	15.56	2.79	1.32	2.08	211	2.52	1.38	1.98	183
Muslims	3.69	4.07	2.22	3.18	183	2.56	1.58	2.09	162
Others	3.31	0.84	0.19	0.53	442	2.94	2.31	2.64	127
In all	100.0	2.05	1.16	1.62	177	2.53	1.38	1.98	184

NOTE: Cat = Category; **⊡AGED 5 YEARS AND OVER: 687,401 (sex-ratio: 108) ;** **Source:** Nayar S et al[25]

Appendix Table (iv): PREVALENCE OF TUBERCULOSIS AMONG POPULATION♦ IN A CENTRAL INDIAN DISTRICT (by selected economic criteria, in 1982)

Selected economic criteria	Popu prop (%)	Prevalence of culture postive tuberculosis/1000 population							
		Male	Female	Total	Sex Ratio (M/F)100	Male	Female	Total	Sex Ratio (M/F)100
Income(in Rs. per month/capita)		URBAN				RURAL			
<100	39.84	2.93	1.45	2.18	200	2.72	1.28	2.01	212
100-199	46.00	1.94	1.18	1.58	164	2.42	1.54	2.01	157
200-299	12.51	1.29	0.86	1.09	150	2.35	1.23	1.83	191
>300	1.65	1.81	--	1.17	--	1.53	--	0.99	--
Occupation:									
Non-worker▫	26.82	3.13	1.36	1.76	230	2.22	1.57	1.73	141
Student	29.01	0.48	0.41	0.45	117	0.50	0.32	0.42	156
Service	5.34	1.65	1.18	1.61	140	2.75	5.20	2.96	53
Professional▪	2.02	3.40	8.49	3.73	40	4.91	--	4.48	--
Cultivator	14.95	3.25	6.80	4.05	48	3.50	2.02	3.06	173
Agri-labour	16.39	2.56	1.14	1.81	225	3.37	1.74	2.49	194
NonAgri-labour	3.92	4.60	1.09	3.96	422	4.51	2.20	3.99	205
Others	1.54	3.86	2.53	3.64	153	7.02	2.45	6.42	287
In all	100.00	2.05	1.16	1.62	177	2.54	1.38	1.98	184

NOTE: Popn= Population; Prop=Proportion; ♦ Population aged 5 year and over: 687,401 (Sex Ratio: 108); ▫Includes house-wives; ▪Includes petty-traders. **Source**: Nayar S et al[25]

Appendix Table (v): SUGGESTED REVISION OF AVERAGE TUBERCULOSIS RATES (INDIA)

	Currently used	Correction (X)	Suggested Rate
RAD	16.0 (10.0 - 19.0)	0.2	3.0 (2.6 - 4.7)
BA	4.0 (2.0 - 8.0)	1.4	6.0 (3.0 - 11.0)
Total	20.0 (13.5 - 25.0)		9.0
BA / Rad	1/4	---	2/1

(Rate per 1000 popn x-rayed)
RAD = Radiologically active, bacteriologically negative; BA = Bacteriologically positive (culture)

Appendix Table (vi): USES OF EPIDEMIOLOGY-TUBERCULOSIS IN INDIA

Presented below are some of the epidemiological features of the disease and their significance, viewed as a rationale for the activities under the National Tuberculosis Programme (NTP) with particular reference to the epidemiological situation in India. The likely interpretation of data and inference regarding the epidemiological situation in the country is also given:

Summary of epidemiological observations from: (a) global studies; (b) Indian surveys	Comments/inference on likely trend or epidemiological situation in India	Epidemiological rationale of NTP in India
1	2	3
(1) Tuberculosis is a long term epidemic spanning several conturies.	(a) Changes in disease trend over a short span of time are not expected, except when efficient interventions are undertaken as in the Eskimos (hypothetically possible). Transient changes in the epidemic curve may occur, e.g., through war, famine etc., but the trend resumes its natural course after their effects disappear(secular trend). (b) Two points of observations,separated by even 10-25 years or more,are so close to each other in the context of the epidemic curve spanning several centuries, that quantitative changes cannot be measured, unless massive (which is unlikely).	(a). Tuberculosis programme should be a long term programme. Vertical programmes not suitable. Case finding/treatment activities to be carried out as service component of an integrated health care delivery system. (b) No quick change in situation to be expected. (c) No all India repeat sample survey at small intervals of 10-25 years called for.
(2) Tuberculosis problem is more or less spread all over the country. Difference in disease prevalence rates between area to area not statistically significant (barring a few exceptions eg., Raichur and urban slums eg., in Calcutta).	Wide spread tuberculinisation has taken place, with the inference that tuberculosis curve is in endemic phase in the country.	Almost a similar and uniform kind of programme is required all over the country. No special programme from place to place was formulated for urban slums etc., considering the infancy of the national endeavour, at the time it was launched!

(3) Prevalence rate of case is same for the rural and urban areas.	Disease not likely to be in the spreading phase: Probably on the descending limb.	In absolute number, 80% of the total problem is distributed in rural areas (since 80% of the population live in villages). Hence, tuberculosis services should cover rural areas adequately. Emphasis on spread of programme.
(4) About 38% of persons all ages both sexes and almost 70 % of males above 40 years of age infected. About 2 % are diseased. Prevalence of bacillary cases:0.4%. Mortality rate: 0.09%.	The wide gap between the rates may mean that the disease is on the descending phase.	Presence of 38% of total persons infected in the community may mean that eradication cannot be conceived as a goal.
(5) Prevalence rate of infection and disease as well as mortality are more in males than females.	The disease is beyond the peak, probably in the descending limb of the curve or endemic phase.	
(6) There is a decreasing trend in the infection rate of about 2% per year, over a long term observation for a period ranging from 5-25 years or more among children (from longitudinal surveys of NTI). But the same is not seen in the adjoining areas of Tumkur, Doddaballapur and in the neighbouring state of Tamil Nadu (the last is over 15 years).	Probably represents a secular trend of infection rate. Tuberculosis situation may be on slow downward trend in some areas and not changing in some other areas. It is logical to postulate different epidemiological age from area to area in India, given its vast expanse.	Surveillance system should be developed to study infection rate in different parts continually, with provision for stratification even within districts. This could serve as effect-evaluation of the programme, if performed every 7-10 years, area wise.
(7) Pulmonary tuberculosis is an adult disease. Population in 0-19 years (comprising 50% of total population) contain only 7% of total prevalence cases. Remaining 93% of cases are distributed in population aged 20+ years. In the first of the longitudinal surveys, in Bangalore area, the proportion of cases above 40 years in age was around 50% (0-39 : 40+ yrs::53:47), which was in about 20% of population. In another 30% of population, i.e., in those 20-39 years age group, 43% of cases were distributed.	Proportional concentration of disease in adults may mean that disease is beyond the peak. It is most likely that the epidemic curve is not on ascending limb. Even as the population aged 40+ would contain 50% of cases, the public health significance of young adults of between 20-39 years in age containing 43% of cases cannot be too over-emphasised - as it happens to be the most productive segment in population. Similar is the situation in women, where the disease burden is borne by those in the reproductive age, nearly half of the cases in women being in this age group.	Since cases in adults can be easily diagnosed by simple tools (microscopy) from among symptomatics, disease among relatively articulate adults is possible to be tackled under a public health programme. (Note: 80% of cases are aware of symptoms and 50% are action taking). Had the disease been more prevalent in children, control programme might not have been feasible (Note: Inarticulate children and difficult diagnostic tools would pose problem: hence programme for wide application would have been less feasible).

8. Relatively higher and higher concentration of cases in higher age groups has occurred in later surveys as compared to earlier surveys. In later surveys in Bangalore rural areas, about 80% of cases were detected among those in 40+ age group.	May mean that tuberculosis is in declining phase.	Programme interference-efficiencies be augmented to hasten the decline.
9. Prevalence rates of cases and suspect cases, reveal almost no change in a period of over 20 years from different surveys in different areas .	No change is expected over a relatively short period of time in disease rates which are already low. Moreover disease is not in its spreading phase: may be on a descending limb or in endemic phase.	No all India repeat sample survey for disease prevalence may be indicated, as this may not yield much additional information.
10. However, the incidence of smear-positive cases in the community is observed to have dwindled in 23 years in Bangalore rural area from around 65 to 23 per 100,000 .	This is commensurate with fall in the annual risk of infection (ARI) from 1% to 0.6% for the area. The ARI in most other areas, except possibly for Kashmir, are static over the years. The high ARI with no or small extent of decline below 3% per year, mark out India to be one of the high prevalence countries, together with the sub-Saharan African countries.	Slow downward trend of tuberculosis in the area, along with high transmission, calls for a highly efficient programme.
11. Nearly 10% of all causes crude mortality in the community are contributed by death due to tuberculosis (tuberculosis mortality rate: about 90 per 100,000) .		Tuberculosis is a major public health problem and deserves appropriate priority.
12. (i) Mortality rate decreasing with time from survey to survey, but is still high . (ii) Survival rate of cases diagnosed in later surveys were better as compared to in earlier rounds of longitudinal surveys. Paediatricians generally report seeing less of miliary, meningeal or fulminant forms of tuberculosis. Same is the experience of tuberculosis specialists, working in clinics.	i) Disease is on downward trend or in the endemic phase. ii) Policy of BCG vaccination to younger children might have been effective in revising the incidence characteristics in children, by arresting haematogenous dissemination.	Better case-holding should be attempted to save life. Treatment services to be widely distributed through integrated delivery approach. BCG vaccination programme to be continued in younger population (0-1 year or 0-4 years).

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