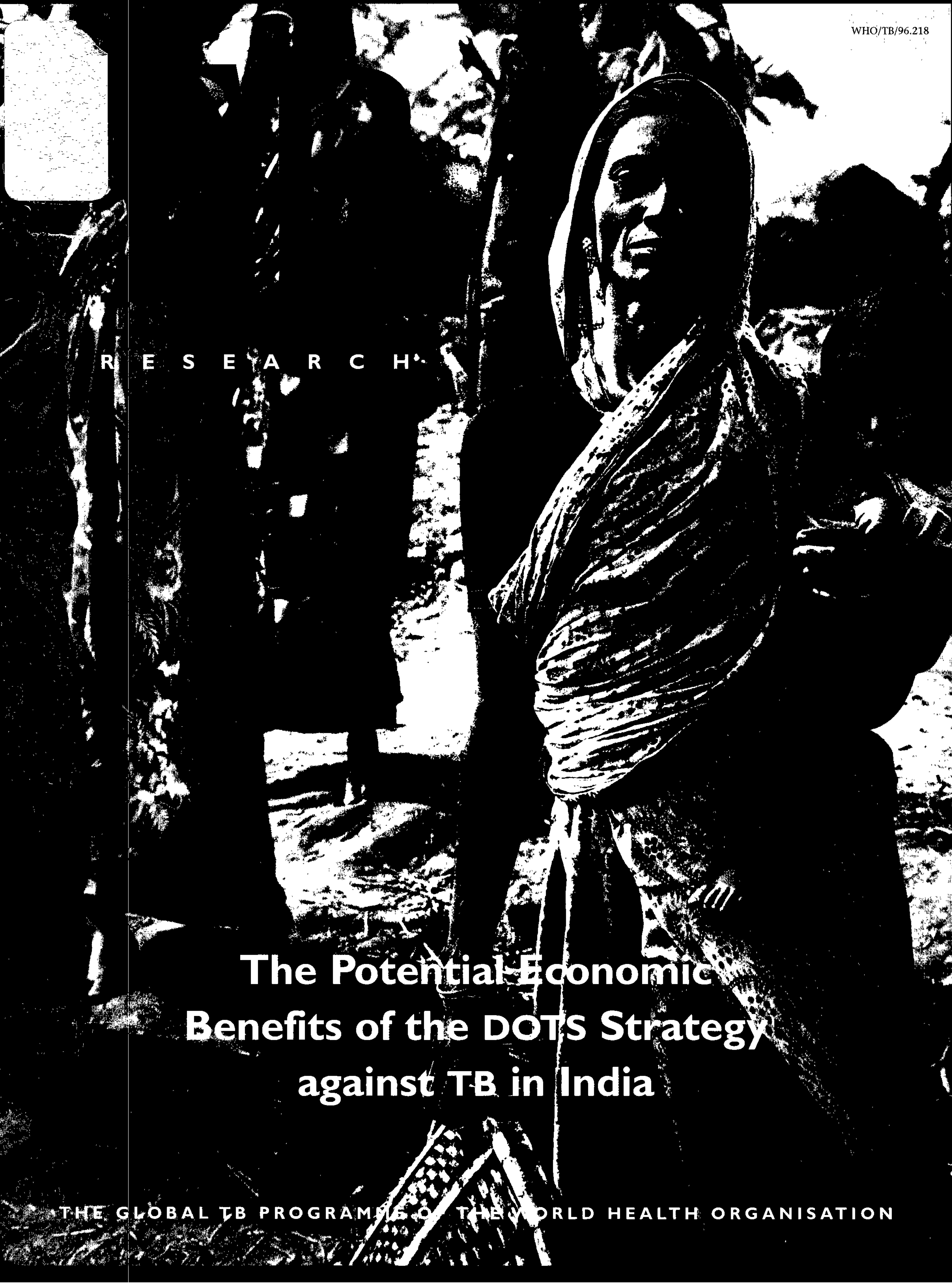
WHO/TB/96.218



R E S E A R C H

The Potential Economic Benefits of the DOTS Strategy against TB in India

THE GLOBAL TB PROGRAMME OF THE WORLD HEALTH ORGANISATION

Acknowledgments

I am grateful to Dr. J. Almeida, WHO/GTB Geneva, for initiating and introducing me to this interesting field of inquiry. I am also grateful to him and his colleagues, particularly Mr. V. Pathania at WHO/GTB, Geneva for some useful comments on my project proposal and for sharing valuable information and documents. I am also grateful to various reviewers from WHO, Geneva who have offered their valuable comments on the earlier draft of this report. I am thankful to Dr. S. Radhakrishna, SEARO, WHO, New Delhi for his valuable help in providing some comments, information and documents pertaining to the project. I have benefitted from discussions with Dr. D. Mavalankar who also facilitated work here by arranging meetings and interactions with the government officials and field trips to some of the TB cure programme centres. I am also grateful to Prof. P. Visaria and Dr. A. Gumber for sharing useful material and allowing me access to their unpublished report. I also received good cooperation from the libraries at Gujarat Institute of Development Research (GIDR), Ahmedabad and M.S. University of Baroda. Discussions with several doctors — particularly Dr. A. Patel of ARCH at Mangrol in Gujarat proved very useful for cross-checking certain estimates.

I am also highly thankful to Dr. G.N.V. Ramana of Administrative Staff College of India (ASCI), Hyderabad for his timely response to some of my queries and for sharing valuable information based on the in-depth studies on TB undertaken at ASCI. Finally I am thankful to Mr. Mallikarjun for computer assistance, to Mr. G.A. Chandrasekaran for providing efficient secretarial assistance including typing of this report and to Mr. T.V. Arunachalam for formatting the report.

Ravindra H. Dholakia

Professor of Economics
Indian Institute of Management, Ahmedabad

Correspondence on this report should be addressed to:
Dr. Joël Almeida
Research and Surveillance Unit,
Global TB Programme,
World Health Organisation
Geneva, Switzerland

telephone: +41 22 791 2655
email: almeidaj@who.ch

TB

RESEARCH

RAVINDRA DHOLAKIA

EDITED BY

JOËL ALMEIDA

The Potential Economic Benefits of the DOTS Strategy against TB in India

THE GLOBAL TB PROGRAMME OF THE WORLD HEALTH ORGANIZATION

Foreword

This report is the second in the Global TB Programme's "DOTS More Widely" Research Series. The DOTS (Directly Observed Treatment, Short-course) strategy has been shown to transform the outcomes of TB treatment from cure rates of below 50% to over 80%. Cure of infectious TB patients is currently the best form of prevention. Innovation and research to achieve "DOTS More Widely" are among the top priorities for efforts against TB.

This report, authored by Prof. Ravindra Dholakia (Indian Institute of Management, Ahmedabad), was initiated and edited by Dr. Joël Almeida of the WHO's Global TB Programme. Peer reviews were obtained from WHO, the World Bank and other organizations.

Table of Contents

1 Preface

3 Executive Summary

7 Potential Economic Benefits of DOTS (TB Cure) in India

- 7 I. Introduction
- 8 II. Steps followed for estimation
- 9 III. Estimates of population and work force, 1993-94
- 10 IV. Estimates of GDP and labour productivity, 1993-94
- 14 V. Deaths due to pulmonary TB in India
- 15 VI. The prevalence of pulmonary TB in India
- 18 VII. Estimates of workers with TB in India
- 19 VIII. Benefits of DOTS – Reduction in TB prevalence
- 21 IX. Benefits of DOTS – Reduction in TB deaths
- 25 X. The rate of discount and future benefits
- 32 XI. Saving of hospital beds due to DOTS
- 36 XII. Potential economic benefits of DOTS in India
- 38 XIII. Benefits of DOTS with gradual coverage of population

40 References

42 Appendices

43 Endnotes

44 List of Tables

45 List of Abbreviations

Tuberculosis destroys people's lives and homes.

Preface

Tuberculosis (TB) kills several millions of people each year. Most of these are in the wage-earning age group. The DOTS (Directly Observed Treatment, Short-course) strategy reduces these deaths several-fold, and replaces ineffective treatment with consistent cure.

This report asks a simple question: How much income would be gained by using DOTS, instead of non-DOTS, against TB in India? The question addressed has a direct bearing on the related question: How much investment and effort is worth devoting to the DOTS strategy, to ensure successful TB control?

One approach, taken in this report, is to estimate the lower (most conservative) bound on the magnitude of the tangible economic benefits from successful implementation of the DOTS strategy. If successful DOTS in place of non-DOTS yields tangible economic benefits worth a given present value, then DOTS deserves resources and efforts to at least that value in order to ensure successful operations.

The main contribution of this report is to place a lower bound on the magnitude of the tangible economic benefits to be gained from successful implementation of the DOTS strategy against TB in India.

Reasonably careful efforts have been made to assess how much of the lost income of TB patients could be salvaged by successful DOTS in place of non-DOTS strategies. Being a lower bound, the estimate of benefits carefully excludes all benefits other than the proximate and tangible economic benefits from DOTS.

The anticipated financial cost per cure within DOTS programmes in India may be noted. About 100 million US dollars extra are being invested in DOTS for 30% of India, in anticipation of producing about one million documented cures of infectious TB during the next five years. Should this extra investment prove sufficient to ensure the success of DOTS, the cost per documented cure will have been about USD 100 (at present, virtually no cures are documented). Assuming that successful DOTS will be extended throughout India to cure all the new cases arising each year (roughly two million new cases per year) the incremental cost of successful DOTS in India could turn out to be of the order of 200 million US dollars per year. Within 15 to 20 years, the number of new cases is predicted to start declining and the investments required for successful DOTS should correspondingly decline.

It is also worth stating the obvious. Effective TB control has benefits far beyond gains in income. Reduced suffering and death are of the first importance, whether or not gains in income follow. Multiple drug-resistant TB is a risk whose upper limit can never be fully known, given the unpredictable nature and virulence of newly arising mutant bacteria. DOTS is currently our best bet against multiple drug-resistant TB. In the longer term, the transmission of TB is expected to be reduced by effective DOTS: a delayed benefit whose present economic value is greatly reduced by discounting. All these benefits have been carefully excluded from the present estimate, so as to avoid any overstatement of the economic benefits of DOTS.

These excluded benefits (which might be captured in further studies which assess the Willingness to Pay) merely underline the main message of the report: much depends on the successful implementation of DOTS. Investing the resources and effort required to ensure the success of DOTS is the logical response.

DR. JOËL ALMEIDA

Research and Surveillance Unit
Global TB Programme
World Health Organisation

Geneva, Switzerland – January 1997

The tangible economic benefits of successful DOTS are likely to exceed the financial costs by several fold.

Executive Summary

1. Pulmonary TB is among the top killer diseases. According to the official statistics on the survey of causes of death in rural India, the relative importance of pulmonary TB, even among the top killer diseases, has been gradually rising in the country. About four million people in India are estimated to suffer from pulmonary TB. It imposes a cost on the economy in terms of current and future output loss because of premature deaths and ill health.

2. Currently, TB is treated with self-administered chemotherapy lasting 6 to 12 months. Patients often discontinue treatment. This creates several problems such as low cure rates, high relapse rates, high case fatality rates, drug resistance, etc.

The DOTS strategy (Directly Observed Treatment, Short-course) has been demonstrated to overcome most of the short-comings of self-administered chemotherapy.

3. There are several benefits from successful application of the of the DOTS strategy. The constraining factors or the impediments to the success of DOTS are a sub-set of the ones responsible for the current situation with self-administered chemotherapy. Therefore DOTS could well succeed if sufficient effort and resources were invested.

4. In order to ensure that DOTS succeeds in India, several aspects of implementation, organisation and management, need to be geared up. However, it is an important first step to believe that all these efforts can be fruitful, that they can yield good returns, that they are feasible and that these efforts can contribute to the larger social goals of alleviating poverty, raising the productivity of the poorer sections, and improving the quality of life in the society. Thus, we need to have some dimensional idea about the lower bound of the economic benefits of successful DOTS in India.

The main aim of this report is to estimate a lower bound for the magnitude of potential tangible economic benefits of the DOTS strategy in India.

5. There are several potential benefits of successful DOTS in India. They can be divided into two broad categories:

Pure social welfare increasing effects of DOTS which do not generate direct tangible economic benefits. These would include reduced suffering of TB patients, quicker and surer cure from the disease, lives saved and disability reduced for dependents and non-workers suffering from TB, poverty alleviation (since TB hits wage-earning age groups), the psychic benefits of living in a more healthy society, etc.

Direct tangible economic benefits of DOTS, which include the following three types of benefits:

- Reduction in the prevalence of TB due to DOTS which improves the efficiency and productivity of workers by reducing their forced absenteeism on account of ill health;
- TB deaths averted among current and future workers, which adds to the productive capacity of the economy; and
- Release of the hospital beds currently occupied by the TB patients, since successful DOTS averts hospitalization of patients.

6. We have estimated only the direct potential tangible economic benefits of successful DOTS. In order to estimate the economic benefits of DOTS, estimates of population for the base year 1993-94 by age-sex-residence are derived using the latest and most reliable figures available. Similarly, the estimates of workers by age-sex-residence and sectors are obtained.

Further, consistent estimates of average and marginal labour productivity in the country are derived, cross-classified by age-sex-area and three broad sectoral categories of the economy for the base year 1993-94. Aggregative macro economic studies and estimates of productivity differentials are used to calculate the rural/urban incomes by sectors, productivities of child workers vis-a-vis adult workers, productivities of young adults (15-44 years) vis-a-vis old adults (45+ years), productivities of male and female workers in each category. These labour productivities are used to calculate the output gains predicted when the DOTS strategy is successfully implemented. All the calculations are therefore made at 1993-94 prices to account for future inflation and to express the estimates in real terms.

7. TB is largely a disease of adults. Within adults, it is prevalent more among older adults than younger adults and more among males than females. Even the deaths due to TB show a similar pattern. Estimates of labour productivities are therefore needed to estimate the economic benefits of DOTS. Workers with pulmonary TB among the existing TB patients, and the future workers among the TB deaths averted/averted by DOTS are also estimated by age-sex and area.

The estimates of deaths averted and the reduction in prevalence of TB on account of DOTS are estimated by comparing the two scenarios "with DOTS" and "without DOTS" and considering the conservative estimates of improvements likely to occur "with DOTS".

8. Since there are two alternative sets of estimates of mortality due to TB in India, each having some followers/users, two alternative sets of estimates have been generated, of benefits due to deaths averted by DOTS. These estimates are generated by using the marginal productivity of labour and future workers among the deaths averted by DOTS in each age-sex-area category. In order to generate these estimates, the average age at death at present within each age group by sex and area was considered, as was the length of productive life for the future workers among the deaths averted by DOTS.

The present discounted value of the contributions of the future workers among the deaths averted in one year due to DOTS, during the remaining part of their economically active life, is considered as the economic benefits of deaths averted by DOTS.

9. Similarly, the benefits of reduction in prevalence of TB due to DOTS are estimated by using the available information on the disability imposed by the disease on workers. The improvement in the average productivity of workers by age-sex and residence due to successful DOTS is estimated.

10. Since benefits are also available in future from the reduced prevalence and the deaths averted by DOTS, these future benefits are estimated using alternative discount rates.

11. The alternative discount rates used are within the broad range of 5% to 16% since the former represents an estimate of the social time preference rate (STPR) and the latter the social rate of return on capital (SRRC) in India. The labour productivity in India is assumed to grow on an average by 3% per annum, though the current trend suggests 4% to 5% p.a. growth. Similarly, the TB deaths and prevalence of TB in future "without DOTS" are assumed to remain level. If they are taken to grow at the annual rate of 1% to 2% per annum (to allow for population growth), the calculated figures remaining the same, the implied discount rate would become higher by the same number of percentage points.

12. Our estimates of the potential economic benefits of DOTS in India at 1993-94 prices in terms of present value are as shown (Rs. in billion) in the chart below:

13. The main implication of our finding is that DOTS is potentially highly beneficial even at relatively high rates of discount. With the most conservative set of estimates, the potential economic benefits of DOTS to the Indian economy are estimated at about 4% of GDP in real terms or U.S. dollar 8.3 billion in 1993-94. This is the present (1993-94) value of the entire future stream of benefits from DOTS, not the annual benefit. So long as the Indian economy spends a total sum whose present value is less than this amount, the economy gets a return of more than 16% p.a. in real terms. Since the present value of all future costs attributable to to DOTS is likely to be considerably

	Discount Rates		
Economic Benefit	**5%**	**10%**	**16%**
A) Reduction in Prevalence of TB due to DOTS	622	186	106
B) Deaths Averted due to DOTS			
i) Set A	4035	703	259
ii) Set B	2469	422	152
C) Release of Hospital Beds due to DOTS	26	13	8
Total Benefits due to DOTS (P.V.)			
i) With Set A (in Rs. billion)	4683	902	373
(as % of GDP in 1993-94)	(13%)	(5%)	(66%)
ii) With Set B (in Rs. billion)	3117	622	266
(as % of GDP in 1993-94)	(44%)	(9%)	(4%)
Annualized Benefits due to DOTS			
i) Set A	234	156	90
(as % of GDP)	(3.3%)	(2.2%)	(1.3%)
ii) Set B	62	60	43
(as % of GDP)	(0.9%)	(0.8%)	(0.6%)

Note: Set A is based on Murray and Lopez (1996) TB Mortality rates. Set B is based on Survey of Causes of Death TB Mortality estimates.

less than 4% of GDP, DOTS can effectively help step up India's future economic growth.

14. The estimates of potential economic benefits of DOTS in India presented above are essentially based on twin optimistic assumptions: a) DOTS can and will succeed in effectively tackling pulmonary TB in India; and b) DOTS would effectively reach 100% of TB patients with full and instantaneous coverage. In order to be more realistic, we may presume that DOTS will reach about 90% patients in an area where the DOTS strategy is working. Special efforts may be presumed necessary for the 10% of patients who are considered "hard to reach." Similarly, we need to consider some phasing in of DOTS implementation over a few years largely because:

- DOTS requires training of personnel;
- organisational and management inputs require some time;
- drug supply systems take time to set up.

Five alternative phasing-in patterns are considered in this study. They are:

- Instantaneous "full" coverage (i.e., 90% covered);
- 5 years with 18% effective coverage every year;
- 10 years with 9% effective coverage every year;
- 15 years with 6% effective coverage every year;
- 10 years with effective coverage of 5%, 10%, 15%, 15%, 15%, 10%, 5%, 5%, 5%, and 5% in successive years.

15. Our estimates of economic benefits of DOTS in Rs. Billion at 1993-94 prices for all these five alternatives are presented in the chart below:

16. Phasing in of DOTS (TB cure) over time reduces the present value of the economic benefits. The longer the time period for phasing in, the lower is the present discounted value of the benefits. Similarly, the higher the discount rate used, the lower is the present value of benefit with a given pattern. Even with a linear phasing in of the coverage over 10 years with a 16% discount rate, the present discounted value of all the future economic benefits of DOTS turns out to be about 2.1% of GDP (in the year 1993-94). Thus, even if the Indian government spends about USD 0.74 billion per year to ensure the success of the DOTS (TB cure) strategy (the present value of which is about USD 4.6 billion or 2.1% of the GDP) the investment would fetch a return of 16% p.a. in real terms. (Projected incremental costs to the government for successful DOTS implementation throughout India are of the order of USD 200 million per year, compared to the tangible economic benefits of at least USD 750 million per year – *Editor's note*).

	Discount Rates		
Alternative Phasing Patterns for DOTS	**5%**	**10%**	**16%**
1. Instantaneous Coverage	2805 (39.7%)	559 (7.9%)	24 (3.4%)
2. 5 Year Linear Coverage	2697 (38.1%)	490 (6.9%)	191 (2.7%)
3. 10 Year Linear Coverage	2507 (35.5%)	420 (5.9%)	147 (2.1%)
4. 15 Year Linear Coverage	2451 (34.7%)	363 (5.1%)	117 (1.7%)
5. 10 Year Non-Linear Coverage*	2603 (36.8%)	436 (6.2%)	156 (2.2%)

**Effective coverage for successive years are: 5%, 10%, 15%, 15%, 15%, 10%, 5%, 5%, 5% and 5%.*

Notes:

1. All these calculations are based on the assumption that there is a "hard to reach" 10% of patients in any area who require special measures, and only 90% are reachable by routine measures.
2. The benefits are based on the most conservative available estimates, from Survey of Causes of Deaths (1993).
3. Figures in parentheses are percentage of Gross Domestic Product in 1993-94 at current prices.
4. The discounting of benefits is done by assuming real growth of 3% p.a. in the labour productivity in the Indian economy over time, and with no growth of TB patients in the "without DOTS" scenario. These are the most conservative assumptions.

Tuberculosis is the leading infectious killer of adults.

I. Introduction

Infectious TB is one of the most dreaded diseases. In India, pulmonary TB is among the leading killers of adults. The mortality rate on account of TB is so high as to imply that every minute, a death occurs due to TB in the country. Moreover, the high prevalence of TB damages the national economy not only because of deaths, but also because of prolonged illness. Regular and complete treatment is required for cure. At least 75% of prevalent TB cases have been previously treated in India through the traditional system in which regularity and continuity of the treatment were not effectively monitored. Thus, they received palliation, not cure.

This is thought to be the main reason why traditional approaches and strategies to deal with the problem of TB in the country have failed. The DOTS strategy attempts to overcome this limitation. Indian pilot projects where the DOTS strategy is rigorously applied have shown consistent, documented cure of TB patients.

The advantages of the DOTS strategy over the traditional TB treatment programmes include the following which are relevant to our estimate (see Datta, 1995 and National TB Control Programme, 1996).

- DOTS cures the existing TB cases and produces a quick reduction in the prevalence of TB in the population.
- The cure rate with successful DOTS can be taken as 85% as against 30% with traditional treatment.
- The relapse rate is only 1% to 2% with DOTS as compared to 15% to 20% with the conventional therapy.
- The failure rates with DOTS are likely to be less than 2% as compared to about 20% with traditional treatment.
- Case fatality rates are likely to drop from about 14% with conventional treatment to less than 2% with DOTS. In lower income groups, to which most Indian households belong, the TB patient is often the sole wage-earner.
- DOTS averts or shortens major illness from TB, and hence could release in future the 4% to 5% of hospital beds currently occupied by TB patients (World Bank, 1995). As far as other costs go, it is most unlikely that the remaining costs "without DOTS" would exceed the total costs "with DOTS". We have therefore ignored here any other cost-saving "with DOTS" over "without DOTS".

After 15 years or so, the annual incidence of TB is also likely to fall and hence the deaths averted by DOTS would further increase. However:

- the rate of decline in the annual incidence is not very predictable;
- the actual further gain is only marginal (because most of the deaths from TB are already averted even without a fall in incidence);
- the benefits lie at least 15 years or more in future (which implies a relatively low present value).

Considering all these, we have preferred to ignore the fall in annual incidence rate in future (after 15 years) on account of DOTS while estimating the economic benefits of DOTS. To the extent the annual incidence declines in future, our estimates represents an underestimate of the true benefits of DOTS. This is in the spirit of conservatism often practised in the field of social cost benefit exercises.

In short, if the DOTS strategy is implemented on a national scale, there would be probably be substantial economic benefits to the country. The main aim of this report is to estimate a lower bound for the magnitude of potential tangible economic benefits from the DOTS strategy in India.

Based on the available secondary data — both in the published and unpublished forms (including surveys conducted by other organisations) — some preliminary estimates of the potential gains in terms of employment, productivity and output in the national economy are attempted here.

II. Steps followed for estimation

It may be noted that the present study is not based on any fresh primary survey. It is based on the secondary sources of data and information already collected for other studies in the field. In order to estimate the potential economic benefits of DOTS in India, the following steps are needed:

i. Estimate the population and total work force in India in 1993-94 by age-sex-residence. The most comprehensive single source is used for estimating both these, in the absence of alternative data sources. The sectoral classification of the work force into the standard primary, secondary and tertiary sectors of the economy is also obtained using the same source.

ii. Estimate the gross domestic product (GDP) for 1993-94 at current prices by rural-urban residence and sectoral classification. Moreover, the average labour productivity by sex and age within the rural-urban classification is obtained, by sectors.

iii. Estimate the total deaths due to TB in India in the base year which is taken to be the year 1993-94. There is more than one estimate of the number of deaths due to TB in India. Murray and Lopez (1996) estimate the deaths due to TB in India in excess of 0.75 million. Survey of Causes of Death for 1993 implies TB deaths number 0.45 million. These two alternative sets of estimates provide TB deaths by five age groups among males and females.

iv. Estimate the prevalence (i.e., stock) of pulmonary TB in the population by age-sex-residence. Here again there are several alternative estimates, though many experts use the parameters from the 1955-58 ICMR survey, with some modifications. About four alternative sets of estimates of the prevalence rates of TB by age-sex-residence have recently been made for India or some Indian states.

v. Estimate the total existing TB patients in 1993-94 by age-sex-residence from the alternative sets of estimates of the TB patients in the country. Also, estimate the number of workers with TB in the base year by age-sex-residence.

vi. DOTS would substantially reduce the number of deaths from pulmonary TB and also the prevalence of TB. Deaths averted among workers lead to a stream of future direct output contribution. Similarly, reduced prevalence of pulmonary TB by DOTS leads to gains in output on account of decreased disability of patients with respect to their economic activity. These latter estimates are based on the productivity differential between workers with TB and other workers.

vii. The benefits accruing in the future are brought to the base year 1993-94 by discounting them at the appropriate rate. Since the benefits are largely in the form of the wastage averted and increased consumption in future by the cured persons and their dependents, the social time preference rate (STPR) for India is considered the best rate of discount to use. In order to take policy decisions, it is relevant to consider some alternative rates of discount. The World Bank as also many other donors/ investors use discount rates varying from 9% to 15% in real terms. We can, therefore, consider some plausible alternative rates of discount.

viii. Finally, an estimate is made of the saving of hospital beds, currently used by the TB patients, from using DOTS.

All these benefits are aggregated to arrive at the estimate of potential economic benefits of DOTS (TB cure) in India with the base year of 1993-94. In the following sections, these steps are discussed and the estimates derived. In the final analysis, we have alternative estimates of the potential economic benefits of DOTS in India using differing estimates of the deaths due to TB and various discount rates.

III. Estimates of population and work force 1993-94

In order to estimate any economic benefits of a TB cure strategy such as DOTS, it is necessary to have a consistent classification of the population by age-sex-residence. The 1991 census estimates with these disaggregations are not yet available in India. The only reliable and comprehensive source of information on this pivotal variable is the latest National Sample Survey. These are available at the required level of disaggregation for the year July 1990 to June 1991 (see, NSSO, 1994). From this source, the age distribution by sex and rural-urban residence for 1993-94 is assumed to be valid for the extrapolated population by sex and rural-urban residence obtained from the 1991 census of India. The age distribution of population by sex and rural-urban residence for the year 1993-94 (mid-year estimate) is presented in Table 3.1.

The estimated distribution of the work force in India by the primary, secondary and tertiary sectors of the economy in 1993-94 is obtained from the NSSO, (1994) taken

TABLE 3.1

Projected population (in '000) as on 1st Oct. 1993 (i.e., 1993-94) in India

	Rural Areas			Urban Areas			All Areas		
Age / Sectors	Males	Females	Persons	Males	Females	Persons	Males	Females	Persons
0 - 4	41920	38081	80001	13581	12959	26540	55501	51040	106541
5 - 14	91818	76702	168520	28968	25641	54609	120786	102343	223129
15 - 44	143076	140559	283635	60193	53583	113776	203269	194142	397411
45 - 59	37740	38707	76447	13665	11097	24762	51405	49804	101209
60 +	21707	20434	42141	6438	6994	13432	28145	27428	55573
All Ages	336261	314483	650744	122845	110274	233119	459106	424757	883863

Source: See the text, Section III.

with the estimates of population presented in Table 3.1 here. It is assumed that the sectoral distribution of workers by age-sex-residence available from the NSSO (1994) is applicable to the estimates of the population in 1993-94. Table 3.2 provides the estimates of the workers for three broad sectors so obtained by sex and rural-urban residence for broad age groups. The primary sector consists of agriculture and allied activities, fishing, and forestry and logging; the secondary sector includes mining and quarrying, manufacturing, construction, and electricity, gas and water supply; and the tertiary sector which is largely a service sector includes the rest of the economy.

IV. Estimates of GDP and labour productivity, 1993-94

The latest data from the Central Statistical Organisation (CSO) on National Accounts Statistics provides estimates of income at current prices by sectors, for the year 1993-94. This is currently the latest year for which confirmed income estimates are officially available. The CSO (1994) also provides official estimates of the Net Domestic Product (NDP) by sectors and rural-urban areas at current prices, for the year 1980-81. This is again the latest year for which official estimates of NDP by rural-urban areas are available. It is possible to derive the

TABLE 3.2

Estimates of workers (in '000) in India in 1993-94 (1st Oct. 1993)

Age / Sectors		Rural Areas			Urban Areas			All Areas		
		Males	Females	Persons	Males	Females	Persons	Males	Females	Persons
5 - 14:	P	8529	4322	12851	89	123	212	8618	4445	13063
	S	407	400	807	533	375	908	940	775	1715
	T	551	180	731	548	159	707	1099	339	1438
Sub Total		9487	4902	14389	1170	657	1827	10657	5559	16216
15 - 44:	P	81231	53777	135008	3554	2557	6111	84785	56334	141119
	S	166684	5416	22100	15549	3575	19124	32233	8991	41224
	T	21880	4432	26312	25952	4778	30730	47832	9210	57042
Sub Total		119795	63625	183320	45055	10910	55965	164850	74535	239385
45 - 59:	P	26744	15713	42457	1154	942	2096	27898	16655	44553
	S	3451	1343	4794	4075	711	4786	7526	2054	9580
	T	5953	1507	7460	7719	1337	9056	13672	2844	16516
Sub Total		36148	18563	54711	12948	2990	15938	49096	21553	70649
60 +:	P	13502	3372	16874	818	175	993	14320	3547	17867
	S	847	347	1194	747	196	943	1594	543	2137
	T	1389	225	1614	1320	350	1670	2709	575	3284
Sub Total		15738	3944	19682	2885	721	3606	18623	4665	23288
All Ages:	P	130006	77184	207190	5615	3797	9412	135621	80981	216602
	S	21389	7506	28895	20904	4857	25761	42293	12363	54656
	T	29773	6344	36117	35539	6624	42163	65312	12968	78280
Grand Total		181168	91034	272202	62058	15278	77336	243226	106312	349538

Source: See the text, Section III.

sectoral average labour productivity by rural and urban areas combining these estimates of income with the estimates of workers from the 1981 Census of India. We assume that the urban-rural productivity differential remains the same in 1993-94 as in 1980-81. Based on this assumption, it is possible to calculate the sectoral average productivities for the urban and the rural areas in 1993-94 consistent with the overall Gross Domestic Product estimates using the break up of the workers given in Table 3.2 (methodology in Appendix 1). The estimates of average labour productivity and GDP at factor cost by rural-urban areas for the year 1993-94, at current prices, are provided in Table 4.1.

In order to estimate the average productivity of the child labour (age 5-14 years) and the adult labour (15+ years) within the urban and the rural areas, we assume that the children's productivity is a third of the average productivity of labour.

Considering the predominantly rural character of the child labour in the primary and low productivity sectors, this assumption seems to be in overall conformity with the B.H. Dholakia study (1974, p.125n) in which similar weights were used based on information then available regarding agricultural labour. Table 4.2 provides the estimates of average labour productivity for the child labour and adult labour by sectors within the rural-urban areas in India in 1993-94. (methodology in Appendix 2).

The labour productivity differential between the young adults (15-44 years) and old adults (45+ years) is obtained from the detailed tabulation of the 1971 Census which provides age-sex distribution of degree holders and technical personnel by salary ranges. Based on this data source, it is estimated that the productivity differential between old adults and young adults is 1.76. Using this productivity differential, the average productivities for the workers belonging to the age groups 15-44 years and 45+

TABLE 4.1

Estimates of labour productivities and GDP, at factor cost, at current prices by rural-urban areas in India, 1993-94.

	Labour Productivity (in Rs.)			GDP at F.C. (Rs. Crores)		
Sectors	Rural	Urban	All Areas	Rural	Urban	All Areas
Primary	9761.67	12884.43	9897.51	202252	12130	214382
Secondary	29115.87	44628.80	36427.11	84130	114966	199096
Tertiary	33244.49	41173.30	37514.95	120069	173598	293667
Total				406451	300694	707145

Source: See the text, Section IV.

TABLE 4.2

Estimates of labour productivity in 1993-94 at current prices of child and adult workers in India (in Rs.)

	Rural Areas			Urban Areas		
Sectors	Child Workers	Adult Workers	All Workers	Child Workers	Adult Workers	All Workers
Primary	3253.89	10192.01	9761.67	4294.81	13082.37	12884.43
Secondary	9705.29	29673.56	29115.87	14876.27	45715.80	44628.80
Tertiary	11081.50	33702.33	33244.49	13724.43	41641.42	41173.30

Source: See the text, Section IV.

years for the three broad sectors are estimated and shown in Table 4.3. (methodology in Appendix 3).

For each sector and age groups in the rural and urban areas, the male-female productivities are estimated with the help of the male-female productivity differential. The 1971 Census, providing the age-sex distribution of the degree holders and technical personnel by the salary ranges, is used to estimate the productivity differentials between male workers and female workers within the age groups 15-44 years and 45+ years to be respectively 1.28 and 1.41. Moreover, it is assumed that among the child labour i.e., in the age group 5-14 years, there is no male-female productivity difference. Based on all these, the male and female average productivities are worked out in

TABLE 4.3

Estimates of labour productivity in 1993-94 at current prices of young and old adult workers in India (in Rs.)

	Rural Areas			Urban Areas		
Sectors	Young Adults	Old Adults	All Adults	Young Adults	Old Adults	All Adults
Primary	8272.57	14559.72	10192.01	10422.72	18343.99	13082.37
Secondary	25536.14	44943.60	29673.56	38900.72	68465.26	45715.80
Tertiary	28205.47	49641.64	33702.33	34798.72	61245.75	41641.42

Source: See the text, Section IV.

TABLE 4.4

Estimates of labour productivity in 1993-94 at current prices of male and female workers by age and area in India (in Rs.)

	Rural Areas		Urban Areas	
Sectors and Age Groups	Males	Females	Males	Females
Primary Sector				
5 - 14	3253.89	3253.89	4294.81	4294.81
15 - 44	9062.19	7079.84	11472.84	8963.15
45 +	16062.09	11391.55	20499.46	14538.63
Secondary Sector				
5 - 14	9705.29	9705.29	14876.27	14876.27
15 - 44	26982.64	21080.19	40559.30	31686.95
45 +	48961.75	34724.65	71769.19	50900.14
Tertiary Sector				
5 - 14	11081.50	11081.50	13724.43	13724.43
15 - 44	29284.50	22878.51	36023.97	28143.72
45 +	52558.79	37275.74	64181.02	45518.46

Source: See the text, Section IV.

each sector, age groups and rural-urban areas in 1993-94 and are presented in Table 4.4. (Appendix 4)

Using productivities as reported in the Table 4.4 along with the estimates of workers given in Table 3.2, we can generate the estimates of Gross Domestic Product at factor cost at current prices in the year 1993-94 cross-classified by the age-sex-sector and area. These estimates are reported in Table 4.5. These estimates are consistent with the available evidence at the macro level and are comparable with the overall GDP estimates available from the CSO. Table 4.5 along with Table 3.2 is useful for calculating the possible contributions of various age-sex-residence categories of workers. The DOTS strategy to cure TB would have a different extent of influence on different categories

TABLE 4.5

Estimates of GDP in India, 1993-94 (Rs. Crores) – classified by age, sex, sector and area

	Rural Areas			Urban Areas			Total of All Areas		
Sector	**Male**	**Female**	**Persons**	**Male**	**Female**	**Persons**	**Male**	**Female**	**Persons**
Primary									
5 - 14	2775	1406	4182	38	53	91	2813	1459	4273
15 - 44	73613	38073	111686	4077	2292	6369	77691	40365	118056
45 - 59	42956	17900	61816	2366	1370	3845	45322	19269	65661
60 +	21687	3841	24568	1677	254	1822	23364	4096	26390
Sub Total	141032	61220	202252	8158	3969	12127	149190	65189	214379
Secondary									
5 - 14	395	388	783	793	558	1351	1188	946	2134
15 - 44	45018	11417	56435	63066	11328	74394	108084	22745	130829
45 - 59	16897	4664	21546	29246	3619	32767	46143	8283	54313
60 +	4147	1205	5366	5361	998	6456	9508	2203	11823
Sub Total	66457	17674	84130	98466	16503	114968	164922	34176	199099
Tertiary									
5 - 14	611	199	810	752	218	970	1363	418	1780
15 - 44	64074	10140	74214	93489	13447	106937	157564	23587	181151
45 - 59	31288	5617	37033	49541	6086	55464	80830	11703	92497
60 +	7300	839	8012	8472	1593	10228	15772	2432	18240
Total Age Wise									
5 - 14	3781	1994	5775	1583	829	2412	5364	2823	8187
15 - 44	182705	59630	242335	160633	27067	187700	343338	86697	430035
45 - 59	91141	28181	120395	81153	11074	92077	172294	39255	212471
60 +	33135	5885	37947	15510	2845	18506	48644	8730	56452
Grand Total	310762	95689	406452	258879	41816	300694	569641	137505	707146

Source: Tables 4.4 and 3.2.

TABLE 5.1

Pulmonary TB importance in mortality in rural India

Year	% of Total Reported Death due to Pulmonary TB	Rank of pulmonary TB Among the Top Killers
1989	5.2%	4th
1990	5.0%	4th
1991	5.3%	3rd
1992	5.9%	2nd
1993	5.7%	2nd

Source: India: Vital Statistics Division: Survey of Causes of Death (Rural) India: Annual Report 1993, Series 3, No.26; p.49.

of workers and hence these estimates provide the basis for further estimates of benefits of DOTS in India.

V. Deaths due to pulmonary TB in India

Pulmonary TB is among the top killer diseases in the country. According to the official statistics on the survey of causes of death in rural India, the relative importance of pulmonary TB, even among the top killer diseases, is gradually rising in the country. (See Table 5.1). In 1993, Pulmonary TB causing about 5.7 percent of the total reported deaths in the country is the second most important cause of death. It is generally stated and believed that TB is widespread and that it is almost equally prevalent across regions in the country as per the one time survey carried out in 1955-58. The death pattern across the regions, however, tells us a different story, particularly in the recent years. The relative importance of TB in the five zones of the country, in the two years 1992 and 1993, in the reported deaths in the rural areas are given in Table 5.2. As it can be seen, in all the five zones in the two years, TB is among the top five killer diseases. However, in the eastern zone, its relative importance is considerably lower as compared to the rest of the zones. On the other hand, in the central and northern zones, TB is considerably more important as a cause of death. Thus, if mortality due to TB is considered an indicator, the disease is not necessarily prevalent equally among different regions of the country. The two tables, however, clearly reveal the magnitude of the problem of Pulmonary TB in the country. In the rural areas it is responsible for five to six percent of the total deaths.

The percentage distribution by age groups for males and females of the reported deaths due to pulmonary TB in rural India is also available (See Table 5.3). As it can be seen from the table, TB deaths as a proportion of total deaths occur relatively more among males than among females. Similarly, the TB deaths are more common among the adults than the children. Even within the adult deaths, it is more common among older adults than the younger adults. Assuming the same percentage distribution by age groups for the deaths due to TB among urban males and females respectively it is possible to derive the estimate of deaths due to TB in India by age-sex and residence. These estimates are reported in Table 5.4. According to this estimate, the TB deaths in the country in 1993-94 were 0.452 million out of the total deaths of 8.090 million. (i.e., about 5.6%). The age pattern of the TB deaths also clearly brings out that children under 15

TABLE 5.2

Pulmonary TB: Relative importance in mortality by regions in (rural) India, 1992 and 1993

Region	1992 % of Reported Death	1992 Rank Among Top Killers	1993 % of Reported Death	1993 Rank Among Top Killers
Northern	6.6%	3rd	5.6%	3rd
Central	6.9%	3rd	7.4%	2nd
Western	5.3%	3rd	5.5%	3rd
Southern	5.4%	4th	5.3%	3rd
Eastern	4.0%	5th	4.0%	4th
All India	5.9%	2nd	5.7%	2nd

Source: The same as Table 5.1; p.64.

years account for only 3.8%, the young adults (15-44 years) account for 42% and old adults above the age of 45 years account for 54.1% of total TB deaths in the country.

The other set of estimates for TB deaths in India is reported by Murray and Lopez (1996) in the context of Global Health Statistics for the year 1990. Based on their rates and our projected population in the year 1993-94, the total TB deaths by sex and age groups are given in Table 5.5. According to the Murray and Lopez (1996) estimates, the TB deaths in India in 1993-94 are 0.76 million out of the total deaths of 8.090 million (i.e., 9.04%). The age pattern of their estimate shows that children below 15 years of age account for 5.5%, young adults (15 to 44 years) account for 28.5%, and old adults above the age of 45 years account for 66% of the deaths due to TB in India. Thus, the two estimates of deaths due to TB in India do differ considerably not only in the magnitude but also in terms of the age patterns. However, according to both the sets of estimates, it is clear that TB death is largely a phenomenon among adults and more so among the old adults who are most likely to be productive and also supporting their respective families (World Bank, 1995, p.14).

VI. The prevalence of pulmonary TB in India

Regarding the prevalence of diseases in the population, there have been very few comprehensive studies carried out in India. There have been several piecemeal and district/city/town specific studies carried out on the subject in recent years. The only reasonable comprehensive study on the subject was carried out in India by the ICMR in 1955 to 1958. Prior to this data the First Five Year Plan in India (1952, p.502) estimated the economic loss of 900 to 1,000 million persons days on account of active TB among 2.5 million persons in the country. The draft outline of the First Five Year Plan (July 1951, p.198) estimated that TB accounts for about 0.5 million deaths in the country (as quoted by Visaria et al 1994). Thus, the prevalence

TABLE 5.3

Age-sex distribution of reported deaths due to pulmonary TB, rural India, 1993

Age Groups	Proportion of Deaths Due to pulmonary TB: Males	Females
< 1	0.79%	0.55%
1 - 4	1.14%	0.91%
5 - 14	1.06%	4.01%
15 - 24	5.73%	10.56%
25 - 34	11.72%	17.67%
35 - 44	19.12%	23.86%
45 - 59	32.60%	21.86%
60 +	27.84%	20.58%
Total	100.00% (6.96%)	100.00% (4.13%)

Note: Figures in the parentheses are proportions of TB deaths to total deaths in the respective category.

Source: The same as Table 5.1; pp.72-77.

TABLE 5.4

Estimates of deaths due to TB in India by age-sex and residence, 1993-94 (in '000)

Age Groups	Rural Areas: Males	Rural Areas: Females	Urban Areas: Males	Urban Areas: Females	Total Persons
0 - 4	4.5	1.9	1.1	0.4	7.9
5 - 14	2.5	5.3	0.6	1.1	9.5
15 - 44	85.6	68.8	21.2	14.6	190.2
45 - 59	76.3	28.8	18.9	6.1	130.1
60 +	65.1	27.2	16.2	5.8	114.3
Total TB Deaths	234	132	58	28	452
Total Deaths	3363	3208	835	684	8090

Source: Table 5.3 above and our estimates of population for 1993-94.

rate estimated by the Planning Commission was about 694 per 100,000 population and death due to TB was estimated to be of the order of 1.39 per 1,000 population which is about 20% of the prevalence of TB. It can be seen from various surveys of the prevalence of TB in the country, that several experts in the field are of the opinion that the ICMR National Sample Survey of 1955-58 remains valid in terms of some epidemiological characteristics regarding TB in the country. (See for instance, Chakraborty 1996, p.38; Murray and Lopez 1996, p.142; Uplekar and Rangan 1995, A 71-72; ASCI 1996, p.50; Datta 1995, p.1; etc.). The National Tuberculosis Institute Longitudinal Surveys from 1961 to 1977 (Chakraborty 1996) have shown that the proportion of outflow of cases on account of death (20%) and cure (18%) is almost balanced by the inflow of about 36% to 38% annually. The frequency of TB thus remains the same with about two-thirds of it being the continuing or the left-over cases. It thus represents a steady state. The same data sources suggest that about 10% of the crude mortality in the society is due to TB which agrees with the Murray and Lopez (1996) estimate. However, the Sample Registration System (SRS) data estimates around 0.4 million annual deaths from TB in India which is very close to the Survey of Causes of Death estimates. (See Tables 5.4 and 5.5).

Regarding firm estimates of the prevalence of Pulmonary TB in India, there are a few recent estimates with fairly detailed age-sex and sometimes urban-rural classification of the prevalence of TB. We have come across five sets of such estimates. They are:

- Murray and Lopez (1996) estimates for the year 1990,
- National Family Health Survey (NFHS) 1992-93 conducted by International Institute for Population Sciences (IIPS) (1995),
- The Andhra Pradesh estimates made by Dr.Ramana et al of Administrative Staff College of India (ASCI) (1996),
- The estimates obtained through a Household Survey of Health Care Utilization conducted by Sundar Ramamani at the National Council of Applied Economic Research (NCAER) (1995), and
- Visaria et-al (1994) estimates based on analysis of data from five states obtained from the National Sample Survey 42nd Round for the year 1986-87.

TABLE 5.5

Alternative estimates of deaths due to TB in India by age and sex, 1993-94 (in '000)

Age Groups	Males	Females	Persons
0 - 4	13.6	10.0	23.6
5 - 14	11.0	7.7	18.7
15 - 44	140.5	77.0	217.5
45 - 59	164.1	90.5	254.6
60 +	177.5	71.4	248.9
Total TB Deaths	506.7	256.6	763.3
Total Deaths	4198	3892	8090

Source: Murray and Lopez (1996), p.142 Our estimates of population for 1993-94.

We have considered the first three estimates for this study because they have the fewest limitations. The NCAER study (Sundar, 1995) considers a group of diseases which includes Mumps, Measles, Chickenpox and TB, but interprets without justification the prevalence as if it were only for TB (See p.17 and pp.54-55 of the Report). This makes the estimates non-usable for our purposes. Visaria et al (1994) covered five states of Gujarat, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal accounting for about 383 million or about 45% of India's population. The survey in the chosen five states covered 11,378 rural households and 7,912 urban households; and provided information on 9,086 cases of illness treated in hospitals during the preceding year of the survey and 18,954 cases treated without hospital admission during the preceding 30 days of the survey. Out of all these cases, only 414 (or 4.6%) in hospital treatment and 360 (or 1.9%) in non-hospital treatment were the TB cases. Recall errors could not be excluded.

Tables 6.1, 6.2, 6.3 and 6.4 presents estimates of the prevalence rates by age, sex and rural-urban areas wherever available. Applying these rates to the common population estimates by age-sex-residence for the year 1993-94 reported in Table 3.1 above, we get the corresponding estimates of the prevalence of TB (in terms of number of patients) in India which is also reported in the respective tables. From the tables, it is clear that although there are some differences in the age distribution of the TB cases across the studies, the overall extent of prevalence is very close in three out of the four studies. The implied prevalence of TB in India in 1993-94 according to the ASCI (1996) study of Andhra Pradesh gives an estimate of 4.1 million, whereas NFHS implies an estimate of 4.0 million and Murray and Lopez (1996) study implies an estimate of 3.9 million of prevalence of TB in India. We take the most conservative estimate[1] of Murray and Lopez (1996) out of the three sets of estimates. Moreover, since these three sets of estimates are very close to each other, we estimate the rural-urban break up of the Murray and Lopez

TABLE 6.1

Prevalence of pulmonary TB in India 1993-94 – Murray and Lopez (1996) estimates

	Prevalence Rate (Per 100,000)		Prevalence (in '000)		
Age Groups	**Males**	**Females**	**Males**	**Females**	**Persons**
0 - 4	83	66	46.07	33.69	79.76
5 - 14	152	123	183.59	125.88	309.47
15 - 44	513	482	1042.77	935.76	1978.53
45 - 59	983	452	505.31	225.11	730.42
60 +	2247	672	632.42	184.32	816.74
All Ages	539	342	2410.16	1504.76	3914.92

Source: Murray and Lopez (1996) and Table 3.1.

TABLE 6.2

Prevalence of pulmonary TB in India 1993-94 – NFHS estimates

	Prevalence Rate (Per 100,000)		Prevalence (in '000)		
Age Groups	**Males**	**Females**	**Males**	**Females**	**Persons**
0 - 4	81	140	64.80	37.16	101.96
5 - 14	117	181	197.17	98.84	296.01
15 - 59	617	368	2221.71	509.82	2731.53
60 +	1771	1019	746.32	136.87	883.19
All Ages	512	344	3230.00	782.696	4012.69

Source: IIPS (1995) p.202 and Table 3.1.

TABLE 6.3

Prevalence of pulmonary TB in India 1993-94 – ASCI (1996) estimates

	Prevalence Rate (per 100,000)				Prevalence (in '000)				
	Rural Areas		Urban Areas		Rural Areas		Urban Areas		Total
Age Groups	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Persons**
0 - 4	15.2	13.6	12.2	11.1	6.37	5.18	1.66	1.44	14.65
5 - 14	28.0	28.9	20.7	21.7	25.71	22.17	6.00	5.56	59.44
15 - 44	617.8	45.7	470.3	233.1	883.92	64.24	283.09	124.90	1356.15
45 - 59	1846.8	1298.5	1301.3	616.9	696.98	502.61	177.82	68.46	1445.87
60 +	2918.2	2078.4	2683.0	211.5	633.45	424.70	172.73	14.79	1245.67
All Ages	714.7	532.3	498.6	301.7	2246.43	1018.90	641.30	215.15	4121.78

Sources: ASCI (1996) pp.58-59 and Table 3.1.

(1996) estimates by age and sex using the proportions of the number of TB cases implied by the ASCI (1996) estimates. This is partly because the NFHS estimates made by the IIPS (1995) do not have the necessary break up of the rural-urban by sex and age group corresponding to Murray and Lopez (1996). Thus, our estimates of the prevalence of TB using both the Murray and Lopez (1996) estimates and ASCI (1996) estimates are presented in Table 6.5.

VII. Estimates of workers with TB in India

Having estimated the prevalence of pulmonary TB in India, the next step is to estimate the number of workers actively engaged in the economically productive activities among those patients. There are hardly any surveys with reasonably large samples providing useful information on this aspect. A recent book, Uplekar and Rangan (1996) provides some bi-variate tables on occupational status, age, literacy, income groups, etc., of TB patients in rural and urban areas of Pune district of Maharashtra State. Their sample size, however, is very limited —103 for rural areas and 196 for urban areas. Moreover, bi-variate information is not very useful for our purpose here. Similarly, the NCAER study (Sundar, 1995) provides estimates of prevalence rate by broad occupations and rural — urban residence of the household heads for serious communicable diseases which include TB. It is also not considered adequate for our purpose here. The study by Nayyar et al (1989) which is an unpublished study provides estimates of culture positive TB by sex, residence and specific occupations based on the study of the Wardha District in Maharashtra State. However, the occupational classification does not match with our all-India sectoral classifications for productivity calculations. It is, therefore, difficult to use these estimates meaningfully. Moreover, the sample size, concepts used and the methodology are not readily available.

TABLE 6.4

Prevalence of pulmonary TB in India 1993-94 – TRC estimates (based on culture test)

	Prevalence Rate (Per 100,000)		Prevalence (in '000)		
Age Groups	**Males**	**Females**	**Males**	**Females**	**Total**
10 - 24	226	124	334	164	498
25 - 44	1934	546	2236	601	2837
45 +	3613	867	2874	670	3544
All Ages	778		5444	1435	6879

Source: P.R. Narayanan (1996) and our estimates of population for 1993-94 by the corresponding age groups based on NSS 42nd Round.

TABLE 6.5

Prevalence of pulmonary TB in India by rural-urban residence, sex and age, 1993-94 (in '000)

	Rural Areas		Urban Areas		All Areas	
Age Groups	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
0 - 4	36.55	26.36	9.52	7.33	46.07	33.69
5 - 14	148.85	100.64	34.74	25.24	183.59	125.88
15 - 44	789.82	317.82	252.95	617.94	1042.77	935.76
45 - 59	402.6	198.12	102.71	26.99	505.31	225.11
60 +	496.92	178.12	135.5	6.2	632.42	184.32
All Ages	1874.73	821.07	535.43	683.69	2410.16	1504.76

Source: Tables 6.1 and 6.3, see the text, Section VI.

Nevertheless, the estimates from all the three studies indicate higher prevalence of TB among the workers than among the total population. This is obvious, because TB is more prevalent among males than females and among adults than the children. When we consider the age structure, sex and rural-urban residence of the TB patients, however, we have no evidence to assume differential prevalence of TB among workers and non-workers. Thus we assume that within an age-sex-residence specific category of population, pulmonary TB is equally prevalent among workers and non-workers. In other words, we can assume that for each of the age-sex-residence specific category, the worker-population-ratio (WPR) for the population and the TB patients is identical. Table 7.1 presents the worker population ratio by age-sex and residence in India for the base year 1993-94. We may, however, exclude the category of child labourers from this because if a child has pulmonary TB he is most unlikely to be employed for long enough to be called a worker. Thus, among the children aged 5-14 years, the WPR among the TB patients is taken as zero. This makes our eventual estimate of the benefits of DOTS even more conservative.

With these assumptions the workers among the TB patients can be derived from the estimates of the prevalence of TB presented in Table 6.5 above. The estimates of workers with TB in the base year 1993-94 are presented in Table 7.2.

VIII. Benefits of DOTS – Reduction in TB prevalence

The Revised National TB Control Programme targets the cure rate with DOTS to increase substantially from the current level of about 25-30% to 85-90%. Thus, the net improvement in the cure rate is likely to be of the order of 55-65%. We may take 60% as the average improvement in the cure rate when DOTS strategy is successfully implemented. TB kills and also disables. Workers with TB are less productive over the year than the workers without TB. It is estimated by Dr. Ramana of ASCI through several case studies of the TB patients in Andhra Pradesh "that even in urban areas one to two months time is taken for the diagnosis of the disease from the day symptoms start. In case of rural areas this could be as long as six months to one year. Most of the patients stated that they could not perform their routine work for a period of

TABLE 7.1

Estimates of worker population ratio in India, 1993-94

	Rural Areas			Urban Areas			Total of All Areas		
Age Groups	**Males**	**Females**	**Persons**	**Males**	**Females**	**Persons**	**Males**	**Females**	**Persons**
0-4	85	11	96	44	3	47	129	14	143
15+	0.8477	0.4313	0.641	0.7583	0.204	0.4969	0.8223	0.3713	0.6015
45+	0.8728	0.3806	0.6273	0.7876	0.2051	0.5117	0.8513	0.3395	0.5992
60+	0.725	0.193	0.4671	0.4481	0.1031	0.2685	0.6617	0.1701	0.4191

Source: Tables 3.1 and 3.2.

TABLE 7.2

Estimates of workers with pulmonary TB in India, 1993-94 (in '000)

	Rural Areas		Urban Areas	
Age Groups	**Males**	**Females**	**Males**	**Females**
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: Tables 7.1 and 6.5.

three months (urban) to six months (rural)." (Dr. G.N.V. Ramana, personal communication). These estimates are not likely to differ considerably across the country. Our preliminary inquiry with some medical practitioners in rural and urban Gujarat confirms this belief. Thus, one of the major economic benefits of DOTS is through the reduction of prevalence of TB among workers which averts the loss in output. Workers with TB are unable to do their routine economic activity for some part of the year. As per Dr. Ramana's estimate, workers with TB lose about 1/4th of the year in the urban areas and almost half of the year in the rural areas. Thus, on the whole, the workers with TB have no more than 75% of the productivity of the other workers in the urban areas, and 50% of the productivity of the other workers in the rural areas. When the prevalence of TB in the population and thereby among the workers reduces, the overall average productivity of the working force would increase. Since this is a purely short run phenomenon, the reduction in the disability induced forced absenteeism does not require any further investment or new capital equipment for its productive use. In fact, such forced absenteeism involves underutilization and wastage of the existing capital stock. Thus, the improvement in production can be directly measured through increased average productivity of labour. Symbolically, the methodology can be presented as follows:

$$\text{Let National Output} = \Sigma a_i . W_i \quad (1)$$

Where a_i and W_i represent respectively the average productivity per worker and the total workers in i-th category; and the subscript i denotes the age-sex-area specific category. Moreover,

$$a_i W_i = b_i WT_i + c_i OW_i \quad (2)$$

Where WT_i and OW_i denote the workers with TB and other workers in the i-th category respectively; and b_i and c_i are their respective average productivities. Then,

$$b_i < c_i \text{ for all i} \quad (3)$$

$$\text{Let } \propto_i = WT_i / Wi \quad (4)$$

Thus, $\propto_i$ represents prevalence of TB among workers in the i-th category. It can be seen from the above equations (2) and (4) that

$$a_i = (1 - s_i \propto i) c_i \quad (5)$$

Where s_i is the proportion of the forced absenteeism due to the disease in the i-th category. It can be seen from equation (5) that other things being given, as DOTS succeeds and $\propto_i$ declines, a_i tends to c_i.

In order to estimate the change in the average productivity, a_i when $\propto_i$ declines, we again use equation (2) and introduce the change in $\propto_i$. Thus,

$$\Delta a_i = - b_i \Delta \propto_i + c_i \Delta \propto_i ; (\Delta \propto_i \text{ being positive}) = \Delta \propto_i (c_i - b_i)$$

$$\text{But } b_i = (1 - s_i) c_i \text{ by definition.}$$

$$\therefore \phi 0 \; \Delta a_i = \Delta \propto_i (s_i c_i) = [(s_i \Delta \propto_i)/(1 - s_i \propto_i)]^* a_i \quad (6)$$

The estimates of s_i, $\propto_i$ and a_i are all derived above for different age-sex-area categories. The $\Delta \propto_i$ representing the decline in the prevalence of TB among workers on account of DOTS can be taken to be 60% (i.e., 0.60) as stated before. Equation (6), thus, makes it possible to estimate the economic impact of DOTS on labour productivity. Table 8.1 presents our estimates of the possible increase in the average productivity of labour in the Indian economy on account of the DOTS strategy. By multiplying these average productivity increases by the total number of workers in respective age-sex-area categories, we can derive the total increase in output on account of reduction in the prevalence of TB due to DOTS. Table 8.2 presents these estimates for the year 1993-94 at current prices.

It is important to recognise that these are the benefits of DOTS in terms of annual additions to the flow of national income during the year when DOTS succeeds in

TABLE 8.1

Increase in APL in India due to DOTS (In Rs.)

	Rural Areas		Urban Areas	
Sectors	**Males**	**Females**	**Males**	**Females**
15 - 44	25.32762	6.364698	22.49732	43.04052
45 - 59	81.12279	23.37125	70.79941	13.51884
60 +	146.2642	39.18964	170.6225	5.250896

Source: See the text, Section VIII.

reducing the prevalence of TB. However, these additions once achieved, would continue in future since the relapse rate with DOTS is almost negligible. If the DOTS strategy continues to be successfully implemented, the percentage addition to the GDP of the country becomes permanent. It almost amounts to shifting the time path of GDP upwards by the same percentage. The present value of these future additions at constant (1993-94) prices should be considered as the benefits of DOTS through reduction of the prevalence of TB in the country. This is because in the scenario without DOTS, the prevalence of TB is likely to be almost stagnant at the present level. Thus, between the two scenarios "with DOTS" and "without DOTS", the percentage increase in GDP due to reduction in the prevalence of TB by DOTS is a permanent annual increase ascribable to DOTS. The question of appropriate rate of discount to be used for the purpose of estimating the present value of these additions to the national income will be considered in the Section X below. We turn to the estimation of another important economic benefit of DOTS, arising from deaths averted.

IX. Benefits of DOTS– Reduction in TB deaths

As stated in Section I, the DOTS strategy is likely to have a very substantial impact on deaths due to TB. The targets of the Revised National TB Control Programme in India (Datta 1995), state that the case fatality rate for TB is expected to be reduced to less than 2% from the current 14%. As we have seen in Section V above, the estimates of the current mortality from pulmonary TB are not confirmed. The Survey of Causes of Death implies a mortality due to TB around 0.45 million per year whereas Murray and Lopez (1996) provide an estimate of around 0.76 million per year. DOTS can save the deaths which would occur in the "without DOTS" case. Moreover, since the Indian situation currently resembles a steady state (See Chakraborty, 1996, P.13), the case "without DOTS" would have the same amount of deaths occurring every year. Sustained successful implementation of DOTS would prevent these additional deaths every year. Moreover, "with DOTS" the prevalence of TB would be substantially reduced and hence the minimum 2% case fatality would also reduce in absolute number.

In order to estimate the economic benefits from the deaths averted by DOTS, we have to estimate the future workers among the deaths averted. These estimates have to be carefully derived. There are no ready made surveys or any empirical findings to go by. It all depends on dynamics of worker participation rates by age and the age pattern of the mortality due to other causes over a fairly long time period. It is difficult to envisage the exact behaviour of these two important parameters. However, the way the Indian economy is shaping particularly with rapid economic reforms introduced in the system, it can be argued that demand for labour is going to increase considerably in future inducing the WPR to rise. The economy is all set to achieve a fairly rapid growth in national income at about 7% p.a. Such a high rate of growth is known to put excessive pressure on the labour market wherever it has occurred. WPR across the age groups in such economies has a tendency to rise. This is clearly borne out by the experience of China, Malaysia, Singapore, Mauritius, etc. On the other hand, age-specific mortality has a depressing effect on the future workers out of the deaths averted by DOTS. The net effect of both these factors would, thus, be largely offsetting. We may, therefore, apply the existing appropriate worker participation rates to the current deaths averted in the particular age-sex-group.

In order to determine the appropriate worker population ratio to apply to the current deaths averted in a particular age group, we need an estimate of the average age of death due to TB in different age-sex groups. Here

TABLE 8.2

Increase in GDP in India due to reduction in prevalence by DOTS in the first year (in Rs. Crores)

	Rural Areas		Urban Areas		All Areas		
Sectors	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Persons**
15 - 44	303	40	101	47	405	87	492
45 - 59	293	43	92	4	385	47	432
60 +	230	15	49	0.4	279	16	295
Total	827	99	242	51	1069	151	1220

Source: See the text, Section VIII.

TABLE 9.1

Average age at death due to TB in India, 1993-94

Age Groups	Average Age at Onset (in years)		Average Duration (in years)		Average Age at Death (in years)	
	Males	Females	Males	Females	Males	Females
0 - 4	3.0	3.0	2.0	2.4	5	5
5 - 14	10.0	10.0	2.7	2.4	13	12
15 - 44	29.7	29.8	2.5	2.5	32	32
45 - 59	52.2	52.3	2.4	2.2	55	55
60 +	70.0	72.6	2.2	1.8	72	74
All Ages	43.0	37.0	2.4	2.3	45	39

Source: Murray and Lopez (1996), p.142 and Section IX of the text.

TABLE 9.2

Worker population ratio for aggregative age groups by sex and area in India, 1993-94

Sex and Area		15+ years	45+ years	60+ years
Rural	Males	0.8477	0.8728	0.7250
	Females	0.4313	0.3806	0.1930
	Persons	0.6410	0.6273	0.4671
Urban	Males	0.7583	0.7876	0.4481
	Females	0.2040	0.2051	0.1031
	Persons	0.4969	0.5117	0.2685
Total	Males	0.8223	0.8513	0.6617
	Females	0.3713	0.3395	0.1701
	Persons	0.6015	0.5992	0.4191

Source: Table 3.2.

TABLE 9.3

Deaths averted by DOTS in India, 1993-94 – set A (in '000)

Age Groups	Males	Females	Persons
0-4	13	9	22
5-14	7	5	12
15-44	120	58	178
45-59	154	86	240
60+	165	68	233
Total	459	226	685

Source: Set A is based on Murray and Lopez (1996) estimates of deaths due to TB and our estimates (See Section IX of the text).

again, Murray and Lopez (1996) provide estimates of the average age of the onset of the disease and average duration by each of the age-sex group. We may assume that the summation of the two is a reasonably close approximation[2] of the average age of death due to TB for our purposes to determine:

- the appropriate WPR to be used; and
- the duration of economically active life of the worker whose life is saved by DOTS in the current year.

We further assume that the worker on an average works up to the age of 65 years. Similarly, we assume that the earliest he/she starts working is 15 years. Table 9.1 provides these estimates for India.

The estimates given in Table 9.1 are for the population — i.e., for workers and non-workers. In order to obtain the future workers from the deaths averted due to DOTS, we need to apply the average WPR which would cover the relevant age groups and the working life. Table 9.2 provides the estimates for the WPR for these three aggregative age groups by sex in India for the years 1993-94.

At this stage, it is important to note that we have two distinct sets of estimates of deaths due to TB in India with the same population base of 1993-94. We, therefore, prepare two alternative sets of the estimates of benefits due to deaths averted by DOTS. We call them:

1. Set A based on Murray and Lopez (1996) estimates of deaths due to TB; and
2. Set B based on SCD (survey of Causes of Death) estimates of deaths due to TB in 1993-94.

These two sets of estimates of deaths averted by DOTS are presented in Tables 9.3 and 9.4. By applying the WPR's given in Table 9.2 to the estimates of deaths averted by DOTS (given in Tables 9.3 and 9.4) we can generate the two alternative sets of the future workers among those whose lives are saved. These estimates are presented in Tables 9.5 and 9.6.

The marginal productivity of labour is the most appropriate concept to determine the contribution of additional workers in the long run in the economy. The contribution of the additional work force in terms of additional potential output is ideally measured through the marginal value product of labour (Solow, 1958).

The marginal productivity of labour is the most appropriate concept to determine the contribution of additional workers to the economy in the long run. This is very well recognised (see for instance, Dornbusch and Fischer, 1994). When a worker dies, he/she gets substituted by some other person from the labour market. Therefore, when the death of a worker is averted, additional employment is generated in the economy to the same extent. This follows from our basic assumption of the economy in the macroeconomic dynamic long-run equilibrium where the natural rate of unemployment (or long-run or structural unemployment rate) remains constant. The steady state growth of output is then determined by the growth of labour supply as per the widely used neo-classical growth model developed by Solow (1958) which is also extensively used for empirical investigations. Accordingly, the contribution of the additional work force in terms of additional potential output is ideally measured through the marginal value product of labour.

A recent study on the growth accounting by Dr. B.H. Dholakia (1995) estimates the relative share of labour for the entire economy for the period 1991 to 1994. Its average value is estimated to be 0.5842 which is also the estimate for the labour elasticity of output in the long run. The labour elasticity of output is defined to be the ratio of the marginal product of labour and the average product of labour. Assuming that the labour elasticity of output remains the same for different age-sex-area categories of workers, it is possible for us to estimate the marginal productivity of labour for different categories of workers in India. These estimates are presented in Table 9.7. It may be noted here that these represent the estimates of the contribution of additional workers on an average in the respective categories in one year. When the death is averted, the person contributes for several years in future. The average life expectancy is going to increase well beyond 65 years in India for both males and females.

Thus, the present discounted value of the contributions of the future workers among the deaths averted in one year due to DOTS for the remaining part of their economically active life needs to be considered as the economic benefits of deaths averted by DOTS. Once the appropriate discount rate is chosen, we can generate these estimates.

It may also be noted that if DOTS continues to be successfully implemented, it will save the deaths at the same rate per annum in future also as compared to the "without DOTS" scenario. The contribution to the GDP of the additional work force arising out of the deaths averted in future would also have to be considered for estimating the benefits of DOTS. As noted in the beginning of this section, in the "with DOTS" scenario there would be an increasing number of deaths averted in future. These future benefits will however have to be discounted at the appropriate discount rate. We turn to this question in the next section.

TABLE 9.4

Deaths averted by DOTS in India, 1993-94 – set B (in '000)

Age Groups	Rural Areas			Urban Areas			All Areas		
	Males	Females	Persons	Males	Females	Persons	Males	Females	Persons
0 - 4	3.7	1.6	5.3	0.9	0.3	1.2	4.6	1.9	6.5
5 - 14	2.1	4.4	6.5	0.5	0.9	1.4	2.6	5.3	7.9
15 - 44	70.8	56.9	127.8	17.5	12.1	29.6	88.4	69.0	157.4
45 - 59	63.1	23.8	87.0	15.6	5.0	20.7	78.8	28.9	107.6
60 +	53.9	22.5	76.4	13.4	4.8	18.2	67.3	27.3	94.6
Total	193.6	109.2	302.8	48.0	23.2	71.2	241.6	132.4	374.0

Source: Set B is based on Survey of Causes of Death 1993-94 estimates of deaths due to TB and our estimates (See Section IX of the text).

TABLE 9.5

Future workers among the deaths averted by DOTS in India, 1993-94 – set A (in '000)

Age Groups	Males	Females	Persons
0 - 4	10	3	14
5 - 14	6	2	8
15 - 44	98	22	120
45 - 59	131	29	160
60 +	109	12	121
Total	355	68	423

Source: Tables 9.2 and 9.3.

TABLE 9.6

Future workers among the deaths averted by DOTS in India, 1993-94 – set B (in '000)

Age Groups	Rural Areas			Urban Areas			All Areas		
	Males	Females	Persons	Males	Females	Persons	Males	Females	Persons
0 - 4	3.2	0.7	3.8	0.7	0.1	0.8	3.8	0.7	4.6
5 - 14	1.8	1.9	3.6	0.4	0.2	0.6	2.1	2.1	4.2
15 - 44	60.0	24.6	84.6	13.3	2.5	15.8	73.3	27.0	100.4
45 - 59	55.1	9.1	64.2	12.3	1.0	13.3	67.4	10.1	77.5
60 +	39.1	4.3	43.4	6.0	0.5	6.5	45.1	4.8	49.9
Total	159.1	40.5	199.6	32.7	4.2	36.9	191.8	44.8	236.6

Source: Tables 9.2 and 9.4.

X. The rate of discount and future benefits

The benefits in future need to be discounted to bring them to the base year. Since the benefits of DOTS over the existing standard chemotherapy to cure TB in India are largely in terms of deaths averted and increased efficiency of work force due to reduction in the prevalence of TB, the rate of interest at which the future benefits should be discounted must be the consumption rate of interest. It is also called the social time preference rate (STPR). It shows the extra amount of future consumption which the society considers necessary in order to forego a unit of present consumption without becoming worse-off or better-off. Thus, if the society sacrifices one unit of consumption today, it needs (1 + STPR) units of consumption in future to yield the same amount of welfare. Fellner (1967) has provided a framework to estimate STPR for any economy. Tiwari and Pandey (1993) made an attempt to estimate the STPR for India by estimating the fundamental relationships suggested by Fellner (1967). Dholakia and Oza (1996) have considered their estimates removing certain flaws in the estimation procedure. The estimate of the STPR for the Indian economy turns out to be around 5%.

On the other side, the labour productivity in Indian economy is likely to be growing almost at 3-5% p.a. This is because the real GDP in India is expected to grow at the rate of about 5-7% p.a. at least during the 9th Plan period and in future too according to the revised Perspective Plan targets. The population (and working force) is growing at the rate of 2% p.a. at present and is most likely to show a decline in the annual growth rate in near future. Hence the working force may grow at around 2% p.a. in India in future. Thus, the labour productivity growing at 3-5% p.a. is a reasonable assumption. When the real income additions in future are growing at 3-5% p.a. considering only the effect of labour productivity growth, the rate of discount has to be reduced by 3-5% to get the effective rate of discount. If STPR is estimated to be 5% in India, and if labour productivity in India is likely to grow at 3-5% p.a., the effective discount rate in this case would turn out to be zero to 2%.

However, the World Bank, Asian Development Bank and several other financial institutions, donors and investors expect a much higher rate of return on the investments. For international investors, it is the return on capital that matters. These institutions, therefore, often evaluate projects at the discount rates (in real terms) of between 9% to 15%. Given that the labour productivity in the country is likely to grow in real terms at 3% to 5% in future, we may also, therefore, consider the range of effective discount rates of 4% to 12%. We have, therefore, considered five effective rates of discounts, viz. 2%, 4%, 7%, 10% and 13%.[3] We present our estimates by the category-wise disaggregation for both the types of benefits of DOTS viz. deaths averted and reduction in prevalence of TB.

It is important to recognise that we should carefully avoid double counting of benefits. For instance, let us consider that the prevalence of TB is 100 during the given year without DOTS. About 14 will die during the year and about 20 to 25 will be cured during the year. On the other hand, about 35 to 37 will be the new cases of TB added during the year. Thus, the situation is more or less repetitive every year "without DOTS". The situation changes considerably with successful implementation of DOTS. Only 2% out of the prevalence will die during the year and the cure rate will be 85 to 90%. As a conservative estimate, we have taken the improvement due to DOTS in the cure rate to be 60% of prevalence. Now the deaths averted by DOTS are largely included in those who are additionally cured during the year. While calculating the economic benefits of DOTS, we have to be careful in avoiding this double counting. We have assumed that the patients who would have died "without DOTS" remained patients

TABLE 9.7

Estimates of marginal product of labour by age-sex-residence in India, 1993-94 at current prices (in Rupees)

	Rural Areas			Urban Areas			All Areas		
Age Groups	Males	Females	Persons	Males	Females	Persons	Males	Females	Persons
15 +	10446	6355	90796	24687	16377	23078	14174	7809	12250
45 +	13993	8842	12434	35666	21913	33055	19060	10692	16725
60 +	12300	8717	11263	31407	23054	29981	15260	10933	14162

Source: Tables 4.5 and 9.2 above.

TABLE 10.1

Discounted present value of gains out of deaths averted in the first year due to DOTS – set A* (in Rs. Crores)

A) Discount Rate of 5%

Age	Male	Female	Persons
0 - 4	380.8922	69.35341	450.2456
5 - 14	257.7056	44.28677	301.9924
15 - 44	3344.215	405.8955	3750.111
45 - 59	2244.916	280.3681	2525.284
60 +	323.2578	24.43525	347.693
Total	6550.986	824.3391	7375.325

B) Discount Rate of 7%

Age	Male	Female	Persons
0 - 4	214.4337	39.0444	253.4781
5 - 14	169.465	28.56254	198.0275
15 - 44	2529.93	307.0638	2836.994
45 - 59	2027.062	253.1603	2280.222
60 +	314.0176	23.73678	337.7543
Total	5254.908	651.5678	5906.476

C) Discount Rate of 10%

Age	Male	Female	Persons
0 - 4	103.6603	18.87463	122.535
5 - 14	102.8496	16.84878	119.6984
15 - 44	1777.988	215.7988	1993.787
45 - 59	1755.326	219.2231	1974.549
60 +	301.0147	22.75388	323.7685
Total	4040.839	493.4991	4534.338

D) Discount Rate of 13%

Age	Male	Female	Persons
0 - 4	56.48156	10.28424	66.7658
5 - 14	69.91482	11.14094	81.05576
15 - 44	1334.056	161.9176	1495.973
45 - 59	1535.648	191.7874	1727.435
60 +	288.9441	21.84146	310.7856
Total	3285.044	396.9717	3682.016

E) Discount Rate of 16%

Age	Male	Female	Persons
0 - 4	33.40784	6.082948	39.49079
5 - 14	51.28617	7.955592	59.24176
15 - 44	1053.371	127.8502	1181.221
45 - 59	1356.106	169.3645	1525.471
60 +	277.7227	20.99322	298.7159
Total	2771.894	332.2464	3104.14

**Set A is based on the Murray and Lopez (1996) estimates of TB death rates.*

Source: See the text, Sections IX and X. We have assumed the growth of labour productivity to be only 3% and not 5% for being conservative. If we consider higher labour productivity growth or growth in the number of TB deaths "without DOTS", the discount rates have to be accordingly increased with the calculated numbers remaining the same.

TABLE 10.2

Discounted present value of gains out of deaths averted in the second and subsequent years due to DOTS – set A* (in Rs. Crores)

A) Discount Rate of 5%

Age	Male	Female	Persons
0 - 4	19553.31	3560.139	23113.45
5 - 14	16751.35	2859.618	19610.97
15 - 44	182512.4	24044.33	206556.7
45 - 59	114738.1	14211.25	128949.3
60 +	16636.05	1240.213	17876.26
Total	350191.1	45915.55	396106.7

B) Discount Rate of 7%

Age	Male	Female	Persons
0 - 4	5398.19	982.8669	6381.057
5 - 14	5401.856	904.4149	6306.27
15 - 44	67708.54	8919.979	76628.52
45 - 59	50805.57	6292.685	57098.25
60 +	7924.868	590.7966	8515.664
Total	137239	17690.74	154929.8

C) Discount Rate of 10%

Age	Male	Female	Persons
0 - 4	1449.37	263.8918	1713.262
5 - 14	1820.863	296.3131	2117.176
15 - 44	26428.67	3481.735	29910.41
45 - 59	24435.07	3026.483	27461.55
60 +	4219.269	314.5453	4533.815
Total	58353.24	7382.969	65736.21

D) Discount Rate of 13%

Age	Male	Female	Persons
0 - 4	537.7277	97.90593	635.6336
5 - 14	842.8161	133.4115	976.2276
15 - 44	13502.36	1778.812	15281.17
45 - 59	14555.82	1802.857	16358.67
60 +	2757.735	205.5884	2963.324
Total	32196.45	4018.574	36215.03

E) Discount Rate of 16%

Age	Male	Female	Persons
0 - 4	238.1634	43.36323	281.5266
5 - 14	462.9507	71.33702	534.2877
15 - 44	7983.397	1051.739	9035.136
45 - 59	9625.196	1192.159	10817.36
60 +	1984.819	147.9677	2132.787
Total	20294.53	2506.567	22801.09

**Set A is based on the Murray and Lopez (1996) estimates of TB death rates.*

Source: Same as Table 10.1.

TABLE 10.3

Discounted present value of gains out of deaths averted in the first year due to DOTS – set B* (In Rs. Crores)

	Rural Areas			Urban Areas			Total of All Areas		
Age	**Male**	**Female**	**Persons**	**Male**	**Female**	**Persons**	**Male**	**Female**	**Persons**
A) Discount Rate of 5%									
0 - 4	85	11	96	44	3	47	129	14	143
5 - 14	55	36	91	28	9	37	83	45	128
15 - 44	1505	374	1879	788	97	885	2292	471	2763
45 - 59	693	72	765	395	20	415	1087	92	1180
60 +	93	7	101	37	2	39	130	10	139
Total	2431	500	2931	1291	131	1422	3722	632	4353
B) Discount Rate of 7%									
0 - 4	49	6	54	24	2	26	73	8	80
5 - 14	36	23	59	18	6	24	55	29	84
15 - 44	1138	283	1421	596	73	669	1734	356	2091
45 - 59	625	65	690	356	18	375	982	83	1065
60 +	91	7	98	36	2	38	126	9	135
Total	1938	385	2323	1031	101	1132	2969	486	3455
C) Discount Rate of 10%									
0 - 4	23	3	26	12	1	13	35	4	39
5 - 14	22	14	36	11	3	15	33	17	50
15 - 44	800	199	999	419	51	470	1219	250	1469
45 - 59	542	56	598	309	16	324	850	72	922
60 +	88	7	94	34	2	36	121	9	130
Total	1474	28	1752	785	74	858	2258	352	2611

Age	Rural Areas Male	Rural Areas Female	Rural Areas Persons	Urban Areas Male	Urban Areas Female	Urban Areas Persons	Total of All Areas Male	Total of All Areas Female	Total of All Areas Persons
D) Discount Rate of 13%									
0 - 4	13	2	14	7	0.4	7	19	2	21
5 - 14	15	9	24	8	2	10	23	11	34
15 - 44	600	149	750	314	39	353	914	188	1102
45 - 59	474	49	523	270	14	285	744	63	807
60 +	83	7	90	33	2	35	116	9	125
Total	1185	216	1401	631	57	688	1816	273	2089
E) Discount Rate of 16%									
0 - 4	7	1	8	4	0.2	4	11	1	13
5 - 14	11	6	17	6	2	7	17	8	25
15 - 44	474	118	592	248	30	279	722	148	870
45 - 59	418	44	462	238	12	251	657	56	713
60 +	80	6	86	31	2	33	112	8	120
Total	991	175	1166	527	47	574	1518	222	1740

** Set B is based on Survey of Causes of Death Estimates of TB deaths.*

Source: Same as Table 10.1.

TABLE 10.4

Discounted present value of gains out of deaths averted in the second and subsequent years due to DOTS – set B* (in Rs. Crores)

	Rural Areas			Urban Areas			All Areas		
Age	**Male**	**Female**	**Persons**	**Male**	**Female**	**Persons**	**Male**	**Female**	**Persons**
A) Discount Rate of 5%									
0 - 4	4734.6	618.7	5353.4	2446.6	158.7	2605.3	7181.2	777.5	7958.7
5 - 14	3081.8	1982.6	5064.5	1563.6	501.5	2065.1	4645.4	2484.2	7129.1
15 - 44	83810.4	20850.4	104660.9	43879.4	5392.8	49272.2	127689.8	26243.3	153933.2
45 - 59	38580.2	4012.3	42592.6	21980.8	1135.2	23116.0	60561.1	5147.5	65708.7
60 +	5195.2	409.5	5604.7	2040.3	123.3	2163.7	7235.6	532.8	7768.5
Total	135402.5	27873.8	163276.3	71910.8	7311.7	79222.6	207313.3	35185.5	242498.9
B) Discount Rate of 7%									
0 - 4	1307.1	170.8	1477.9	675.4	43.8	719.2	1982.5	214.6	2197.2
5 - 14	993.8	627.0	1620.8	504.2	158.6	662.8	1498.0	785.6	2283.7
15 - 44	31092.0	7735.1	38827.1	16278.4	2000.6	18279.0	47370.4	9735.7	57106.2
45 - 59	17083.2	1776.6	18859.8	9733.0	502.6	10235.7	26816.2	2279.3	29095.5
60 +	2474.8	195.0	2669.9	971.9	58.7	1030.7	3446.8	253.8	3700.6
Total	52951.0	10504.7	63455.7	28163.0	2764.5	30927.6	81114.1	13269.3	94383.4
C) Discount Rate of 10%									
0 - 4	350.9	45.8	396.8	181.3	11.7	193.1	532.3	57.6	589.9
5 - 14	334.9	205.4	540.4	169.9	51.9	221.9	504.9	257.4	762.3
15 - 44	12136.1	3019.2	15155.4	6353.9	780.9	7134.8	18490.1	3800.1	22290.2
45 - 59	8216.2	854.4	9070.7	4681.1	241.7	4922.8	12897.3	1096.2	13993.5
60 +	1317.6	103.8	1421.4	517.4	31.2	548.7	1835.1	135.1	1970.2
Total	22355.9	4228.9	26584.8	11903.8	1117.6	13021.5	34259.8	5346.6	39606.4

Age	Rural Areas Male	Rural Areas Female	Rural Areas Persons	Urban Areas Male	Urban Areas Female	Urban Areas Persons	All Areas Male	All Areas Female	All Areas Persons
D) Discount Rate of 13%									
0 - 4	130.2	17.0	147.2	67.2	4.3	71.6	197.4	21.3	218.8
5 - 14	155.0	92.4	247.5	78.6	23.3	102.0	233.7	115.8	349.6
15 - 44	6200.3	1542.5	7742.8	3246.2	398.9	3645.1	9446.5	1941.4	11388.0
45 - 59	4894.3	509.0	5403.3	2788.5	144.0	2932.5	7682.8	653.0	8335.8
60 +	861.2	67.8	929.0	338.2	20.4	358.6	1199.4	88.3	1287.7
Total	12241.1	2228.9	14470.1	6518.9	591.1	7110.1	18760.0	2820.1	21580.2
E) Discount Rate of 16%									
0 - 4	57.6	7.5	65.2	29.8	1.9	31.7	87.4	9.4	96.9
5 - 14	85.1	49.4	134.6	43.2	12.5	55.7	128.3	61.9	190.3
15 - 44	3666.0	912.0	4578.0	1919.3	235.8	2155.2	5585.3	1147.9	6733.2
45 - 59	3236.4	336.5	3573.0	1843.9	95.2	1939.1	5080.3	431.8	5512.2
60 +	619.8	48.8	668.6	243.4	14.7	258.1	863.2	63.5	926.8
Total	7665.1	1354.4	9019.6	4079.7	360.2	4440.0	11744.8	1714.7	13459.6

** Set B is based on Survey of Causes of Death estimates of TB deaths.*

Source: Same as Table 10.1.

throughout the year with reduced efficiency if they were also workers. Thus, the economic benefits of deaths averted by DOTS during the particular year when the patient is put on DOTS would be the same as any other patient getting cured by DOTS. The benefits of deaths averted are thus only the additional benefits accruing in future and therefore appropriately discounted.

Secondly, we must also consider the future flow of benefits of DOTS due to future deaths averted. As we have already discussed, "without DOTS", the situation is repetitive and therefore the deaths remain the same. On the other hand, with successful DOTS, the prevalence sharply declines to about 33 to 35% of the present level. The number of deaths occurring "with DOTS", therefore, would be 0.7% of initial prevalence as compared to 2% as in the initial year of DOTS. The number of deaths averted during the second year of DOTS is thus 13.3% of initial prevalence as compared to 12% in the initial year of DOTS. After 15 years or so, the annual incidence is also likely to fall and hence the deaths averted by DOTS would further increase. However:

- the rate of decline in the annual incidence is not very predictable;
- the actual further gain is only marginal (because at best it can reach 14% from 13.3% of initial prevalence); and
- the benefits lie at least 15 years or more in future (which implies very low present value).

Considering all these, we have preferred to ignore the fall in annual incidence rate in future (after 15 years) on account of DOTS while estimating the economic benefits of DOTS. To the extent the annual incidence declines in future, our estimates represents an underestimate of the true benefits of DOTS. This is in the spirit of conservatism often practised in the field of social cost benefit exercises.

The estimates of present value of economic benefits of DOTS due to deaths averted in the first year and due to deaths averted in the subsequent years are presented in Tables 10.1 and 10.2 according to the Murray and Lopez (1996) estimates of TB deaths and in Tables 10.3 and 10.4 according to the Survey of Causes of Death estimates of TB deaths. Similarly Table 10.5 provides the present discounted value of the future economic benefits due to reduction in prevalence of TB on account of DOTS in India at different discount rates.

We have so far considered the estimates of the tangible economic benefits of DOTS given in Tables 8.2 and 10.1 to 10.5, from reduced prevalence and deaths averted by DOTS. It is stated that when the prevalence is significantly reduced, the transmission cycle of the infectious TB gets effectively interrupted and the incidence of new TB patients in the distant future also gets reduced. However, these effects usually take a long time because as such about 40-50% of the country's total population is believed to be already infected by the TB bacilli. The disease can become active even years after the initial infection. Thus, even when the annual risk of infection which is currently estimated for India to be around 1.5% as per the World Bank (1995, p.5), starts declining at a rate of 10% as against the current rate of 2-2.5%, it would take more than 25 years to reach the level of 0.1% of the annual risk of the disease. Significant reduction in the annual incidence rate of TB due to intervention through DOTS can, therefore, be expected only after about 15 years. Until then, the annual incidence rate is likely to be about one-third of the prevalence rate in the initial period given the epidemiological situation of TB in India. Under these circumstances, if the prevalence (stock) of TB were rapidly lowered with successful DOTS therapy the cost of tackling TB would fall by two-thirds and remain at that level for about 15 years after which it would again start declining. This feature of the DOTS strategy has implications on the cost "with DOTS" as compared to "without DOTS". As we have already seen, India has reached a steady state which has a tendency to repeat itself in an epidemiological sense with respect to TB. Thus, if things do not change, the present cost (both private and public) would have to be incurred annually just in order to keep the situation from worsening.

XI. Saving of hospital beds due to DOTS

In 1993-94 hardly 1.2 million TB cases out of the probable 3.9 million were detected and put on treatment (See, Datta, 1995). Moreover, most of these cases receive palliation and not cure. Therefore, it is believed that almost 75% to 80% of the existing TB patients in India have received some treatment for TB at one time or another. The treatment does not result in cure because it is neither complete nor of proper quality. The unit cost incurred for such treatment — both by the patients and the provider institutions — are possibly lower than what would be needed if the treatment was complete and of proper quality. DOTS on the other hand, cures the patients and could cost more particularly because we have to consider all the social costs necessary to ensure that the DOTS strategy succeeds in India.

In the scenario "with DOTS" as compared to "without

TABLE 10.5

Discounted present value of future increase in GDP in India due to reduction in prevalence due to DOTS (in Rs.Crores)

	Rural Areas		Urban Areas		All Areas		
Ages	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Persons**
A) Discount Rate of 5%							
15 - 44	15170.61	2024.77	5068.083	2347.861	20238.7	4372.63	24611.33
45 - 59	14662.13	2169.203	4583.554	202.1067	19245.69	2371.31	21617
60 +	11509.53	772.8197	2461.229	18.92948	13970.76	791.7491	14762.51
Total	41342.27	4966.792	12112.87	2568.897	53455.14	7535.689	60990.83
B) Discount Rate of 7%							
15 - 44	7585.306	1012.385	2534.041	1173.93	10119.35	2186.315	12305.66
45 - 59	7331.066	1084.601	2291.777	101.0533	9622.843	1185.655	10808.5
60 +	5754.765	386.4098	1230.615	9.464739	6985.379	395.8746	7381.254
Total	20671.14	2483.396	6056.433	1284.448	26727.57	3767.844	30495.41
C) Discount Rate of 10%							
15 - 44	4334.461	578.5056	1448.024	670.8173	5782.484	1249.323	7031.807
45 - 59	4189.181	619.7723	1309.587	57.74476	5498.768	677.517	6176.285
60 +	3288.437	220.8056	703.2084	5.408422	3991.645	226.214	4217.859
Total	11812.08	1419.083	3460.819	733.9705	15272.9	2153.054	17425.95
D) Discount Rate of 13%							
15 - 44	3034.123	404.9539	1013.617	469.5721	4047.739	874.5261	4922.265
45 - 59	2932.427	433.8406	916.7108	40.42133	3849.137	474.2619	4323.399
60 +	2301.906	154.5639	492.2459	3.785896	2794.152	158.3498	2952.501
Total	8268.455	993.3584	2422.573	513.7794	10691.03	1507.138	12198.17
E) Discount Rate of 16%							
15 - 44	2333.94	311.503	779.705	361.2093	3113.645	672.7123	3786.358
45 - 59	2255.713	333.7235	705.1621	31.09333	2960.875	364.8169	3325.692
60 +	1770.697	118.8953	378.6507	2.912227	2149.347	121.8076	2271.155
Total	6360.35	764.1219	1863.518	395.2149	8223.868	1159.337	9383.205

Source: See the text, Sections VIII and X and also the note in Table 10.1.

DOTS" the costs to the society[4] are, therefore, not likely to be saved in spite of the declining costs of the DOTS in the distant future. If there is any net saving of cost to society in the "with DOTS" over "without DOTS" scenario, it can be considered as a net benefit of DOTS. However, when we are using a high rate to discount the future, there may be negligible net saving in terms of social costs "with DOTS" over the situation "without DOTS". This is because successful DOTS might well cost more in the short run.

There is some obvious saving of resources due to DOTS which we have not considered so far. DOTS strategy to cure TB averts hospitalization of the TB patients. If the strategy is properly implemented, it can save the economy the cost of hospital beds currently used for TB patients. This again is not a one time benefit but is a permanent benefit to the society. In order to estimate this benefit of DOTS, we need to know the number of hospital beds and the duration for which they are used by the TB patients in the base year 1993-94 in India. Secondly, we need to estimate the cost of providing a hospital bed per day on an average in India. We are not interested in estimating how much a TB patient has to pay for the hospitalized treatment in the government hospital and the private hospital or how much subsidy he receives from the government or non-government organisation. Our interest is to estimate the amount the society has to spend in order to create the infrastructural facility equivalent to the number of TB beds released by DOTS. In this context, a set of some relevant estimates are derivable from the Gujarat Institute of Development Research, Ahmedabad study about TB from the NSS 42nd round data on five states (see, Visaria et al. 1994).

Table 11.1 presents the proportion of public and private hospital treatment among the selected sample of TB patients in the rural and urban areas of the five states.

TABLE 11.1

Proportion of public and private hospitalization by TB patients, 1986-87 (in %)

States	Rural Areas			Urban Areas		
	Public	Private	All	Public	Private	All
Gujarat	75.7	4.3	100	67.2	32.8	100
Maharashtra	76.9	23.1	100	62.0	38.0	100
Tamil Nadu	63.9	36.1	100	93.5	6.5	100
Uttar Pradesh	70.7	29.3	100	70.7	29.3	100
West Bengal	95.7	4.1	100	95.5	4.5	100

Source: Visaria et al. (1994), pp.34-35.

TABLE 11.2

Average amount per day paid to the private hospital by the TB patient for hospitalization, 1986-87 (in Rs.)

States	Rural Areas	Urban Areas
Gujarat	19.75	94.44
Maharashtra	65.82	61.55*
Tamil Nadu	58.33	100.67
Uttar Pradesh	22.82	11.20*
West Bengal	22.61	241.22*
Average	38	102

** Some error is suspected but Visaria et al. (1994) are silent about it.*

Source: Calculated from Visaria et al. (1994) pp.38 and 40.

Based on these figures, we may take the average proportion of the government to non-government hospital beds used by the TB patients in India to be 75:25. The total TB beds in the government hospitals is reported to be 47,326 by the end of 1991. Assuming the same number of beds in the year 1993-94, and applying the proportion of 75:25 to obtain the beds in the non-government hospitals, the total number of hospital beds in 1993-94 used by the TB patients turns out to be 63,101 or say, 63,000.

In order to estimate the cost of a hospital bed to the provider — whether government or non-government, it is most relevant to consider the market value of the bed. It is, therefore, the private hospital's charges which should provide some guidance. However, in the light of non-availability of precise data, we use whatever rough and ready estimates one can derive from Visaria et al. (1994). Table 11.2 presents the average amount per day spent by TB patient for hospitalized treatment in the five states. Taking a simple average in the rural and urban areas, the overall weighted average amount works out to be Rs.57 per day per bed in 1986-87.[5] Taking 30% of this as the cost of medicine, the profits of the private sector and other incidental service charges, the cost of the hospital bed for TB patient per day would work out at Rs.40 per day in 1986-87. Considering the overall inflation rate of 9.4% per annum (based on GDP deflator), the cost of a hospital bed per day in the economy works out to about Rs.75 per day in 1993-94. Considering the utilization of the bed by the TB patients on an average for 275 days out of 365 days (i.e., at about 75%), the cost saved by DOTS per bed released by the TB patients would be Rs.20.6 thousands per year.

The estimate of the benefit of DOTS in terms of releasing the hospital beds currently used by the TB patients, thus, works out to 63,000 beds * Rs.20,600 per bed = Rs.129.8 crores per annum. Since this is an annuity, its present discounted values at different discount rates are reported in Table 11.3. It may be noted here that the discount rate in this case is not reduced by the labour productivity growth since that is not a factor in the numerator. But the discount rate will get reduced by the growth rate of the hospital beds used by the TB patients in future in the scenario "without DOTS".

XII. Potential economic benefits of DOTS in India

The DOTS strategy is an effective way of tackling TB. The strategy has worked elsewhere and is expected to work in India too. Regular treatment is a major factor in curing TB. DOTS aims to tackle that factor directly. It is important to consider the various aspects of the problem of TB in India to ensure that DOTS succeeds in India. However, it is important to have some dimensional idea about the potential benefits of DOTS in India so that any extra or additional resources required to make the strategy work effectively in the country can be considered in the light of the likely benefits of those interventions. In this context, we have to consider the potential benefits of DOTS and not its actual performance in the pilot projects or any operational constraints on the implementation of DOTS in the country. Identification of such constraints, factors to improve the effectiveness of DOTS, and finding out management solutions to make DOTS succeed to the desired extent are important studies, the justification and feasibility of which depends critically on some idea about the potential economic benefits the country may derive if DOTS succeeds. In our exercise, therefore, we have assumed that DOTS can and will succeed to the desired extent in India. Another crucial assumption we make to begin with is that of full and instantaneous coverage of the whole population (100%) by the DOTS strategy in India. This assumption is made initially for two reasons: 1) It gives us an idea of the potential benefits of the DOTS strategy in India; and 2) It would serve as a good reference and the base estimate from which we can easily derive the flow of benefits according to the desired pattern of the coverage of the population "with DOTS" in India. Thus, although this assumption may sound unrealistic, it has great utility for considering more realistic scenarios.

Having made these basic assumptions, we have derived the most conservative estimates of the economic benefits of DOTS to the country's economy. Here again we have not considered the pure social welfare increasing effects which do not generate direct tangible economic benefits. Thus, we have not considered here the benefits arising from reduced suffering of TB patients, quicker and surer cure from the disease, increased welfare on account

TABLE 11.3

Present discounted value of the benefit of DOTS in terms of hospital beds released (in Rs. Crores)

Discount Rates	5%	7%	10%	13%	16%
PDV in Rs.Crores	2596	1854	1298	998	811

Source: See the text, Section XI.

of lives saved and disability reduced for the dependents and non-workers suffering from TB, the income distribution gains and poverty alleviation effects because TB is known to be more prevalent among the poor than the rich, the psychic benefits of living in a society where the risk of the infection and the disease is substantially reduced, etc. We have considered here only the obvious and direct potential economic benefits of DOTS succeeding in India. These include mainly the following three benefits:

1. Reduction in the prevalence of TB due to DOTS which improves the efficiency and productivity of workers by reducing their forced absenteeism on account of ill-health;
2. TB deaths averted among the current and the future workers which add to the productive work force in the country;
3. Release of the hospital beds currently occupied by the TB patients since the DOTS strategy averts hospitalization of patients.

These benefits are to be evaluated within the framework of comparing two scenarios — "with DOTS" and "without DOTS". The benefits at 1) and 2) are largely in terms of additions to the national income over the future years. While calculating the present discounted value, therefore, we have to adjust for the expected growth in labour productivity. Although the current growth rate of labour productivity in India is around 5% which is also targeted in the ensuing 9th Plan, we have effectively assumed the growth rate in labour productivity to be only 3% which is more realistic in a very long term perspective. Similarly, we have assumed constant absolute prevalence and incidence rates of TB in the "without DOTS" scenario. Given this, the population growth rate would also apply to the annual benefit flows such as the real labour productivity growth. Thus, if real labour productivity growth is more than 3% p.a. or the number of TB patients without DOTS grow at some positive rate, our calculated figures for potential benefits remaining the same, the corresponding discount rates would be higher to that extent.

All the benefits are estimated considering five alternative discount rates, viz. 5%, 7%, 10%, 13% and 16%.[6] This range should cover any realistic expectations of return on capital since all these calculations are in real terms or at constant base year (1993-94) prices. These discount rates are therefore real rates of interest. If the benefits exceed the costs despite a 16% discount rate, the nominal rate of return on the investment would be (16% + inflation rate). This is likely to exceed 20% to 22% if inflation runs at 4% to 6% per annum. A discount rate as low as 5% is considered here because ideally, these benefits from DOTS should be discounted at the social time preference rate (STPR) which is estimated at 5% for India.

The second parameter where we have preferred to consider alternative sets of estimates is the mortality due to TB. There are two usable sets of estimates of the deaths due to TB in the country — having dimensionally very different estimates. Murray and Lopez (1996) estimates of death rates due to TB provide a very high estimate of TB deaths consistent with the old 1955-58 NSS Survey. As against this, the Survey of Causes of Death in 1993 gives a substantially lower mortality due to TB. Since deaths averted at present and in future are very important components of economic benefits of DOTS, we have considered both the sets of estimates as alternatives. We summarise the potential economic benefits of DOTS in India in Table 12.1.

It can be seen from the table that the DOTS strategy to cure TB in India is beneficial even at higher discount rates. As the discount rates increase, the present value of all future economic benefits falls dramatically from 66% of GDP in 1993-94 at a 5% discount rate to only 5% of GDP in 1993-94 at a 16% discount rate with Murray and Lopez estimates of mortality due to TB. More conservative estimates are obtained when we use the Survey of Causes of Deaths estimates of TB mortality. Even with these most conservative estimates of TB mortality, the present value of all future potential economic benefits of DOTS turns out to be about 4% of GDP in 1993-94 at a 16% discount rate.

DOTS is potentially highly beneficial even when we consider extremely high discount rates such as 16%. Even then and with the most conservative set of estimates, the present value of all future potential economic benefits of DOTS to the Indian economy turns out to be at least 3.8% of its GDP in 1993-94 or about Rs.266 billion or USD 8.3 billion in 1993-94. If the present value of the stream of future costs in successfully implementing DOTS works out to anything less than 3.8% of the GDP at factor cost in the country, the effective rate of return from DOTS would be at least 16% in real terms. Since the budget and other managerial inputs required to successfully implement DOTS in India are most likely to be less than 3.8% of GDP, DOTS represents an opportunity to step up India's economic growth in future. (Rough projected costs for successful DOTS implementation throughout India are of the order of 200 million US dollars per year, lower than the benefits of at least USD 750 million per year — *Editor's note*). Moreover, there can be few better examples of a project which offers accelerated growth with significant social justice because its poverty alleviating and equity promoting effects are known to be substantial.

XIII. Benefits of DOTS with gradual coverage of population

As mentioned in the beginning of the Section XII, the estimates of the potential benefits of DOTS presented so far have been derived on the basis of the following two assumptions:

- DOTS can and will succeed in effectively tackling TB in India; and
- Coverage of the population with DOTS is full and instantaneous.

It can be readily seen that the second one is an extreme assumption primarily made to get an idea about the potential benefits DOTS can offer in India. In a geographically large and relatively densely populated country like India, instantaneous coverage of 100% population by any TB cure programme like DOTS may appear to be almost infeasible. This is not only because trained manpower, organisational and management inputs required for such a task must first be generated, but also because such large investments might exceed readily available finances.

TABLE 12.1

Potential economic benefits of DOTS in India (in Rs. Billion)* at 1993-94 prices

Economic Benefits	Discount Rates				
	5%	7%	10%	13%	16%
1-A Reduction in Prevalence of TB in First Year of DOTS	12.30	12.20	12.20	12.20	12.20
1-B Reduction in Prevalence of TB in Subsequent Years	609.91	304.95	174.26	121.98	93.83
Sub-Total (1A+1B)	622.11	317.15	186.46	134.18	106.03
2-A Deaths Averted in the First Year of DOTS – Set A	73.75	59.06	45.34	36.82	31.04
2-B Deaths Averted in the Subsequent Years – Set A	3961.07	1549.30	657.36	362.15	228.01
Sub-Total (2A+2B)	4034.82	1608.36	702.70	398.97	259.05
2-C Deaths Averted in the First Year of DOTS – Set B	43.53	34.55	26.11	20.89	17.40
2-D Deaths Averted in the Subsequent years – Set B	2424.99	943.83	396.06	215.80	134.60
Sub-Total (2C+2D)	2468.52	978.38	422.17	236.69	152.00
3 Release of Hospital Beds	25.96	18.54	12.98	9.98	8.11
Total with Set A (1+2+3)	4682.89 (66.2%)	1944.05 (27.5%)	902.14 (12.8%)	543.13 (7.7%)	373.19 (5.3%)
Total with Set B (1+2+3)	3116.59 (44.1%)	1314.07 (18.6%)	621.61 (8.8%)	380.85 (5.4%)	266.14 (3.8%)

**Rs. 1 Billion = Rs. 100 Crores.*

Notes:

1. Figures in parentheses are percentages to the GDP in the base year 1993-94 at current prices.
2. Set A is based on Murray and Lopez (1996) Mortality Rates.
3. Set B is based on Survey of Causes of Death Mortality estimates.

Source: See the text, Tables 8.2, 10.1 to 10.5 and 11.3.

TABLE 13.1

Economic benefits of DOTS (TB Cure) in India with alternative patterns of coverage (Rs. in billion at 1993-94 prices)

Alternative Phasing Patterns for DOTS	Discount Rates 5%	7%	10%	13%	16%
A) Total Present Discounted Value of Benefits					
1. Instantaneous Coverage	2805 (39.7%)	1183 (16.7%)	559 (7.9%)	343 (4.9%)	240 (3.4%)
2. 5 Year Linear Coverage	2697 (38.1%)	1095 (15.5%)	490 (6.9%)	286 (4.0%)	191 (2.7%)
3. 10 Year Linear Coverage	2507 (35.5%)	998 (14.1%)	420 (5.9%)	232 (3.3%)	14 (2.1%)
4. 15 Year Linear Coverage	2451 (34.7%)	912 (12.9%)	363 (5.1%)	191 (2.7%)	11 (1.7%)
5. 10 Year Non-Linear Coverage*	2603 (36.8%)	1022 (14.5%)	436 (6.2%)	243 (3.4%)	156 (2.2%)
B) Annualized Benefits					
1. Instantaneous Coverage	140 (2%)	83 (1.2%)	56 (0.8%)	46 (0.6%)	38 (0.5%)
2. 5 Year Linear Coverage	135 (1.9%)	77 (1.1%)	49 (0.7%)	37 (0.5%)	31 (0.4%)
3. 10 Year Linear Coverage	125 (1.8%)	70 (1%)	42 (0.6%)	30 (0.4%)	24 (0.3%)
4. 15 Year Linear Coverage	123 (1.7%)	64 (0.9%)	36 (0.5%)	25 (0.4%)	19 (0.3%)
5. 10 Year Non-Linear Coverage*	130 (1.8%)	72 (1%)	44 (0.6%)	32 (0.4%)	25 (0.4%)

**Effective coverage for successive years are 5%, 10%, 15%, 15%, 15%, 10%, 5%, 5%, 5% and 5%.*

Notes:
1. All these calculations are based on the assumption of effective total coverage of 90% of population by DOTS.
2. The benefits are based on more conservative survey of causes of deaths estimates of TB deaths.
3. Figures in parentheses are percentage of Gross Domestic Product in 1993-94 at current prices.
4. The discounting of benefits are done by assuming real growth of 3% p.a. in the labour productivity in the Indian economy over time, and with no growth of TB patients in the "without DOTS" scenario. These are most conservative assumptions.

Source: Calculated by taking Table 12.1 as the base.

In order to guard even more carefully against any possible overstatement of the economic benefits of DOTS, the following steps are taken. Assume that the DOTS services may be able to reach effectively 90% of the population in any unit area unless special efforts are made to reach the last 10%. The hard-to-reach (last) 10% in each area unit is likely to be covered by special augmentation of DOTS efforts to overcome hurdles of varying and often unknown difficulty. Therefore, for all practical purposes, the most conservative estimate of the benefits of DOTS should consider no more than 90% effective coverage in any area unit serviced by DOTS.

We may now consider a few alternative phasing in patterns for DOTS implementation eventually to cover the whole population of India. The important considerations in phasing in of coverage by DOTS are:

- training of the personnel;
- organisational and management inputs needed;
- supply of medicines;
- budget allocation for the programme.

All these concerns get finally translated into the number of years required and the exact distribution of the coverage of the total population. We may consider the following options assuming that 90% of a "covered" population gets effective DOTS services.

- Instantaneous full coverage, i.e., 90% effective coverage in the first year.
- 5 years with 18% effective coverage every year.
- 10 years with 9% effective coverage every year.
- 15 years with 6% effective coverage every year.
- 10 years with effective coverage of 5%, 10%, 15%, 15%, 15%, 10%, 5%, 5%, 5%, and 5% respectively in successive years.

The results are presented at the same five alternative discount rates for these five alternative patterns of coverage of DOTS in India in Table 13.1.

It can be readily observed from the table that phasing in reduces the present discounted value of the benefits at any given discount rate. Similarly, the economic benefits also decline for the given type of phasing in of DOTS implementation as the discount rate rises. ■

References

1. ASCI (1995): *Preliminary Results of Andhra Pradesh Disease Burden & Cost Effectiveness – Annexure VII – Tuberculosis,* Unpublished Study, October 9; pp.44-59.

2. Central Bureau of Health Intelligence (1994): *Health Information of India – 1993,* Ministry of Health and Family Welfare, GOI, New Delhi, December.

3. Central Statistical Organisation (CSO) (1994): National Accounts Statistics 1994, Ministry of Planning, GOI (Regular Publication).

4. Centre for Monitoring Indian Economy (CMIE) (1996): *India's Social Sectors,* Bombay, February.

5. Chakraborty, A.K. (1996): *Prevalence & Incidence of Tuberculous Infection & Disease in India – A Comprehensive Review* (Draft dt. Aug.1996), Unpublished project report sent to WHO, New Delhi.

6. Chakraborty, A.K., Rangan, S., and Uplekar, M. (Eds.) (1995): *Urban Tuberculosis Control – Problems and Prospects,* The Foundation for Research in Community Health (FRCH).

7. Datta, K.K. (1995): "National Tuberculosis Control Programme", in FRHS (1995), pp.1-13.

8. Dholakia, Bakul H. (1974): *The Sources of Economic Growth in India,* Baroda: Good Companions.

9. Dholakia, Bakul H. (1995): "Sources of India's Economic Growth", *IIMA Working Paper No. 1288,* December.

10. Dholakia, Bakul H. (1996): "Functional Distribution of National Income in India", in *Economic and Political Weekly,* Vol.31, No.4, Jan. 27, pp.229-236.

11. Dholakia, Ravindra H. (1993): "Sectoral Targets of the Eighth Plan: Some Implications", in *Economic and Political Weekly,* Vol.28, Nos.32 and 33, August 7-14; pp.1685-1687.

12. Dholakia, Ravindra H. (1993): "Sectoral Targets of the Eighth Plan: Some Implications", in *Economic and Political Weekly,* Vol.28, Nos.32 & 33, August 7-14; pp.1685-1687.

13. Dholakia, Ravindra H., and Oza Ajay N. (1996): *Microeconomics for Management Students,* Delhi: Oxford University Press.

14. Dornbusch R. and Fischer S. (1994): *Macroeconomics,* Sixth Edition, McGraw-Hill Inc.

15. Fellner W. (1967): "Operational Utility: The Theoretical Background and Measurement" in W. Fellner (ed.), *Ten Economic Studies in the Traditions of Irwing Fisher,* New York: J.Wiley.

16. Foundation for Research in Health Systems (1995): *Health Monitor 1995,* Ahmedabad.

17. Indian Council of Medical Research (ICMR): *Tuberculosis in India – A Sample Survey,* 1955-58, Special Series Report No.34, ICMR, New Delhi.

18. International Institute for Population Sciences (IIPS): *National Family Health Survey,* 1992-93; August.

19. Murray, C.J.L. and Lopez, A.D. (eds.) (1994): *Global Comparative Assessments in the Health Sector – Disease Burden, Expenditures and Intervention Packages,* collected Reprints from Bulletin of the WHO, WHO Geneva.

20. Murray, C.J. and Lopez, A.D. (1996): *Global Health Statistics,* Boston: Harvard University Press.

21. Murray, C., Styblo, K. and Rouillon, A. (1993): "Tuberculosis", in *Disease Control Priorities in Developing Countries,* edited by D.T. Jamison, Oxford Medical Publication, Ch.11, pp.233-259.

22. Narayanan, P.R. (1996): *Epidemiological Study of Thiruvallur District,* unpublished study undertaken at Tuberculosis Research Centre (TRC), Madras. Some preliminary estimates were made available through e-mail by Dr. S. Radhakrishna, ORC-TB-India, WHO.

23. National Sample Survey Organisation (NSSO) (1994): "Results on the 4th Annual Survey on Consumer Expenditure & Employment – Unemployment (46th Round), July 1990 – June 1991", in *Sarvekshana,* January-March, 1994.

24. National Tuberculosis Control Programme (1996): "A Summary Statement", Cyclostyled Hand-out pp.1-7.

25. Nayyar, S., Narayang, P., Tyagi, N.K. et al. (1989): *Field Trial of Short Term Intermittent Chemotherapy Against Tuberculosis,* an ICMR project (unpublished) Department of Community Medicine & Department of Microbiology, M.G. Institute of Medical Sciences, Sevaram Wardha, pp.1-325.

26. Planning Commission (1952): *First Five Year Plan,* New Delhi.

27. Ramana, G.N.V. (1996): "Model Scenario: Tuberculosis", A part of Unpublished Study on *Technology Forecast* sponsored by TIFAC, Department of Science & Technology.

28. Ramana, G.N.V. (1996): "Reply to Querries by Fax", Administrative Staff College of India (ASCI) Fax of Sept.12.

29. Rangan, Sheela (1995): "User Perspective in Urban Tuberculosis Control", in Chakraborty et al. (1995); pp.97-106.

30. Registrar General: *Census of India 1971 Series – India Part VII (i): Degree Holders and Technical Personnel Special Tables G-I to G-IV,* GOI, New Delhi.

31. Registrar General of India (1991): *Vital Statistics of India 1987,* Ministry of Home Affairs, New Delhi.

32. Solow, R.W. (1958): "Technical Change and the Aggregate Production Function", *Review of Economics & Statistics,* August.

33. Sundar, R. (1995): *Household Survey of Health Care Utilization and Expenditure,* National Council of Applied Economic Research, Working Paper No.53, March.

34. Tiwari, D.D. and Pandey, I.M. (1993): "An Estimation of Social Time Preference Rate for India and Its Public Policy Implications", *Indian Journal of Economics,* Vol. LXXIV, pt.I, No.292, July pp.61-75.

35. Uplekar, M. and Rangan, S. (1996): *Tackling TB – The Search for Solutions,* FRCH.

36. Visaria, P., Gumber A. and Jacob, P. (1994): *Tuberculosis in India, 1986-87 – An Analysis of Data for Five States,* Unpublished Monograph, Gujarat Institute of Development Research, Ahmedabad, pp.1-57.

37. Vital Statistics Division (1994): *Survey of Causes of Death (Rural) India – Annual Report 1993,* Series 3, No. 26, Ministry of Home Affairs.

38. World Bank (1993): *World Development Report 1993 – Investing in Health,* Oxford University Press.

39. World Bank (1995): *India – Policy and Finance Strategies for Strengthening Primary Health Care Services,* Report No.13042-IN, May 15.

Appendix I:

The methodology can be described through symbols as follows:

Let P_i, U_i and R_i be the average labour productivity in the i-th sector in the whole economy, urban area and rural area respectively; and u_i and r_i be the proportion of workers in the i-th sector in urban and rural areas respectively. Then,

$$P_i = u_i U_i + r_i R_i \text{ and if } U_i / R_i = \propto_i \text{ then,}$$
$$R_i = P_i / (\propto_i u_i + r_i) \text{ and } U_i = \propto_i P_i / (\propto_i u_i + r_i)$$

Estimates of P_i, $\propto_i$, u_i and r_i are available as described in the text. Hence, estimates of U_i and R_i are obtained. Multiplying these productivities with respective workers, we can get the respective income estimates.

Appendix 2:

The methodology for estimating the average labour productivity for child and adult workers by sector and area is as follows: (see Table 4.2).

Let P_i, C_i and A_i be the average productivities of all workers, child workers and adult workers in the i-th sector of the given area respectively; and c_i and a_i be the proportion of workers in the i-th sector of the given area belonging to the age groups 5-14 years and 15+ years respectively. Then,

$$P_i = c_i C_i + a_i A_i \text{ and } C_i = (1/3)\, P_i \text{ by assumption.}$$
$$\therefore \phi 0 \; A_i = P_i (3 - c_i)/3a_i$$

Estimates of P_i, c_i and a_i are available from Table 4.1 and Table 3.2.

Appendix 3:

The methodology is for calculating the productivity of young and old adult workers (see Table 4.3) as follows:

Let A_i, Y_i and O_i be the average productivities of respectively the adult (15+ age) workers, young adult (15-44 age) workers and old adults (45+ age) workers in the i-th sector of the given area and y_i and o_i be the proportion of workers respectively in the young and old adult workers in the i-th sector of the given area. Then,

$$A_i = y_i Y_i + o_i O_i \text{ and } O_i = 1.76 Y_i;$$
as described in the text.

$$\therefore \phi 0 \; \Psi_i = A_i/(y_i + o_i * 1.76) \text{ and } O_i = 1.76\, A_i/(y_i + o_i * 1.76)$$

Estimates of A_i, y_i and o_i are available from Table 4.2 and Table 3.2.

Appendix 4:

The methodology used to calculate the productivities by sex, sector, age group and rural/urban residence is as follows:

Let YP_i, YM_i and YF_i be the average productivities of respectively the young adult (15-44 age) workers, young adult male workers and young adult female workers in the i-th sector of the given area; and ym_i and yf_i be the proportion of young male and female workers in the i-th sector of the given area. Then,

$$YP_i = ym_i\, YM_i + yf_i\, YF_i \text{ and } YM_i = 1.28 * YF_i$$

as described in the text.

$$\therefore \phi 0\ \Psi\Phi_i = YP_i/(1.28\, ym_i + yf_i) \text{ and } YM_i = 1.28\ YP_i/(1.28\, ym_i + yf_i)$$

Similarly, we get,

$$OP_i = om_i\, OM_i + of_i\, OF_i \text{ and } OM_i = 1.41 * OF_i$$

as described in the text.

$$\therefore \phi 0\ O\Phi_i = OP_i/(1.41 * om_i + of_i) \text{ and } OM_i = 1.41 * OP_i/(1.41 * OM_i + of_i)$$

Estimates of YP_i, ym_i, yf_i, OP_i, om_i and of_i are available from Table 4.3 and Table 3.2.

Endnotes

1. Since the higher the prevalence of TB the greater the predicted benefits of the DOTS strategy, the lowest estimate of prevalence of TB is used for the most conservative estimate.

2. Actually the summation of the two would provide an upper limit to the average age of death occurring currently. Thus, this is a conservative assumption to estimate the benefits of DOTS due to deaths averted.

3. We have made calculations at these effective rates of discount. The advantage is that the calculations and the numbers do not change if we change our assumptions about the growth of labour productivity and/or the growth in the TB cases and TB deaths in future. Thus, if it is assumed that labour productivity would grow at 3% p.a. and TB deaths at 1% p.a., the rates of discount corresponding to our effective rates of discount would be 6%, 8%, 11%, 14% and 17%, and so on.

4. The costs of TB cure to the society would include the expenditures incurred by the patients and the expenditures with subsidies by the government and non-government sectors on TB cure. The consistent costing exercise would consider only additional costs "with DOTS" over "without DOTS" scenario just as the benefits of DOTS are estimated in the present study in terms of additional benefits "with DOTS" over "without DOTS".

5. The weights for rural areas and urban areas are taken as 0.7 and 0.3 respectively as per the cases of hospitalization reported by Visaria et al. (1994) pp.4.

6. A discount rate of 16% is taken here because the implied economic rate of return in the VIII Plan estimates for achieving the growth rate of 5.6% during the Plan period was 16%. For details of calculations and implications, see Dholakia, Ravindra H. (1993).

This is essentially the estimate of the "expected" social rate of return on capital in India. Thus, the discount rates considered here are in the range of social time preference rates and social rate of return on capital in India.

List of Tables

9 **Table 3.1:** Projected population of India (in '000) as on 1st October, 1993

10 **Table 3.2:** Estimates of workers (in '000) in India in 1993-94

11 **Table 4.1:** Estimates of labour productives and GDP at factor cost at current prices by rural-urban areas in India, 1993-94

11 **Table 4.2:** Estimates of labour productivity in India 1993-94, at current prices by rural-urban areas in India, 1993-93

12 **Table 4.3:** Estimates of labour productivity in 1993-94 at current prices of young and old adult workers in India

12 **Table 4.4:** Estimates of labour productivity in 1993-94 at current prices of male and female workers by age and area in India

13 **Table 4.5:** Estimates of GDP in India in 1993-94 classified by age, sex, sector and area

14 **Table 5.1:** Pulmonary TB – importance in mortality in rural India

14 **Table 5.2:** Pulmonary TB – relative importance in mortality by regions in (Rural) India, 1992 and 1993

15 **Table 5.3:** Age-sex-distribution of reported deaths due to pulmonary TB in rural India, 1993

15 **Table 5.4:** Estimates of deaths due to TB in India by age-sex and residence

16 **Table 5.5:** Alternative estimates of deaths due to TB in India by age and sex, 1993-94

17 **Table 6.1:** Prevalence of pulmonary TB in India, 1993-94 – Murray and Lopez (1996) estimates

17 **Table 6.2:** Prevalence of pulmonary TB in India, 1993-94 – NFHS estimates

17 **Table 6.3:** Prevalence of pulmonary TB in India, 1993-94 – ASCI (1996) estimates

18 **Table 6.4:** Prevalence of pulmonary TB in India, 1993-94, – TRC estimates (based on culture test)

18 **Table 6.5:** Prevalence of pulmonary TB in India by rural-urban residence, sex and age in 1993-94

19 **Table 7.1:** Estimates of worker population ratio in India, 1993-94

19 **Table 7.2:** Estimates of workers with pulmonary TB in India, 1993-94

20 **Table 8.1:** Increase in average productivity of labour in India due to DOTS

21 **Table 8.2:** Increase in GDP in India due to reduction in prevalence by DOTS in the first year

22 **Table 9.1:** Average age at death due to TB in 1993-94 in India

22 **Table 9.2:** Worker population ratio for aggregate age groups by sex and area in India, 1993-94

22 **Table 9.3:** Deaths averted by DOTS in India, 1993-94 – Set A

24 **Table 9.4:** Deaths averted by DOTS in India, 1993-94 – Set B

24 **Table 9.5:** Future workers among the deaths averted by DOTS in India, 1993-94 – Set A

24 **Table 9.6:** Future workers among the deaths averted by DOTS in India, 1993-94 – Set B

25 **Table 9.7:** Estimates of marginal product of labour by age-sex-residence in India, 1993-94 at current prices

26 **Table 10.1:** Discounted present value of gains out of deaths averted in the first year due to DOTS – Set A

27 **Table 10.2:** Discounted present value of gains out of deaths averted in the second and subsequent years due to DOTS – Set A

28 **Table 10.3:** Discounted present value of gains out of deaths averted in the first year due to DOTS – Set B

30 **Table 10.4:**
Discounted present value of gains out of deaths averted in the second and subsequent years due to DOTS – Set B

34 **Table 10.5:**
Discounted present value of future increase in GDP in India due to reduction in prevalence by DOTS

35 **Table 11.1:**
Proportion of public and private hospitalisation by TB patients, 1986-87

35 **Table 11.2:**
Average amount per day paid to the private hospitals by the TB patients for hospitalisation

36 **Table 11.3:**
Present discounted value of the benefits of DOTS in terms of hospital beds released

38 **Table 12.1:**
Potential economic benefits of DOTS in India (in Rs. Billion) at 1993-94 prices

39 **Table 13.1:**
Economic benefits of DOTS (TB Cure) in India with alternative patterns of coverage (Rs. in billion at 1993-94 prices)

List of Abbreviations

ASCI	Administrative Staff College of India
CSO	Central Statistical Organisation
DOTS	Directly Observed Treatment, Short-course
GDP	Gross Domestic Product
GTB	Global TB Programme
IIPS	International Institute for Population Sciences
NSS	National Sample Survey
NCAER	National Council of Applied Economic Research
NFHS	National Family Health Survey
NDP	Net Domestic Product
NGO	Non-government Organisation (PVO)
NSS	National Sample Survey
NTI	National Tuberculosis Institute, Bangalore
NTP	National Tuberculosis Programme
PVO	Private Voluntary Organisation (NGO)
RS	Indian Rupees
SCC	Short-course Chemotherapy
SCD	Survey of Causes of Death
SRRC	Social Rate of Return on Capital
SRS	Sample Registration System
STPR	Social Time Preference Rate
TB	Tuberculosis
TRC	Tuberculosis Research Center, Madras
WHO	World Health Organisation
WPR	Worker Population Ratio
USD	United States Dollars

Notes