# MEASURING THE BURDEN OF TUBERCULOSIS IN SOUTH AFRICA USING THE DISABILITY-ADJUSTED LIFE YEAR


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## Background

In order to identify priorities in health and allocate resources, knowledge of the scale of health problems is required. A new indicator, the Disability Adjusted Life Year (DALY), which incorporates one set of information that is both mortality and morbidity, was developed to measure the global burden of disease (GBD) for the World Bank. National burden of disease studies, using the DALY as the unit of measure, are being promoted and a project is currently under way in South Africa. This study attempted to derive a set of consistent estimates for mortality and morbidity due to tuberculosis and to calculate the burden of tuberculosis using the DALY. It has served as a pilot for the South African national burden of disease study.

## Methods

The burden of tuberculosis in South Africa for 1990 was measured using the DALY. Best estimates of tuberculosis incidence, mortality, case fatality, duration of disease and age of onset of disease or death were made using the global burden of disease methodology. This involved a review of available tuberculosis epidemiological data, selection of internally consistent epidemiological estimates using an expert panel review and a model of disease process, and finally the calculation of Years lived with Disability (YLDs), Years of life Lost (YLLs) and Disability Adjusted Life Years (DALYs) lost due to tuberculosis.

## Results

The burden of tuberculosis in South Africa in 1990 was estimated to be 410107 DALYs. This was mainly due to premature mortality, with Years of Life Lost (YLLS) accounting for 95% of the total burden. As expected, large differences in the burden of tuberculosis were found between population groups, highlighting the inequalities of the apartheid era. Males accounted for almost 70% of the total burden of tuberculosis. Sensitivity analysis demonstrated the negligible effect of age weighting and discounting on the burden of tuberculosis results. While the quality of tuberculosis surveillance data and vital registration data in South Africa are problematic, a surprising degree of coherence between the best estimates for tuberculosis mortality and incidence could be achieved.

## Discussion

Tuberculosis morbidity contributed very little to the burden of tuberculosis in South Africa in 1990, in comparison with GBD results. The reasons for this are unclear. Males contributed twice as much

to the burden of tuberculosis as females. This contrasts with the GBD findings for sub-Saharan Africa where females contributed slightly more than males (53%) to the burden of tuberculosis. This is probably partly due to the HIV/AIDS epidemic being more advanced in areas north of South Africa in 1990. One of the main problems facing burden of disease studies in developing countries is the lack of good quality health data. However, conducting a burden of disease study in a country like South Africa, could provide the stimulus and process whereby the quality and use of health information can be substantially improved.

# 1. INTRODUCTION

## 1.1. Background

The formulation of priorities for the allocation of health resources is becoming increasingly important for health policy makers (Janovsky 1996). The gap between the resources allocated for health care and the demand is growing. This has been exacerbated by increases in life expectancy, advances in technology and stagnation in public spending (Ham 1996). Objective, comparable and reliable information on health status is essential for setting health priorities (Murray 1996). In order to allocate public health resources appropriately, information on the interventions available to address priority health problems, their costs and their effectiveness, is also required (Murray 1996; Bobadilla 1996).

Health status has traditionally been assessed in terms of mortality. However, with increasing life expectancies it has become more important to include assessments of morbidity. During the past few decades, extensive work has been done on the measurement of non-fatal health outcomes. Some of this work has attempted to develop time-based measures of health status that combine information on mortality and morbidity. The development of the disability-adjusted life year (DALY) is the latest step in this process (Murray 1994; Murray 1996). The DALY is a measure of the time lost due to both premature death and disability, adjusted by a discounting and an age-weighting function. It was developed as the measure of health status for the Global Burden of Disease Study (GBD) which was commissioned by the World Bank and World Health Organization in 1992 (World Bank 1993). Despite the fact that much of the data required for calculating the DALY were not available and estimates had to be used, the findings of this study have provided the first comprehensive picture of current health needs in the world. This has contributed much to the current debate on setting global health priorities within the health sector. One of the consequences of this study has been the promotion of national burden of disease studies, in order to improve the quality of data on health status. This will enable the accuracy of future global burden of disease estimates to be improved.

The DALY has been used to measure the burden of disease due to specific diseases and certain risk factors (Murray 1996) as well as the outcome in cost effectiveness analyses (Jamison et al. 1993). A common unit for burden of disease and cost effectiveness allows for comparisons between interventions for different diseases and programs. This is extremely useful when considering the allocation of resources within the health sector.

## 1.2. Rationale and significance of this study

South Africa has recently undergone major political change. In 1994, the first democratically elected government came into power. The new government has committed itself to redressing the inequalities of the apartheid system. In the health sector, the aim is to provide a free comprehensive primary health care system for the whole population. As a result, the South African health system is currently undergoing reform and redefining priorities in health. In order to identify priorities in health and allocate resources, knowledge of the scale of health problems is required. The rationale for estimating the burden of disease using the DALY has been briefly discussed above. A project is currently being developed in South Africa to review the available epidemiological data and estimate the national burden of disease using the DALY. This is being piloted through calculating the DALY for three selected conditions, one of which is tuberculosis. These pilot studies have provided valuable information on the feasibility of the South African burden of disease study.

Tuberculosis accounts for a large burden of disease in South Africa. However, the accuracy of national statistics for the epidemiological indices of tuberculosis has been widely questioned. The process of this study has provided health policy makers and tuberculosis experts in the country with an opportunity to review the available epidemiological data for tuberculosis, check the consistency of the data from various sources, and identify gaps and areas requiring improvement. It has also provided a similar opportunity with regard to the available demographic data. In addition, the calculations of the DALY for tuberculosis in South Africa by population group, sex and age have been useful in identifying groups carrying the largest burden of tuberculosis, and assessing the contribution of morbidity to the overall burden of tuberculosis.

## 1.3. Statement of the problem

The setting of health priorities requires, amongst other things, a comprehensive assessment of health status. The results of the GBD have shown that morbidity contributes significantly to the burden of disease (Murray 1996). The burden of disease in South Africa is not known. Tuberculosis is a major source of morbidity and mortality in South Africa, yet the extent of this problem is not accurately known. A South African national burden of disease study is currently being planned. This study served as a pilot for the planned national burden of disease study. The purpose of this study was to review the available tuberculosis epidemiological data, and measure the burden of tuberculosis in

South Africa in 1990, using the DALY methodology. This is one of the first attempts to quantify the burden of tuberculosis in terms of both mortality and morbidity in South Africa.

## 1.4. Research question

This study has attempted to answer the question "What is the burden of tuberculosis measured in DALYs, in South Africa in 1990". The contribution made by tuberculosis morbidity is of particular interest.

## 1.5. Definitions

**Burden of disease (BOD):** refers to a quantification of the burden of disease and injury in human populations using a unit of measure for health outcomes

**Disability-adjusted life year (DALY):** a new measure of health status or burden of disease that incorporates mortality (years of life lost) and morbidity (years lived with disability) and is adjusted by an age weighting and discounting function

**Years of life lost (YLL):** years of life lost due to premature mortality i.e. the difference between a selected life expectancy and age at death.

**Years of life lived with disability (YLD):** time lived in a health state of less than perfect health and weighted for the severity of the health state

**Age weighting:** assigning a greater value to a year of life lived at certain ages

**Discounting:** assigning a lower value to years lived in the future

**Case fatality rate (CFR):** $$\text{CFR} = \frac{\text{Number of deaths from a disease (in a given period)}}{\text{Number of diagnosed cases of that disease (in same period)}} \times 100$$

## 1.6. Ethical statement

This study made use of secondary data so patient confidentiality was not compromised. The protocol for this study was approved by the Medical Research Council Ethics Committee on 17 June 1998 (see appendix 1).

# 2. LITERATURE REVIEW

This section reviews the following: recent developments in measuring health status culminating in the DALY, a description of the DALY, a brief summary of the GBD study, the experience with application of the burden of disease methodology at national level, and an overview of the tuberculosis epidemic in South Africa.

## 2.1. Measuring health status

The health status of populations has traditionally been assessed in terms of mortality with little attention being paid to morbidity. Commonly used indicators of mortality include crude or age-standardized death rates with much importance being given to infant and child mortality rates. The concept of measuring the time lost due to mortality rather than death-rates was introduced in the late 1940's (Murray 1994). Since then various methods for measuring years of life lost have been proposed. Murray has summarized these and introduced terms to clarify the different methods of calculation (Murray 1994).

Disease-specific measures of morbidity have been used since the nineteenth century. Attempts to develop more general measures of non-fatal health outcomes that are commensurate with time lost due to premature mortality were commenced in the 1960s (Sullivan 1971). Composite indicators, that incorporate losses due to disability and premature mortality, have been developed as measures of disease burden and outcome indicators for health status in economic analyses (Morrow and Bryant 1995). These include quality-adjusted life years (QALYs), health-adjusted life expectancies, amount of healthy life lost and DALYs, see Table 1.

The quality-adjusted life year (QALY) is the equivalent number of years of full health that a series of years spent in less than perfect health represent, according to individual's expressed preferences (Goerdt et al. 1996). QALYs have mainly been used at an individual level to measure health gained from a health intervention in cost-utility analyses (Goerdt et al. 1996; Torrance 1986). The health gained is a combination of the survival time and health-related quality of life for that period. Since a common unit of measure is used in cost-utility analyses, QALYs gained; it should allow comparisons across all programs. However, in practice, study methods have differed and preference weights are not always consistent, making comparisons difficult (Torrance 1986). Controversy exists over which

group (health providers, public, persons with disabilities or their families) is most appropriate to derive utility weights for QALY type indicators (Goerdt et al. 1996).

The Ghana Health Assessment Project was the first effort to evaluate the burden of disease due to disability and premature mortality by cause in an entire population (Ghana health assessment project 1981). The aim was to assist with resource allocation decisions within the health sector. Healthy days of life lost from disability and premature mortality were used to measure disease impact and gains from particular health interventions. However, the methods for defining, measuring and weighting disability in this study were not well described.

## 2.2. The Disability-adjusted life year (DALY)

The DALY is a measure of the time lost due to premature death and disability, adjusted by both a discounting and an age-weighting function. This measure was developed both to quantify and compare relative burdens among different diseases and among different populations and also to analyze the cost-effectiveness of health interventions (Murray 1994; Murray 1996). It builds upon the preceding work on composite health indicators summarized above. It is a type of QALY, which has been standardized for comparative purposes. However, where a QALY generally refers to a healthy life year gained, the DALY refers to a healthy life year lost (Murray and Acharya 1997). In contrast to the Ghana approach to disability, a standardized method for defining, measuring and weighting disability was developed for use in DALY calculations. Health-adjusted life expectancy measures cannot easily be used to disaggregate the burden of disease into component causes, in order to target interventions. The DALY methodology, however, is used to measure the burden of disease disaggregated into component biological causes and risk factors. It can also be used for cost-effectiveness analysis of health interventions.

The DALY is based upon the following principles:

- any health outcome which represents a loss of welfare should be included;
- age and sex are the only individual characteristics included in the set of variables used to calculate the DALY;
- like health outcomes are treated as like, irrespective of where or to whom they occur.

In contrast to previous composite health indicators some important social preferences or values are incorporated into the DALY (Murray 1994; Murray 1996). These include value choices for:

- **the duration of life lost due to premature mortality** – the highest observed national life expectancy has been chosen as the standard, in order to ensure equity and comparability across countries. A model life table, Coale and Demeny West Level 26, with a life expectancy at birth of 82.5 years for females was selected. An arbitrary biological difference of life expectancy at birth of 2.5 years was chosen. Thus the standard life expectancy at birth for males was 80 years.
- **the comparison of time lived with disability with time lost due to premature death** - a set of weights for time spent in different health states is required. The person trade-off (PTO) method was used to define, measure and value disabilities for the latest estimates of the GBD (Murray 1996).
- **discounting future health** – this reflects the concept that people prefer benefits now rather than sometime in the future. A discount rate of 3% per year was selected for the GBD.
- **age weighting** - a continuous age-weighting function which assigns a greater value to a year of life lived in a young or middle aged adult versus the very young or elderly, is included in the DALY formula.
- **equity and DALYs** - the DALY is considered the same in all settings. Thus, no distributional preferences for benefits across individuals, age groups or socioeconomic groups are incorporated into the calculations of burden of disease.

**Formulae for Years of Life Lost (YLLs), Years of Life with Disability (YLDs) and DALYs**

The DALYs from any given condition *i* are simply the sum of YLLs and YLDs from that condition:

$$\mathbf{DALY_i = YLL_i + YLD_i}$$

As discussed above, Years of Life Lost (YLLs) are calculated using standard expected years of life lost. The standard used is a model life-table, namely Coale and Demeny West Level 26, which has been described above. An exponential function of the form $Cxe^{-\beta x}$ has been used to value time lived at different ages. A continuous discounting function of the form $e^{-rt}$ has been used where $r$ is the discount rate and $t$ is time. A parameter $K$ has been included which can be used in sensitivity analysis to remove non-uniform age weights. The general formula for calculating YLLs is:

$$YLLs = \frac{KCe^{ra}}{(r+\beta)^2}\left[e^{-(r+\beta)(L+a)}\left[-(r+\beta)(L+a) - 1\right] - e^{-(r+\beta)a}\left[-(r+\beta)a - 1\right]\right] + \frac{1-K}{r}\left(1 - e^{-rL}\right)$$

where $r$ is the discount rate, $\beta$ is the parameter from the age weighting function, $K$ is the age weighting modulating factor, $C$ is a constant, $a$ is the age at death and $L$ is the standard expectation of life at age $a$. For the GBD study, $r$ is 0.03, $\beta$ is 0.04, $K$ is 1, and $C$ is 0.1658. For calculating YLLs with uniform age weighting $K$ is set to 0. To calculate the number of YLLs lost to a specific

condition, the number of YLLs lost per death at each age must be multiplied by the number of deaths due to that condition at each age, and then summed across all ages.

In the formula for Years Lived with Disability (YLDs), a disability weight for each condition is added and $a$ and $L$ take on different meanings. The formula for YLDs from a single disabling event is:

$$YLDs = D\{\frac{KCe^{ra}}{(r+\beta)^2}\ [e^{-(r+\beta)(L+a)}\ [-(r+\beta)(L+a) - 1] - e^{-(r+\beta)a}\ [-(r+\beta)a - 1]] + \frac{1-K}{r}(1 - e^{-rL})\}$$

where $D$ is the disability weight for a particular condition, $a$ is the age of onset of disability, $L$ is the duration of disability, and the other the parameters are exactly the same as for YLLs. The number of YLDs lost per incident case must be multiplied by the number of incident cases, in order to calculate the number of YLDs lost to a condition.

## 2.3. Global burden of disease study (GBD)

The DALY was developed for the Global Burden of Disease study (GBD). The GBD was designed to address three goals: 'to provide information on non-fatal health outcomes for debates on international health policy, which are usually focused on mortality; to develop unbiased epidemiological assessments for major disorders; and to quantify the burden of disease with a measure that could also be used for cost-effectiveness analysis.', (Murray and Lopez 1997a). This study assessed the global burden of disease for 107 disorders and the burden attributable to 10 major risk factors, using the DALY. Assessments were made for the following eight geographic regions: established market economies (EME), formerly socialist economies of Europe (FSE), Latin America and the Caribbean (LAC), China (CHN), India (IND), middle eastern crescent (MEC), other Asia and islands (OAI) and sub-Saharan Africa (SSA). Expert panels were set up to review available epidemiological data and to decide on the most plausible estimates for calculating the DALY. The consistency of epidemiological data from different sources was assessed using an incidence/prevalence/mortality model (DISMOD) developed for the GBD by Harvard University (Murray 1996).

The results of this study clearly demonstrate the huge differentials in the burden of disease between the developed and underdeveloped countries (Murray and Lopez 1996). In 1990, these ranged from 124 DALYs per 1000 population in the Established Market Economies (EME) to 574 DALYs per 1000 in Sub Saharan Africa (SSA). It also demonstrates that communicable diseases persist as a problem for the whole world, non-communicable diseases account for a significant proportion of the

burden in developing countries, and injuries are a large health problem in all regions. Disability accounts for 34% of the burden of disease. The rank order of conditions changes when disability is included in the disease burden, with mental health problems emerging as a major contributor to the burden of disease, despite being a relatively small cause of mortality (Murray and Lopez 1996).

## 2.4. National burden of disease studies

Mexico was the first country to conduct a national assessment of burden of disease using the DALY (Lozano et al. 1995). This study again demonstrates the large increase in disease burden (42%) when disability is included with mortality. It also shows interesting differences in the ranking of diseases according to three different indicators: mortality rates, potential years of life lost (PYLL) and DALYs. The results of this study made an important contribution to the health policy debate in Mexico. The authors conclude that the DALY is not intended as a substitute for indicators frequently used to assess the health of populations but rather to supplement them. A study of the burden of disease in the South and West region of England also shows that disability accounts for 48% of the burden of disease and changes the ranking of diseases according to mortality alone (Bowie et al 1997). Mental disorders move up in the rankings. The authors conclude that the DALY may be a useful tool for health authorities in established market economies (EME). A number of other countries have or are currently undertaking national burden of disease assessments (Bobadilla and Cowley 1995). The main problems with attempting a BOD study in middle or low income countries are the weak information bases on disability for most diseases, and the poor information on the efficacy and effectiveness of interventions to control non-communicable diseases and injuries (Bobadilla and Cowley 1995).

## 2.5. Critique of the DALY

The DALY has attracted much comment in the published literature. The supporters of this indicator have generally commended it for

- providing a single indicator of both morbidity and mortality using a time measure, thus enabling comparisons between disease conditions, specific diseases and between health outcomes from health interventions (Bobadilla 1996)
- providing a rational system for defining burden of disease and evaluating interventions and public health programs and thus guiding appropriate resource allocations (Foege 1994; Morrow and Bryant 1995)

- demonstrating that disability contributes substantially to the burden of disease and may change the ranking of diseases based on mortality alone (Lozano et al. 1995; Bowie et al. 1997)

In addition, other benefits and potential benefits have been identified. The development and use of the DALY has stimulated a discussion of health priorities and the empirical basis for these priorities amongst a broad range of experts (Lozano et al. 1995; Morrow and Bryant 1995; Barker and Green 1996). Deficiencies in existing health information systems have been identified, and health care providers have been brought into the debate on health reform (Lozano et al. 1995). The use of the DALY will highlight the importance of basic epidemiological data and promote attempts at interpreting available data (Bradshaw 1996).

Criticism of the DALY can be divided into three main areas namely, the social preferences incorporated into the indicator, the utility of the DALY for resource allocation and practical application of the DALY methodology. Criticism has focused mainly on the social preferences incorporated into this indicator namely, the age weighting, disability weights and discounting functions. It is argued that the DALY imposes social preferences that were selected by a poorly defined, unrepresentative group of experts (Barker and Green 1996; Anand and Hanson 1997), have not been validated (ACHR 1996) and need to be tested at local level (Morrow and Bryant 1995; Black and McLarty 1996). Murray (1996), argues that current practice in setting health priorities, using mortality and particularly infant mortality information, imposes an equivalent set of implicit values. He has attempted to make the values used in the DALY explicit, and thus open to discussion. Bobadilla (1996), suggests that, whilst more research is required on the social preferences, criticism of these preferences does not detract from the usefulness of the DALY as a single indicator of morbidity and mortality.

Many critics, and even some supporters of the DALY, feel that it is ethically unacceptable to value time lived at different ages differently and that the chosen age weightings do not reflect common preferences (Lancet 1993; Barker and Green 1996; Anand and Hanson 1997; Morrow and Bryant 1995; Bowie et al. 1997; Werner and Sanders 1997). Murray argues that given the different roles and changing levels of dependency with age, it is appropriate to consider valuing the time lived at a particular age unequally. He supports this argument with various studies of the relative valuations of a death at each age, which appear to assign greater importance to preventing deaths or disability in young adults and adolescents than of the very young or elderly (Murray 1996). He also suggests that the current practice of focusing on child mortality for setting health priorities, implicitly places a higher value on time lived during childhood. He also argues that the DALY does not discriminate on

the basis of age because each person's life is considered through all the age ranges. The DALY formula does, however, include a parameter *K*, which can easily be used to remove non-uniform age weights.

The discounting of future life is also questioned on ethical grounds (Lancet 1993; Anand and Hanson 1997; ACHR 1996), and it is felt that this compounds the effects of age weighting (Anand and Hanson 1997). Murray presents a wide array of arguments for and against discounting, and acknowledges that this issue is not easily resolved. While he does choose to include a low discount rate of 3% in the DALY measure, both the DALYs with and without discounting are published in the latest estimates (Murray 1996).

Different cultures or social groups perceive and experience health and disability differently. Many critics feel that it is thus unlikely that agreement on a common definition of disability, as required by the DALY, could be achieved (Ugalde and Jackson 1995; ACHR 1996; Sayers and Fliedner 1997). Various methods for measuring health state preferences have been proposed (Torrance 1986). However, as Morrow and Bryant (1995) point out, developing common measures of disability is not an easy task. Disability has many dimensions including pain, discomfort, physical dysfunction, emotional distress, loss of dignity, amongst others. Murray believes that if these measures are to be used to inform social choices they must be based upon a deliberative process where individuals are faced with the policy consequences of their value choices. For this reason, a measurement protocol based on the person-trade-off approach was developed to investigate variation in preferences for time spent in different health states, for the GBD. He acknowledges that further work on health state preferences is required. However, he argues that uncertainty about basic epidemiological parameters, e.g. incidence or mortality rates, is a far greater determinant of uncertainty in DALY estimates than variation in disability weights for a given condition (Murray and Lopez 1997b).

With regard to resource allocation, the objective is to minimize DALY loss. There is concern that using the DALY in its current formulation will lead to inequitable resource allocation (Barker and Green 1996; ACHR 1996; Anand and Hanson 1997; Sayers and Fliedner 1997). In particular, it is felt that the young and the elderly, lower socioeconomic groups and the disabled will be disadvantaged. The debate on age weighting has been summarized above. Some authors feel that variables such as income and socioeconomic status should be included in the DALY to ensure equitable resource allocation (ACHR 1996; Anand and Hanson 1997; Sayers and Fliedner 1997). Murray feels that this implies valuing a life-year as more or less important based on the income status

of the individual, which he finds ethically unacceptable (Murray 1996). He argues that describing the patterns of burden in different socioeconomic groups will help describe the extent of inequity, without having to incorporate this in the calculation of burden of disease. The handling of the disabled is more problematic. As Anand and Hanson (1997) have pointed out '[T]he DALYs prevented by an intervention which extends the life of a disabled person will be less than those prevented for an able-bodied person'. This implies that more resources should be allocated to healthy people than to disabled people. Murray argues that existing practice in organ donor banks and available preference measurements supports this view, and suggests that individuals prefer to extend the life of healthy individuals rather than those in less than perfect health (Murray and Acharya 1997).

The practical application of the DALY methodology for the GBD has raised further concern in the literature. Some authors have pointed out that much of the good quality data required for the DALY are not available and estimates or modeling have had to be used (ACHR 1996). This is often a problem in developing countries, where resources and technical expertise are lacking. Some authors have questioned whether the expense of a national burden of disease study is justified in such countries (Barker and Green 1996). However, they do suggest that if one could get a clearer picture of the gap between basic health needs and resources available, this could be a positive step in securing more funding for health. Others feel that attempts to estimate the burden of disease in developing countries will highlight the importance of basic epidemiological data, promote the use and development of alternative methods (e.g. verbal autopsy and sentinel surveillance) for collecting it, and promote interpretation of available data. These are all valuable public health developments in their own right (Bradshaw 1996).

In addition to the above, there are concerns that information on regional heterogeneity may be suppressed in the aggregation of data required for the DALY (Sayers and Fliedner 1997). Some authors feel that these factors limit the usefulness of the burden of disease results for resource allocation decisions (ACHR 1996; Sayers et al. 1997). Interestingly, the Mexican National Burden of Disease study undertook the analysis of burden of disease separately for 32 states. Within each state urban and rural areas were analyzed separately (Lozano et al. 1995). This enabled regional heterogeneity to be taken into account when setting health priorities for the country.

## 2.6. Tuberculosis in South Africa

Tuberculosis is a major contributor to the burden of disease in South Africa. According to a recent WHO report, South Africa ranked twelfth amongst the 22 countries with the highest tuberculosis burdens in the world in 1996 contributing 1.4% of all tuberculosis cases globally (Global Tuberculosis Programme, WHO 1998). A joint review of the South African TB programme, conducted by the WHO and the government in June 1996, noted that South Africa had one of the highest annual tuberculosis incidence rates in the world (Department of Health, South Africa and WHO 1996). Despite an annual expenditure of approximately R 500 million on tuberculosis control the situation is not improving. Multi-drug resistance is emerging and notification rates are rising. These factors coupled with the growing HIV epidemic have the potential to create a very serious situation indeed. For these reasons, tuberculosis was declared a 'provincial emergency' in the Western Cape province and a national priority in South Africa, during 1997.

Tuberculosis accounts for approximately 80% of communicable disease notifications to the Department of Health (Department of National Health and Population Development 1993), with approximately 80 000 cases notified in 1990 (Department of National Health and Population Development 1995). An analysis of mortality in South Africa for 1990, ranked tuberculosis as the seventh largest cause of death and identified it as a public health priority (Bradshaw et al. 1995). The national notification rate reported in 1990 was 216 per 100 000. However, great variation in notification rates is observed among population groups and geographical regions, reflecting the inequalities of the apartheid era. For example, notification rates per 100 000 ranged from 17 in Whites and 59 in Asians to 211 in Africans and 603 in Coloureds in 1990 (Department of National Health and Population development 1995). Reported notification rates varied from 778 per 100 000 for the Western Cape to 66 per 100 000 for the Northern Transvaal in 1990 (Department of National health and Population Development 1991).

Despite the fact that tuberculosis has been a notifiable disease since 1919, there is controversy about the true extent of the tuberculosis epidemic in South Africa. An excellent report by Weyer and Fourie (1996) provides a detailed evaluation of current tuberculosis information. Only a summary of the salient points will be attempted here. The tuberculosis notification system has been limited by the lack of standardized case definitions and underreporting in areas with poor access to health services (i.e. former 'homelands' and self governing states). As a result, the true incidence of tuberculosis in South Africa is not accurately known. Tuberculosis treatment outcomes were not measured

accurately in the past. For example, standardized definitions for outcome measures were lacking, and cohort analysis was not used to measure outcomes. Thus, accurate information on cure rates is lacking. Available data does suggest that a large percentage of tuberculosis patients interrupt their treatment and many of these are lost to follow up. This makes it difficult to estimate tuberculosis case fatality and treatment failure rates with accuracy. In addition, there are large discrepancies in the number of tuberculosis deaths reported by different sources. Bradshaw et al. (1995) estimated that tuberculosis caused approximately 10 000 deaths in 1990, based upon vital registration data. However, only 2384 tuberculosis deaths were notified in the same year (Department of National Health and Population Development 1994b). A more recent study found that only 25% and 21% of tuberculosis deaths recorded under the vital registration system were recorded by the national tuberculosis notification system in 1994 and 1995 (Kleinschmidt 1999).

With the health system reform measures introduced in 1994, a new recording and reporting system for tuberculosis was introduced in order to improve the accuracy of reporting, and facilitate assessment of the outcome of tuberculosis control program activities at both national and local levels (Weyer and Fourie 1996). This system is a standardized tuberculosis register, modified from that recommended by the WHO and IUATLD and currently runs in parallel with the notification system. This system enables the treatment outcome of cohorts of patients to be measured. Initial results from the tuberculosis register have enabled a more objective assessment of the tuberculosis epidemic. However, accurate tuberculosis data will only be available once widespread implementation and effective use of the register has occurred.

## 2.7. Summary

Notwithstanding its limitations, the DALY has contributed a great deal to describing the burden of disease and thus the debate on setting health priorities. Even some of the harshest critics of the DALY acknowledge that there is a case for further work on DALY type indicators, for the purposes of describing health status (ACHR 1996). There are clearly important factors other than epidemiological and economic that need to be taken into account when setting health priorities. Bobadilla (1996) has summarized the main elements of health priority setting in a conceptual framework. This framework incorporates the following: societal values with regard to health, life, reproduction, welfare and equality of opportunity, equity, community satisfaction and quality of care, amongst others. However, the use of the DALY can contribute a lot to our understanding of the health status of populations and can certainly inform the debate on health priority setting and

resource allocation in the health sector. For these reasons we felt that it was worthwhile to attempt a national burden of disease study in South Africa, a country which is currently undergoing major health reform. Bradshaw (1996) has argued that the most important aspect of a National Burden of Disease study for South Africa will be the careful review of available epidemiological data and the attempts to develop coherent and consistent estimates for mortality and morbidity. This will provide health status information that has previously been lacking

The South African national burden of disease study is being piloted through three diseases, one from each major cause group: communicable diseases, non-communicable diseases and injuries. Tuberculosis was selected as the communicable disease, for two main reasons: firstly, it is a major contributor to the burden of disease in South Africa, and secondly, epidemiological data from various sources are readily available.

# 3. STUDY PROCEDURES

## 3.1. Aim

The aim of this study was to estimate the burden of disease due to tuberculosis in South Africa in 1990, using the disability-adjusted life year (DALY) as the indicator. Initially, the South African National Burden of Disease study planned to use the latest data available at the time (1993). However, the decision was later made to focus on 1990, since routine data systems were more stable at that point and it was prior to the impact of HIV/AIDS. Thus, in the national study, the strategy changed to get a best estimate of the burden of disease for 1990 and to project to the year 2000.

### 3.1.1. Objectives

The specific objectives of this study were as follows:

1. To provide the most plausible estimates of age- and sex-specific incidence, case fatality, mortality and remission rates for tuberculosis for the four population groups in South Africa for 1990
2. To test the internal consistency of these parameters using a model of the disease process, incorporated in DISMOD software (Murray and Lopez 1996a)
3. To calculate the burden of disease due to tuberculosis in South Africa in 1990 using the DALY as the unit of measure.

## 3.2. Methods

The methodology used in the Global Burden of Disease Study (Murray and Lopez 1996) was applied in this study, with some modifications to take the South African situation into account. There are, for example, marked differences in the disease profile amongst the four population groups in South Africa. For this reason, the burden of tuberculosis was calculated separately for each population group. The use of the terms African, Coloured, Asian and White to describe the population groups in South Africa is thus not meant to be discriminatory. The process of estimating the burden of disease due to tuberculosis in South Africa included the following steps:

1. Review of available descriptive epidemiological data for tuberculosis in South Africa
2. Selection of epidemiological estimates for tuberculosis for South Africa, 1990
3. Internal consistency check of epidemiological parameters from various sources
4. Expert panel review of estimates
5. Calculation of YLDs, YLLs and DALYs
6. Sensitivity analysis

### 3.2.1. Review of available data

A review of all available descriptive epidemiological data for tuberculosis in South Africa was undertaken. The data were collated into four summary tables (annual risk of infection; mortality/case fatality; incidence and remission rates). The quality of the data was assessed using a literature review, expert opinions and personal observations. The main sources of data included the following:

1. Tuberculosis notifications for 1993, which were obtained from an EPI INFO file provided by the Tuberculosis Control Program of the Department of Health, South Africa.
2. Mortality data for 1990, which were obtained from computer tapes provided by Central Statistical Services.
3. All relevant published literature obtained through Medline and Popline searches.
4. Unpublished reports produced by the Tuberculosis Research Programme and Centre for Epidemiological Studies of the Medical Research Council, the National and Provincial offices of the Department of Health and Medical Officers of Health from various local authorities

### 3.2.2. Selection of epidemiological estimates and internal consistency checks

In order to calculate the DALYs lost due to tuberculosis, internally consistent age/sex/population group specific estimates for tuberculosis mortality, incidence, age of onset/death and duration of disease are required. The internal consistency of these estimates can be ascertained using a model of the disease process, DISMOD. This model formalizes the relationship between incidence, remission, case fatality and prevalence and can be used to assist in identifying inconsistent estimates and modifying them to be consistent (Murray and Lopez 1996a). Disease specific parameters as well as population estimates and underlying mortality rates are required as inputs for DISMOD. The average age of onset and duration of disease can be generated using DISMOD with the inputs mentioned above.

For this study, an estimate of tuberculosis mortality was made initially. Thereafter, two estimates of tuberculosis incidence were made (IRE1 based upon notifications, and IRE2 based upon Tuberculosis Research Programme provincial estimates). The internal consistency of these mortality and incidence estimates was compared using DISMOD. For this process, estimates of case fatality and remission rates had to be made. Inconsistencies were detected. In order to achieve internal consistency between the mortality and incidence estimates, we refined the incidence estimates (IRE3). These were compared with the two initial incidence rate estimates (IRE1 and IRE2). For all population groups the IRE3 estimates showed very high rates in the older population groups, in

comparison with the initial two estimates. This suggested that the case fatality rate estimates were too low in the older age groups. A literature review of reported age-specific case fatality rates for tuberculosis, mainly from the Netherlands and England and Wales, confirmed that tuberculosis case fatality rates increase with age (Cullinan and Meredith 1991; Nisar and Davies 1991; Humphries et al.1984; Borgdorff et al. 1998). The review also revealed slightly lower rates for females. We have assumed that HIV and AIDS did not play a major role in the death rates among tuberculosis cases in SA in 1990. This would have been expected to increase the death rates among younger age groups. The case fatality estimates were thus revised to reflect this and the incidence estimates refined again to be consistent with the mortality estimates (IRE4). The final internally consistent estimates were then used to calculate the burden of disease.

The detailed methods used to derive the tuberculosis epidemiological estimates mentioned above are described below.

3.2.2.a. Population Estimates

Population estimates for Coloured, Asian and White populations were taken from the 1991 census and decreased by annual growth rates of 2% for Coloureds and Asians and 1.8% for Whites (Central Statistical Services 1992). The population figures for Africans were taken from the 1991 census of Africans in the Republic of South Africa, plus estimates of the population in the TBVC states (Dorrington R et al.1999) and decreased by an annual growth rate of 2.2%.

3.2.2.b. Incidence

Four estimates of age/sex/population group specific incidence were made for 1990:

Incidence rate estimate 1 (IRE1)

For this estimate the 1993 notification rate was applied to 1990 population estimates. The 1993 notification data were chosen because they were considered more complete than the 1990 data, and they had been collected within the new provincial boundaries. The 1993 notification rate was calculated using the Development Bank population estimates for 1993 (Development Bank of Southern Africa 1994) as the denominator.

Incidence rate estimate 2 (IRE2)

For this estimate, the age/sex/population group distribution of the 1993 notification data was applied to 1994 provincial estimates of tuberculosis incidence rates. The rates for 1994 were estimated by the Tuberculosis Research Program (TBRP), South African Medical Research Council. An estimate of the proportion of notified tuberculosis cases that met a standard case definition (i.e. smear positive

for acid fast bacilli) was made by comparing the case detection using the new tuberculosis register with the notification system for each province. The ratio of 1.22 smear negative tuberculosis cases to each smear positive case was then used to estimate the incidence of total tuberculosis cases in each province (Department of Health, South Africa and WHO 1996).

Incidence rate estimate 3 (IRE3)

This estimate is based upon the estimated number of tuberculosis deaths for 1990. The DISMOD software was used to calculate the incidence rate that would be expected for the estimated number of deaths, using initial estimates for case fatality rates (no increase in older age groups) and remission rates.

Incidence rate estimate 4 (IRE4)

This estimate was calculated as for IRE3 above, using revised case fatality rates, which reflect an increase with age (see description above).

### 3.2.2.c. Mortality

For the National Burden of disease study, the underlying mortality levels for Coloureds, Whites and Asians were taken from 1985 life tables published by Central Statistical Services (Central Statistical Services 1987). The mortality for Africans was taken from life tables calculated by Dorrington et al. (1999) for the years 1984-1986. These mortality estimates are currently being revised for the National Burden of Disease Study. However, for the purposes of this study, we decided to use the current best estimates mentioned above. Central Statistical Services data for 1990 were used to obtain cause specific mortality from tuberculosis and were adjusted as follows:

1. The "ill-defined" category was redistributed within age, sex and population groups to determine the actual proportion of total deaths due to tuberculosis.
2. To estimate the number of deaths due to tuberculosis with an adjustment for under-reporting, the proportion of deaths due to tuberculosis was multiplied by the estimates of the total number of deaths for each age/sex/population group. The estimates for total number of deaths were calculated by multiplying the overall death rate $M_{(x)}$ by the population estimate for that age/sex/population group.

### 3.2.2.d. Case fatality

Since the case fatality in treated and untreated tuberculosis cases differs, a composite case fatality rate was calculated based upon the proportion of incident tuberculosis cases estimated to receive treatment in South Africa. Since case finding efficiency is estimated to be 70% (Weyer and Fourie 1996), it was assumed that approximately the same proportion received treatment. However, since

certain population groups in South Africa have poor access to health services, it was assumed that the proportion of incident tuberculosis cases receiving treatment differed by population group. In the South African health services, much effort has been put into preventative health services for children. For this reason, we felt that a higher proportion of incident tuberculosis cases amongst children were likely to receive treatment, than amongst adults.

For treated cases, case fatality rate estimates from recent cohort analyses were used (Weyer and Fourie 1996). The summary table of studies, which provided a basis for these estimates is set out in Appendix 2. Initially, since no age-specific case fatality rates were available for treated cases, a rate of 4% was used for all age groups. Following comments by the expert panel the rates for age groups 0-4 years and 5 –14 years were reduced to 1%. A literature review confirmed that case fatality rates increase with age and the estimates were revised to reflect this (see above). For untreated cases, the age specific case fatality rates applied in the Global Burden of Disease Study were used (Kumaresan et al. 1994). The case fatality rates used in the GBD are summarised in Appendix 3.

3.2.2.e. Remission

A composite remission rate was calculated in a similar way to the case fatality rate. For untreated cases a remission rate of 25%, as used by the Global Burden of Disease study (Kumaresan et al. 1994), was applied. For treated cases, estimates from the same cohort analyses mentioned above were used (Weyer and Fourie 1996). The summary table for remission rates is presented in Appendix 4.

3.2.2.f. Duration of disease and average age of onset.

These parameters were generated using the DISMOD model. The inputs used were the same as those for incidence estimate IRE4.

### 3.2.3. Expert Panel Review

An expert panel was convened in December 1996 to comment on and discuss the initial epidemiological estimates. The panel consisted of South African researchers in tuberculosis epidemiology, members of the Tuberculosis Control Programme of South Africa, health policy makers from the Directorate Infectious Disease, Department of Health responsible for tuberculosis management, clinicians who specialise in tuberculosis, and experts in demography and mortality in South Africa. The estimates were revised on the basis of comments made by the panel, another

internal consistency check and a further literature review. It was decided to conduct the second review via mail and email, for various reasons. Firstly, getting the experts to a meeting is expensive as they are based in different parts of the country. Secondly, it was clear that the mortality estimates needed review for the national burden of disease study. It was thus felt that for the purposes of this study, the expense of holding a meeting was not justified. A summary of the revised estimates was thus sent to the expert panel for their comment.

### 3.2.4. Calculation of YLLs, YLDs and DALYs for tuberculosis for 1990

The burden of tuberculosis in 1990 was calculated for each population group using a spreadsheet with the formulae for YLLs and YLDs.

1. The Years of Life Lost (YLL) due to premature mortality from tuberculosis in South Africa in 1990 were calculated using the following inputs:
   - The estimated number of deaths due to tuberculosis in 1990
   - The average age at death, which was generated using DISMOD
2. The Years lived with Disability (YLD) due to tuberculosis in South Africa in 1990 were calculated using the following inputs:
   - The final estimates of incidence (IRE4)
   - The age of onset and duration of disease generated using DISMOD
   - The tuberculosis disability weights for Sub Saharan Africa used by the Global Burden of Disease study were used in this calculation (see Appendix 5). Defining a set of disability weights for tuberculosis in South Africa would be desirable but would require a separate study which was beyond the scope of this mini-thesis.
3. The DALY for tuberculosis in South Africa in 1990 was then calculated by adding the YLLs and YLDs obtained above.

### 3.2.5. Sensitivity Analysis

The effect of changes in the discount rate and the age-weights on the composition of the DALY, was investigated. The discount rate, $r$, and age-weighting modulation factor, $K$, in the formulae for YLLs and YLDs can be varied. When $K$ is set to zero, the age-weights are equivalent at all ages. To distinguish DALYs based upon different parameter assumptions, the following notation is used 'DALYs[$r$,$K$]', (Murray and Lopez 1996a). The standard form of the DALY is thus DALYs[0.03,1]. The following five combinations of $r$ and $K$ were chosen for the sensitivity analysis: DALYs[0,0], DALYs[0,1], DALYs[0.03,0], DALYs[0.1,0] and DALYs[0.1,1]. These

combinations were chosen to investigate the effects of zero age weighting or discounting (DALYs[0,0]), the effects of a range of discount rates (3%,10%) without age weighting (DALYs [0.03,0], DALYs[0.1,0] and with age weighting (DALYs[0.1,1]), and lastly the effect of age weighting without discounting (DALYs[0,1]).

# 4. RESULTS

## 4.1. Assessment of the quality of available tuberculosis epidemiological data

### 4.1.1. Tuberculosis incidence data

Where notification data are accurate they can be used as proxy for incidence data. Tuberculosis became a notifiable disease in South Africa in 1919, under Section 18 of the Public Health Act 36. However, some serious limitations in the tuberculosis notification system in South Africa have been identified. Firstly, the lack of standardised case definitions has resulted in both over- and under-reporting of tuberculosis cases (Dept of Health, South Africa and WHO 1996). Under-utilisation of bacteriology and over-reliance on chest radiography has contributed to this. Tuberculosis cases requiring re-treatment have regularly been re-notified (Weyer and Fourie 1996). This has resulted in considerable over-reporting in certain areas (i.e. the Western Cape), resulting in an overestimate of the tuberculosis incidence amongst the Coloured population (Weyer K, Eggers R et al. 1996). Secondly, underreporting from areas with poor access to health services (i.e. former "homelands' and self governing states) has resulted in an underestimate of the extent of the tuberculosis problem amongst the African population (Dept of Health, South Africa and WHO 1996). Lastly, some experts have commented on the very high notification rates found amongst children, and suggested that this may be due to including cases of asymptomatic tuberculin test conversion (which indicates infection not disease) amongst notifications of tuberculosis disease. Preliminary results from the new tuberculosis register, introduced in 1994, have helped define the extent of some of these limitations (Department of Health, South Africa and WHO 1996).

The 1993 notification data used for the first incidence estimate (IRE1) for this study, were selected because they were considered to be the most complete available for the African population, and they were collected by the new provincial boundaries. No adjustments were made for the above limitations. However, the TBRP provincial estimates (1994) used for the second incidence estimate (IRE2) did attempt to standardise the case definition and adjust for under- and over-reporting (see methods). Unfortunately, no age/sex/population group specific data were available for these estimates. Thus, any problems inherent in the age/sex/population group distribution of the notification data will have been incorporated into our second incidence estimates.

4.1.2. Mortality data

A comprehensive analysis of mortality data in South Africa was published in 1995 based on the 1990 data (Bradshaw et al. 1995). This report suggests that only 55% of African mortality data were reported. In addition, there was inadequate classification of cause of death with a high proportion (23%) classified as 'ill-defined'. The estimates of tuberculosis deaths that were used for this study included adjustments for these problems. However, it was subsequently discovered that the total number of deaths reported for 1990 was much lower than previous and subsequent years. This is currently being investigated further. At this stage there is no indication of how this might affect the estimates of tuberculosis deaths for 1990. Any changes to the death estimates would affect the incidence estimates, which are based upon death data (IR3, IR4), as well as the calculations for Years of Life lost due to tuberculosis.

4.1.3. Case fatality data

The case fatality rates for treated tuberculosis cases are based upon the results from small cohort studies of treated new smear positive cases, which were used to pilot the implementation of the tuberculosis register. They are the rates as assessed at six months. The treatment interruption rate is extremely high (16-20%) in South Africa (Department of National Health and Population Development 1994a). Many of the cases that interrupt treatment are lost to follow up, so it is difficult to estimate an accurate CFR from available data. The results of the cohort studies are thus likely to be underestimates. In addition, no recent age/sex/population group specific data for tuberculosis case fatality exist in South Africa. We have thus drawn on studies from the Netherlands and England and Wales, to estimate the age- and sex- specific case fatality rates (Cullinan and Meredith 1991; Nisar and Davies 1991; Humphries et al. 1984; Borgdorff et al. 1998). However, the data are aggregated for ages under 15 or 25 years of age. Thus, no data specific to the age groups 0-4 years and 5-14 years could be found.

4.1.4. Proportion of tuberculosis cases receiving treatment and remission rate

It is estimated that the case detection rate for tuberculosis in South Africa is approximately 70% overall (Weyer and Fourie 1996). However, no evidence supporting this estimate could be found. The remission rate is based upon the cure and treatment completion rates found in the cohort studies mentioned above. No age/sex/population group specific data are available.

4.1.5. Population estimates

There is a lack of certainty about the size of the South African population in 1990, due to the apartheid fragmentation of the country. The results of the 1996 census suggest that the estimate used for this study may have been a little high (Bradshaw, personal communication). However, for the purposes of estimating the DALY, this estimate has been applied consistently through the exercise. It is thus unlikely to affect conclusions drawn from comparisons between the YLDs and YLLs.

## 4.2. Demographic estimates for South Africa, 1990

The population figures by population group, age and sex that were used for this study are set out in Appendix 6. These assume a total population of approximately 37 million comprising 28 million Africans, 3.2 million Coloureds, 1 million Asians and 5 million Whites. The South African Life Tables (Central Statistical Services 1987) with the underlying mortality rates used in the Dismod programme can be found in Appendix 7.

## 4.3. Initial tuberculosis epidemiological estimates

4.3.1. Tuberculosis incidence

The four tuberculosis incidence and incidence rate estimates, by population group, age and sex, are presented in Appendices 8 and 9. The incidence rate estimates have been plotted in Figures 1 to 8, for graphical comparison. For the African and Asian groups, IRE1 (notifications) is the lowest estimate overall whilst IRE2 (TBRP estimates) is the highest. For the Coloured group, IRE1 is the highest estimate. This is likely to reflect the problem of over notification mentioned earlier. The IRE3 estimate (based upon TB deaths; CFR unadjusted for age) showed very high rates amongst the older age groups in comparison with other estimates, for all population groups. With adjustment of the CFR for age (IRE4), however, the rates for older age groups were reduced to more acceptable levels. In the African and Asian groups, the IRE4 estimates fell between IRE1 and IRE2. For the Coloured group, the IRE4 estimates were the lowest of all the estimates. The four estimates of total incident cases are compared in Appendix 10. There is a difference of only 1008 cases between the IRE1 and IRE4 estimates. In general, incidence rates for the age group 0-4 were higher than for 5-14, and thereafter increased with age. The Coloured population had the highest rates followed by Africans then Asians and Whites. For all population groups, adult males had much higher rates than females. This was the case for both the IRE1 (notifications) and IRE4 (based upon deaths) estimates, see Appendix 11.

4.3.2. Tuberculosis mortality

The reported tuberculosis deaths for 1990 (Central Statistical Services data) and tuberculosis death estimates after adjustment (see methods) are presented in Appendix 12. The total number of reported tuberculosis deaths was 11695 for 1990. The estimated number of deaths due to tuberculosis, after adjustments for the ill-defined category and underreporting, was 18515. The majority of these deaths (16440) were amongst Africans.

4.3.3. Case Fatality and Remission

The estimates for the proportion of cases treated for tuberculosis, case fatality rates and remission rates, by age, sex and population group, are set out in Appendix 13. The case fatality rates are quite low in comparison with the estimates selected for the Global Burden of Disease Study, see Appendix 3. They are probably underestimates for the reasons discussed already. Unfortunately, there is a paucity of data on age-specific case fatality rates for treated tuberculosis cases in South Africa. It is very difficult to obtain an accurate assessment of tuberculosis case fatality in South Africa given the high treatment interrupter rate amongst tuberculosis patients.

## 4.4. Review process

This is a potentially useful process for examining available data and identifying gaps and areas needing improvement. However, South Africa is a large country and the tuberculosis experts live in various parts of the country. It is therefore an expensive process to set up expert panel meetings. Since the DALY methodology is a new development, a long initial explanatory session to explain BOD methodology and implications is required to ensure that the expert panel understand what the process requires. The mail review process is not satisfactory. There were long delays before people responded and it was difficult to stimulate discussion or to pick up misunderstandings.

## 4.5. Final epidemiological estimates for tuberculosis

The final estimates for tuberculosis incidence, average age of onset, average duration of disease, and mortality by age, sex and population group, are presented in Tables 2 to 5. The incidence rates varied greatly by population group. Amongst Coloureds the incidence rate was 436 per 100 000, Africans 229 per 100 000, Asians 58 per 100 000 and Whites 11 per 100 000. Coloured males had the highest incidence rate of 547 per 100 000. The tuberculosis mortality was, however, similar

amongst Africans and Coloureds (59.17 vs. 58.45 per 100 000). The tuberculosis mortality rates were much lower amongst Asians (7.96) and Whites (2.31).

## 4.6. Burden of tuberculosis (YLLs, YLDs and DALYs)

The Years Lived with Disability (YLDs), Years of Lost (YLLs) and Disability Adjusted Life Years (DALYs) due to tuberculosis in South Africa in 1990 are presented in Table 6. The total burden of tuberculosis was estimated to be 410107 DALYs. The burden of tuberculosis was mainly due to YLLs (391059), with YLDs contributing only 5% to the total burden of tuberculosis, see Figure 9. Africans contributed the bulk of the tuberculosis burden (88%), see Figure 9. The burden was concentrated in the 15-44 (59%) and 45-59 (20%) age groups, see Figure 10. Males contributed twice as much as females to the total burden, see Figure 11.

The age distribution of tuberculosis DALYs varied between population groups, see Figure 12 . In Africans and Coloureds the burden was concentrated in the younger age groups while in Whites the burden was greatest in the 60+ age group. A comparison of the YLD and YLL rates between population groups revealed that Coloureds have the highest rates per 100 000, see Table 7 and Figure 13. A comparison of the DALY rates by population group, age and sex show that the rates were highest in African and Coloured males in the older age groups and lowest in Whites and Asians under 14 years of age, see Figure 14.

The male/female YLD and YLL rate ratios varied markedly between population groups with Whites having the highest ratios (3.3 ; 3.4) and Asians the lowest (1,1.4), see Figure 15.

## 4.7. Sensitivity Analysis

The effects of changing the discount rate, $r$, and the age weighting modulation factor, $K$, on the composition of the DALY are summarised in Table 8. The percentages of total DALYs for YLD/YLL, sex, age group and population group for each DALY variant are compared. Changes in the age weights and discount rates from zero to standard DALY values [0.03,1], had very little effect on the population group and sex composition of DALYs. However, at a higher discount rate of 10% per year, marked changes occurred in the age distribution and YLD/YLL proportions of the DALY. The effects of changes in age weights and discount rate on the YLD/YLL and age distribution are graphically demonstrated in Figure 16.

# 5. DISCUSSION

The problems with vital registration and surveillance data in South Africa have been discussed already. One of the aims of the burden of disease methodology is; however, to try and use available data in order to come up with internally consistent best estimates. The results of this study showed that the tuberculosis death data (IRE4) were fairly consistent with the notification data (IRE1), for 1990. Whilst there were some differences in age, sex and population group distribution, the estimates of total incident cases from the above sources of data, differed by only 1000 cases. This gave us the confidence to select the IRE4 estimates as best estimates of incidence, for calculation of the burden of tuberculosis.

The DALY rates per 100 000 varied markedly by population group, with the rate per 100 000 amongst Africans being 1295, Coloureds 1461, Asians 162 and Whites 30, see Table 7 and Figure 13. This highlights the inequalities in socioeconomic status between population groups in South Africa. Interestingly, males contributed almost 70% of the burden of tuberculosis. This contrasts with the GBD results for sub-Saharan Africa where females contributed more than males (53%) to the burden of tuberculosis (Murray and Lopez 1996). The gender differential in South Africa appears to be changing, however, as the HIV/AIDS epidemic progresses. During 1994 and 1995 rapid increases of 74 – 130% in tuberculosis deaths amongst women, were reported in provinces with the highest HIV prevalence (Kleinschmidt 1999).

A national burden of disease study would compare the burden of disease caused by tuberculosis with that caused by other diseases in South Africa and rank them accordingly. Obviously this is not possible at this stage. It is possible, however, to consider the contribution of morbidity to the burden of tuberculosis. The results of this study indicate that morbidity (as measured by YLDs) due to tuberculosis contributes a very little (5%) to the total burden of tuberculosis in South Africa. This is unexpectedly low when compared with the results of the Global Burden of Disease Study, where the contribution of tuberculosis morbidity to the total burden of tuberculosis in the 8 regions of the world ranged from 7 – 19% (Murray and Lopez 1996), see Table 9. Overall, tuberculosis morbidity contributed 11% to the burden of tuberculosis in the GBD. Since many factors (duration of disease; incidence rate; case fatality rate; disability weights; age distribution of cases etc.) can impact on the contribution of morbidity to the burden of disease, it is difficult to identify the reasons for the small contribution in South Africa with any certainty.

An interesting finding was the negligible effect of the standard DALY [0.03,1] age weighting and discounting on the composition of the DALY, when compared with no age weighting or discounting. With the exception of an increase in YLD percentage from 2% to 4.6%, there were virtually no differences in the composition of the DALY by sex, age group or population group. This does raise the question of whether there is actually any benefit in including age weighting or discounting in the DALY calculation.

With regard to conducting a national burden of disease study in South Africa, we would like to raise the following points. Firstly, given the disparities in health status between regions and between population groups in South Africa, we would suggest estimating the burden of disease for each population group and defined region separately. Secondly, given the difficulties in obtaining good quality data for tuberculosis, a disease under routine surveillance, there are likely to be major problems with obtaining data for many other diseases. Lastly, the process of getting expert groups to function well will require considerable input on burden of disease methodology and high levels of collaboration. The use of e-mail alone did not work well, thus this process is likely to be time consuming and costly.

The major problem facing national burden of disease studies in developing countries is without doubt the lack of health data. The appropriateness of estimating the burden of disease for regions where basic health data are lacking has been questioned. Some authors suggest that, given the lack of health data in many developing countries, the GBD estimates of burden of disease for these regions amount to guesstimates and, as such should not be used as a basis for public health policy (Cooper et al. 1998). Many would agree with these sentiments. Others have questioned whether the expense of a national burden of disease study is justified in countries where data, resources and technical expertise are lacking (Barker and Green 1996). These are valid concerns. However, we do believe that there are benefits in attempting a burden of disease study in countries like South Africa, which are already putting significant resources into vital registration and disease surveillance. Given the poor quality of South Africa health data, one could question whether this is money well spent? In addition there is evidence that available data are not being utilized where it may be useful. It is astonishing, for example, that Tuberculosis Control Programme reports generally mention only the notified tuberculosis deaths, which are known to account for only about a third of the certified tuberculosis deaths (Department of National Health and Population Development 1990; 1991; 1993). This gives a very distorted view of tuberculosis mortality. The burden of disease methodology provides health ministries with a focused, logical and disciplined approach to assessing all available

health data in a country. This could be done in a number of steps, depending on what resources are available. For example, the project could focus on demographic and mortality data initially, and at a later stage move on to disability. A burden of disease study could thus provide the stimulus to improve the quality and use of health data in South Africa through the following:

- highlighting the importance of basic demographic and epidemiological data
- promoting the interpretation and use of available data from various sources
- encouraging and developing the use of alternative methods for collecting essential data.

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**Table 1. Composite indicators of disease burden which measure time lost to both premature mortality and morbidity**

| Indicator | Description | Use | Level | Health state preferences | Comments | References |
|---|---|---|---|---|---|---|
| **QALY** | The equivalent number of healthy years that a series of years spent in less than full health represent, according to individuals preferences | Measures health gained from a health intervention based on combination of survival time and health-related quality of life for that period; used for cost utility analysis | Individual | Weights selected by individuals | Comparisons across programs hindered by non-standardized preference weights | Torrance 1985<br>Goerdt 1996 |
| **Amount of healthy life** | Amount of healthy life lost to premature mortality (using local expectation of life) and disability (weights unclear) | Measured burden of disease (premature mortality and disability) by cause and the benefits of certain health interventions in order to inform national health resource allocation decisions in Ghana | Population | Unclear how weights selected | | Ghana Health assessment team 1981 |
| **DFLE, IFLE, HFLE*** | Life expectancies free of disability, impairment or handicap | For comparisons between and within populations over time | Population | Assigned weights implied | Not easily dis-aggregated into component biological causes, risk factors or socio-economic determinants | Goerdt 1996 |
| **DALY** | Healthy life years lost to premature mortality (using a standard expectation of life) and disability (according to assigned health state preference weights); adjusted by age weighting and discounting functions | Measures burden of disease (premature mortality and disability) by proximal and distal cause in populations; also used as outcome measure in cost-effectiveness studies; aims to aid resource allocation decisions in the health sector | Individual and population | Assigned weights stated | Social value choices explicit<br>Preference weights standardized enabling comparisons across programs and populations | Murray 1994<br>Murray 1996<br>Murray 1997 |

* DFLE, IFLE, HFLE – disability-free, impairment-free and handicap-free life expectancy

**Table 2: Africans: Final epidemiological estimates for tuberculosis, South Africa 1990**

| Age group | Incidence 1990 | | Average age at onset (years) | Average duration (years) | Deaths 1990 | |
|---|---|---|---|---|---|---|
| | Number | Rate (per 100 000) | | | Number | Rate (per 100 000) |
| ***Males*** | | | | | | |
| **0 – 4** | 3414 | 168 | 2.5 | 0.929 | 389 | 19.13 |
| **5 – 14** | 2058 | 57 | 10.0 | 1.074 | 162 | 4.48 |
| **15 – 44** | 20122 | 320 | 29.5 | 0.864 | 4356 | 68.84 |
| **45 – 59** | 10350 | 869 | 52.1 | 0.608 | 3403 | 285.64 |
| **60+** | 7260 | 1198 | 69.2 | 0.338 | 3226 | 521.00 |
| **All ages** | 43204 | 314 | | | 11536 | 83.72 |
| | | | | | | |
| ***Females*** | | | | | | |
| **0 – 4** | 2468 | 123 | 2.5 | 0.931 | 282 | 14.04 |
| **5 – 14** | 1463 | 41 | 10.0 | 1.076 | 116 | 3.25 |
| **15 – 44** | 10103 | 161 | 29.7 | 0.883 | 2108 | 33.64 |
| **45 – 59** | 2971 | 228 | 52.3 | 0.651 | 943 | 72.26 |
| **60+** | 3486 | 408 | 70.7 | 0.409 | 1455 | 167.67 |
| **All ages** | 20491 | 146 | | | 4904 | 34.99 |
| | | | | | | |
| **Total** | 63695 | 229 | | | 16440 | 59.17 |

**Table 3: Coloureds: Final epidemiological estimates for tuberculosis, South Africa 1990**

| Age group | Incidence 1990 | | Average age at onset (years) | Average duration (years) | Deaths 1990 | |
|---|---|---|---|---|---|---|
| | Number | Rate (per 100 000) | | | Number | Rate (per 100 000) |
| ***Males*** | | | | | | |
| **0 – 4** | 545 | 299 | 2.5 | 0.920 | 35 | 19.19 |
| **5 – 14** | 104 | 29 | 10.0 | 0.978 | 8 | 2.23 |
| **15 – 44** | 5639 | 691 | 29.5 | 0.852 | 614 | 75.25 |
| **45 – 59** | 1482 | 1002 | 52.1 | 0.668 | 300 | 202.86 |
| **60+** | 837 | 1230 | 69.5 | 0.397 | 283 | 403.80 |
| **All ages** | 8607 | 547 | | | 1240 | 78.76 |
| | | | | | | |
| ***Females*** | | | | | | |
| **0 – 4** | 596 | 329 | 2.5 | 0.921 | 38 | 21.03 |
| **5 – 14** | 61 | 17 | 10.0 | 0.981 | 6 | 1.68 |
| **15 – 44** | 3687 | 436 | 29.8 | 0.876 | 359 | 42.46 |
| **45 – 59** | 761 | 459 | 52.3 | 0.726 | 134 | 81.06 |
| **60+** | 344 | 355 | 71 | 0.481 | 106 | 107.31 |
| **All ages** | 5449 | 331 | | | 643 | 38.98 |
| | | | | | | |
| **Total** | 14056 | 436 | | | 1883 | 58.45 |

**Table 4: Asians: Final epidemiological estimates for tuberculosis, South Africa 1990**

| Age group | Incidence 1990 | | Average age at onset (years) | Average duration (years) | Deaths 1990 | |
|---|---|---|---|---|---|---|
| | Number | Rate (per 100 000) | | | Number | Rate (per 100 000) |
| ***Males*** | | | | | | |
| **0 – 4** | 1 | 1 | 2.4 | 0.904 | 3 | 6.12 |
| **5 – 14** | 1 | 1 | 10.0 | 0.946 | 0 | 0 |
| **15 – 44** | 171 | 70 | 29.8 | 0.824 | 14 | 5.71 |
| **45 – 59** | 43 | 70 | 52.2 | 0.685 | 7 | 11.66 |
| **60+** | 68 | 270 | 69.7 | 0.411 | 20 | 80.50 |
| **All ages** | 284 | 74 | | | **44** | 9.18 |
| | | | | | | |
| ***Females*** | | | | | | |
| **0 – 4** | 0 | 1 | 2.5 | 0.923 | 0 | 0 |
| **5 – 14** | 1 | 1 | 10.0 | 0.951 | 0 | 0 |
| **15 – 44** | 112 | 45 | 29.9 | 0.876 | 8 | 3.24 |
| **45 – 59** | 141 | 220 | 52.3 | 0.747 | 18 | 28.05 |
| **60+** | 25 | 80 | 70.7 | 0.498 | 7 | 22.47 |
| **All ages** | 279 | 57 | | | **33** | 6.76 |
| | | | | | | |
| **Total** | 563 | 58 | | | **77** | 7.96 |

**Table 5: Whites: Final epidemiological estimates for tuberculosis, South Africa 1990**

| Age group | Incidence 1990 | | Average age at onset (years) | Average duration (years) | Deaths 1990 | |
|---|---|---|---|---|---|---|
| | Number | Rate (per 100 000) | | | Number | Rate (per 100 000) |
| *Males* | | | | | | |
| 0 – 4 | 2 | 1 | 2.5 | 0.915 | 0 | 0.00 |
| 5 – 14 | 4 | 1 | 10.0 | 0.949 | 0 | 0.00 |
| 15 – 44 | 109 | 9 | 29.8 | 0.851 | 9 | 0.74 |
| 45 – 59 | 103 | 25 | 52.3 | 0.687 | 17 | 4.11 |
| 60+ | 197 | 71 | 70.2 | 0.412 | 60 | 21.24 |
| **All ages** | **415** | **17** | | | **86** | **3.47** |
| | | | | | | |
| *Females* | | | | | | |
| 0 – 4 | 2 | 1 | 2.5 | 0.924 | 0 | 0 |
| 5 – 14 | 4 | 1 | 10.0 | 0.951 | 0 | 0 |
| 15 – 44 | 24 | 2 | 29.9 | 0.876 | 2 | 0.17 |
| 45 – 59 | 24 | 6 | 52.4 | 0.749 | 3 | 0.74 |
| 60+ | 91 | 25 | 71.8 | 0.501 | 24 | 6.41 |
| **All ages** | **145** | **6** | | | **29** | **1.16** |
| | | | | | | |
| **Total** | **560** | **11** | | | **115** | **2.31** |

**Table 6: YLDs, YLLs and DALYS due to tuberculosis in SA 1990 by population group, age and sex**

| | Africans | | | Coloureds | | | Asians | | | Whites | | | South Africa | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | YLDs | YLLs | DALY | YLDs | YLLs | DALY | YLDs | YLLs | DALY | YLDs | YLLs | DALY | YLDs | YLLs | DALY | YLD p |
| **Male** | | | | | | | | | | | | | | | | |
| 0-4 | 393 | 13417 | 13810 | 62 | 1207 | 1269 | 0 | 103 | 103 | 0 | 0 | 0 | 455 | 14727 | 15182 | 0.03 |
| 5-14 | 718 | 6010 | 6728 | 33 | 297 | 330 | 0 | 0 | 0 | 1 | 0 | 1 | 752 | 6307 | 7059 | 0.11 |
| 15-44 | 6653 | 132512 | 139165 | 1839 | 18678 | 20517 | 54 | 424 | 478 | 35 | 272 | 307 | 8581 | 151886 | 160467 | 0.05 |
| 45-59 | 1788 | 57021 | 58809 | 281 | 5027 | 5308 | 8 | 117 | 125 | 20 | 283 | 303 | 2097 | 62448 | 64545 | 0.03 |
| 60+ | 470 | 28487 | 28957 | 63 | 2479 | 2542 | 5 | 174 | 179 | 15 | 516 | 531 | 553 | 31656 | 32209 | 0.02 |
| Total | 10022 | 237447 | 247469 | 2278 | 27688 | 29966 | 67 | 818 | 885 | 71 | 1071 | 1142 | 12438 | 267024 | 279462 | 0.04 |
| | | | | | | | | | | | | | | | | |
| **Female** | | | | | | | | | | | | | | | | |
| 0-4 | 285 | 9756 | 10041 | 68 | 1315 | 1383 | 0 | 0 | 0 | 0 | 0 | 0 | 353 | 11071 | 11424 | 0.03 |
| 5-14 | 511 | 4303 | 4814 | 19 | 223 | 242 | 0 | 0 | 0 | 1 | 0 | 1 | 531 | 4526 | 5057 | 0.11 |
| 15-44 | 3408 | 64157 | 67565 | 1233 | 10908 | 12141 | 37 | 243 | 280 | 8 | 61 | 69 | 4686 | 75369 | 80055 | 0.06 |
| 45-59 | 547 | 16093 | 16640 | 156 | 2287 | 2443 | 30 | 307 | 337 | 5 | 51 | 56 | 738 | 18738 | 19476 | 0.04 |
| 60+ | 262 | 13111 | 13373 | 30 | 947 | 977 | 2 | 63 | 65 | 8 | 210 | 218 | 302 | 14331 | 14633 | 0.02 |
| Total | 5013 | 107420 | 112433 | 1506 | 15680 | 17186 | 69 | 613 | 682 | 22 | 322 | 344 | 6610 | 124035 | 130645 | 0.05 |
| | | | | | | | | | | | | | | | | |
| **Total** | **15035** | **344867** | **359902** | **3784** | **43368** | **47152** | **136** | **1431** | **1567** | **93** | **1393** | **1486** | **19048** | **391059** | **410107** | **0.05** |
| | | | | | | | | | | | | | | | | |

**Table 7: Tuberculosis DALYs per 100 000 by population group in South Africa**

| Age group | DALYs per 100 000 population | | | | |
|---|---|---|---|---|---|
| | African | Coloured | Asian | White | South Africa (all groups) |
| **Male** | | | | | |
| 0-4 | 679 | 696 | 210 | 0 | 622 |
| 5-14 | 186 | 92 | 0 | 0.3 | 158 |
| 15-44 | 2209 | 2514 | 195 | 25 | 1871 |
| 45-59 | 4936 | 3589 | 208 | 73 | 3560 |
| 60+ | 4677 | 3627 | 720 | 188 | 3232 |
| Total | 1799 | 1903 | 185 | 46 | 1528 |
| | | | | | |
| **Female** | | | | | |
| 0-4 | 500 | 765 | 0 | 0 | 475 |
| 5-14 | 135 | 68 | 0 | 0.3 | 115 |
| 15-44 | 1076 | 1436 | 114 | 6 | 935 |
| 45-59 | 1275 | 1478 | 525 | 14 | 1005 |
| 60+ | 1541 | 989 | 209 | 58 | 1066 |
| Total | 801 | 1043 | 140 | 14 | 700 |
| | | | | | |
| Total | 1295 | 1464 | 162 | 30 | 1109 |

**Table 8: South African population: Comparison of the effects of changing the discount rate ($r$) and age weighting modulating factor ($K$) on the composition of DALYs due to tuberculosis (as percentages of total DALYs)**

| | DALYs[$r$,$K$] | | | | | |
|---|---|---|---|---|---|---|
| | $r$=0 $K$=0 | $r$=0 $K$=1 | $r$=0.03 $K$=0 | $r$=0.03 $K$=1 | $r$=0.1 $K$=0 | $r$=0.1 $K$=1 |
| ***By outcome*** | | | | | | |
| Total YLD | **1.9** | 2.7 | 3.5 | **4.6** | 8 | 2.9 |
| Total YLL | **98.1** | 97.3 | 96.5 | **95.4** | 92 | 97.1 |
| | | | | | | |
| ***By sex*** | | | | | | |
| All males | **67.1** | 67.2 | 68.3 | **68.1** | 69.0 | 69.3 |
| All females | **32.9** | 32.8 | 31.7 | **31.9** | 31.0 | 30.7 |
| | | | | | | |
| ***By age group*** | | | | | | |
| 0 – 4 | **7.0** | 9.0 | 5.4 | **6.5** | 4.8 | 0.3 |
| 5 – 14 | **2.7** | 3.5 | 2.2 | **3.0** | 2.1 | 0.2 |
| 15 – 44 | **56.7** | 61.3 | 49.3 | **58.6** | 42.9 | 16.8 |
| 45 – 59 | **20.2** | 17.6 | 24.1 | **20.5** | 25.6 | 28.4 |
| 60+ | **13.4** | 8.6 | 19.0 | **11.4** | 24.6 | 54.3 |
| | | | | | | |
| ***By population group*** | | | | | | |
| African | **88.0** | 87.8 | 88.2 | **87.7** | 88.0 | 89.3 |
| Coloured | **11.2** | 11.5 | 10.9 | **11.5** | 10.9 | 9.1 |
| Asian | **0.4** | 0.4 | 0.4 | **0.4** | 0.4 | 0.5 |
| White | **0.4** | 0.3 | 0.5 | **0.4** | 0.6 | 1.1 |

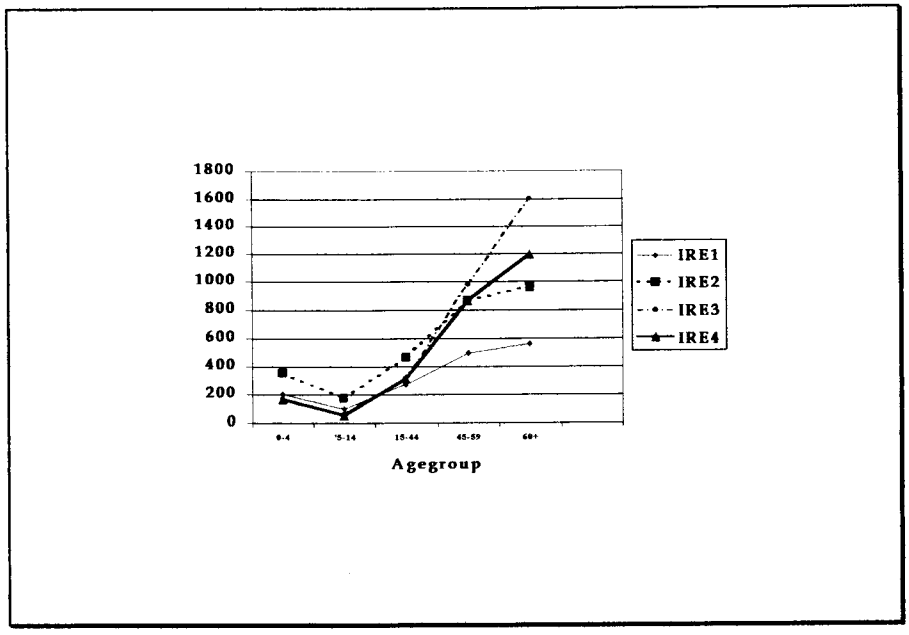
**Table 9: Tuberculosis morbidity (YLDs) as a percentage of total burden of tuberculosis (DALYs) in world regions (Murray and Lopez, 1996)**

| Region* | DALYs due to TB *(thousands)* | YLDs due to TB *(thousands)* | Proportion YLDs (%) |
|---|---|---|---|
| **MEC** | 2549 | 243 | 10 |
| **LAC** | 1778 | 179 | 10 |
| **SSA** | 10184 | 750 | 7 |
| **OAI** | 5501 | 1040 | 19 |
| **CHI** | 4155 | 673 | 16 |
| **IND** | 13763 | 1199 | 9 |
| **FSE** | 378 | 27 | 7 |
| **EME** | 118 | 11 | 9 |
| **World** | 38426 | 4122 | 11 |

* MEC – middle eastern crescent; LAC – Latin America and the Caribbean; SSA – sub-Saharan Africa; OAI – other Asia and islands; CHI – China; IND – India; FSE – formerly socialist economies of Europe; EME – established market economies

**Figure 1: Tuberculosis incidence rate estimates; African males: South Africa, 1990**

**(per 100 000)**

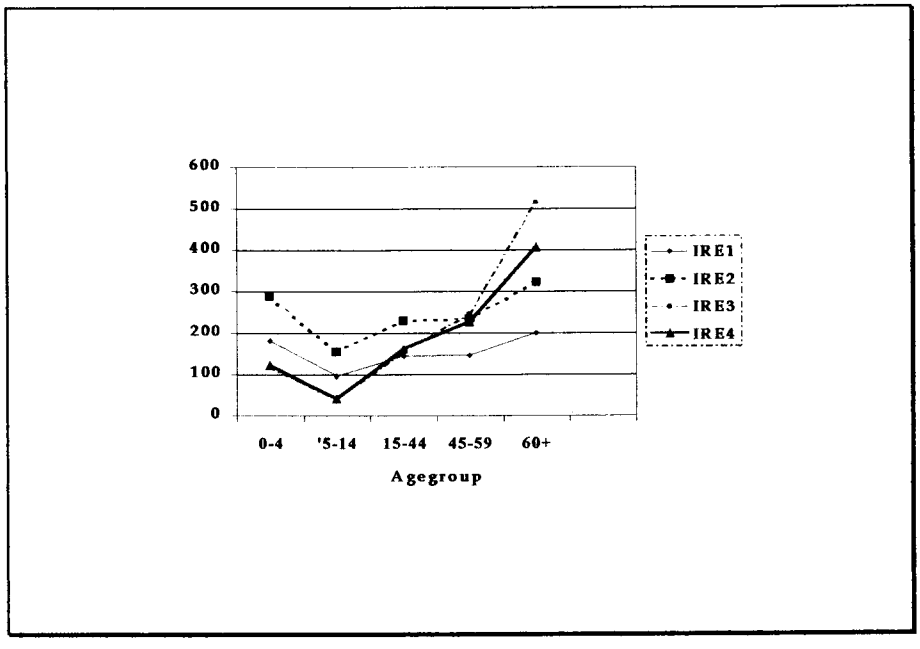



IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;

IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 2: Tuberculosis incidence rate estimates; African females: South Africa, 1990**

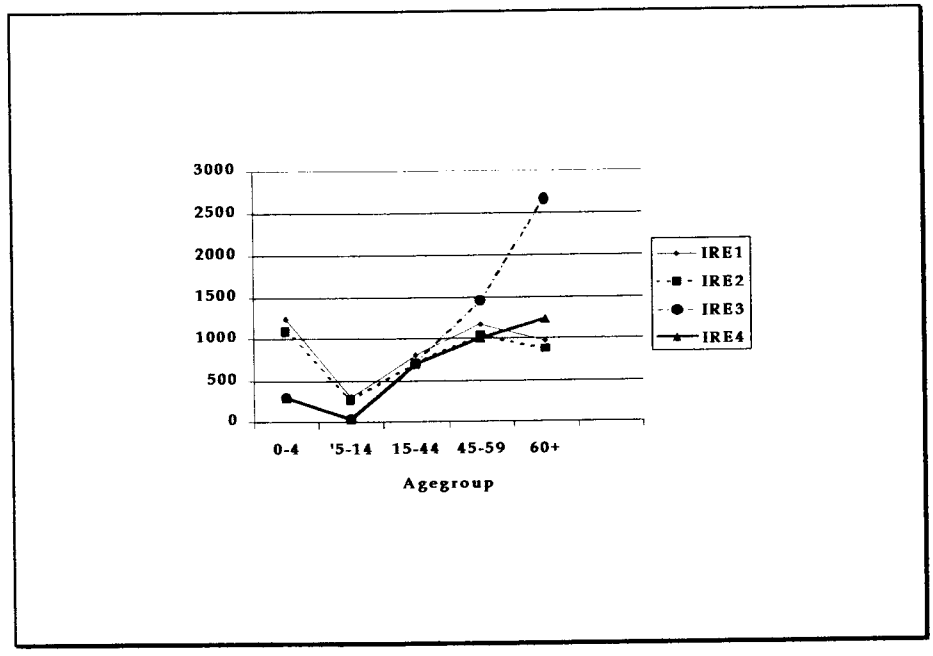
**(per 100 000)**




IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;

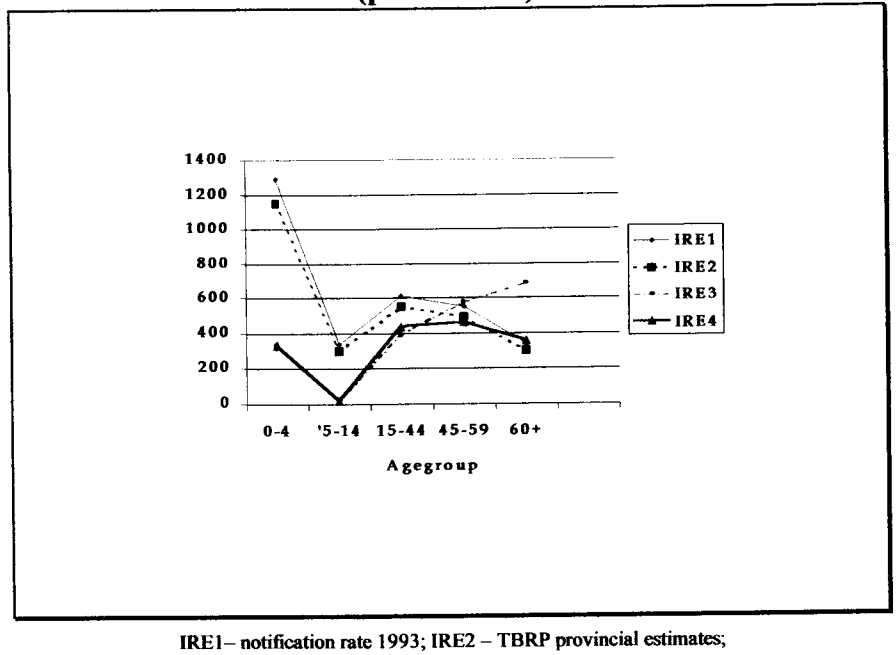
IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 3: Tuberculosis incidence rate estimates; Coloured males: South Africa, 1990 (per 100 000)**



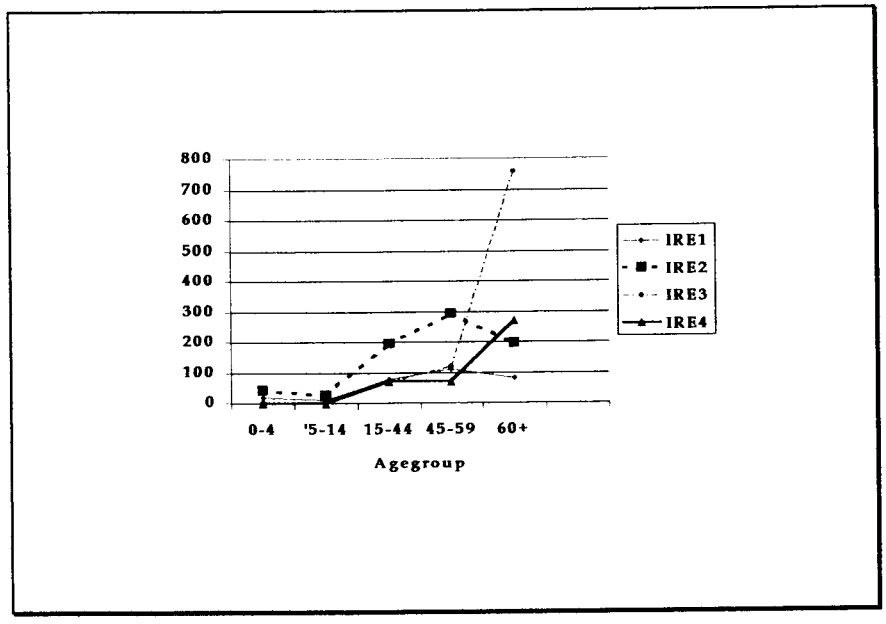

IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;
IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 4: Tuberculosis incidence rate estimates; Coloured females: South Africa, 1990 (per 100 000)**



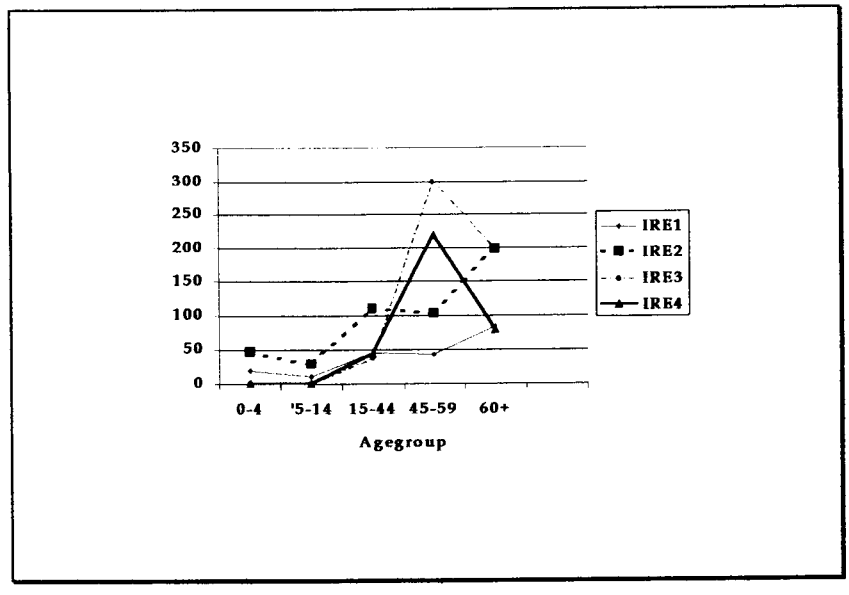

IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;
IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 5: Tuberculosis incidence rate estimates; Asian males: South Africa, 1990 (per 100 000)**



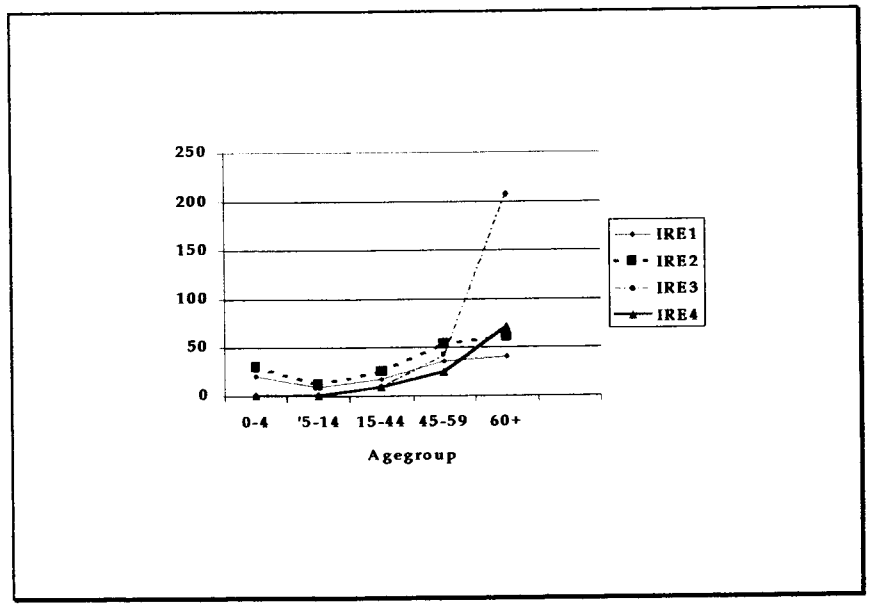

IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;
IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 6: Tuberculosis incidence rate estimates; Asian females: South Africa, 1990 (per 100 000)**



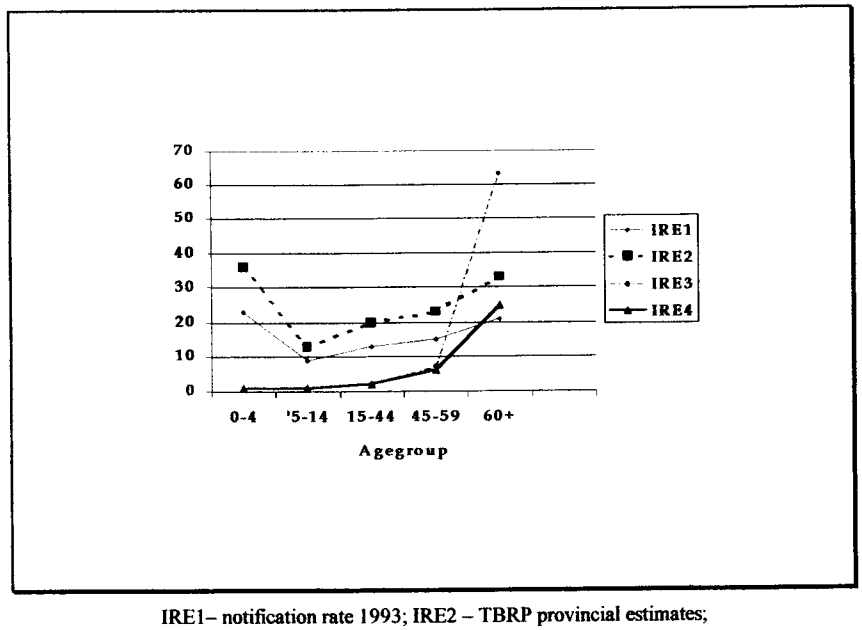

IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;
IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 7: Tuberculosis incidence rate estimate; White males: South Africa, 1990 (per 100 000)**




IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;
IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 8: Tuberculosis incidence rate estimates; White females: South Africa, 1990 (per 100 000)**




IRE1– notification rate 1993; IRE2 – TBRP provincial estimates;
IRE3 - DISMOD estimates (CFRs not adjusted for age); IRE4– DISMOD estimates (CFRs adjusted for age)

**Figure 9: Distribution of TB DALYs by population group, SA 1990**

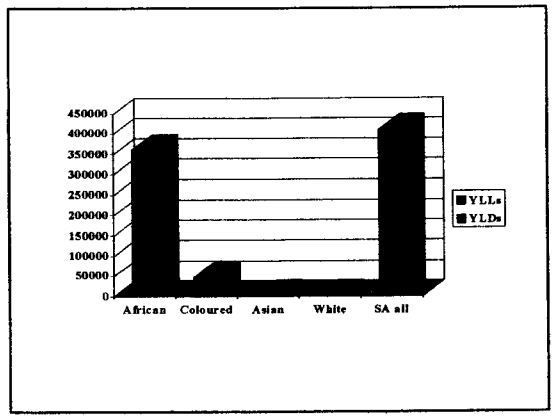



**Figure 10: Distribution of TB DALYs by age group, SA 1990**

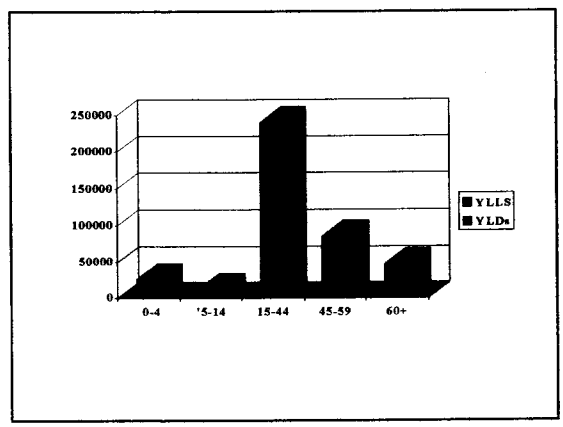



**Figure 11: Distribution of TB DALYs by gender and population group**

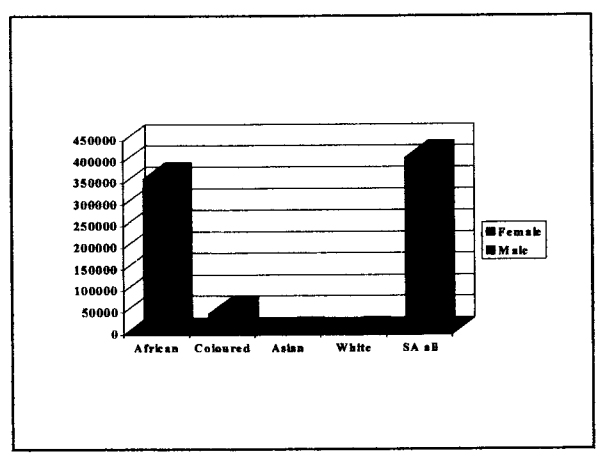


**Figure 12: Age distribution of tuberculosis DALYs by population group, SA 1990**

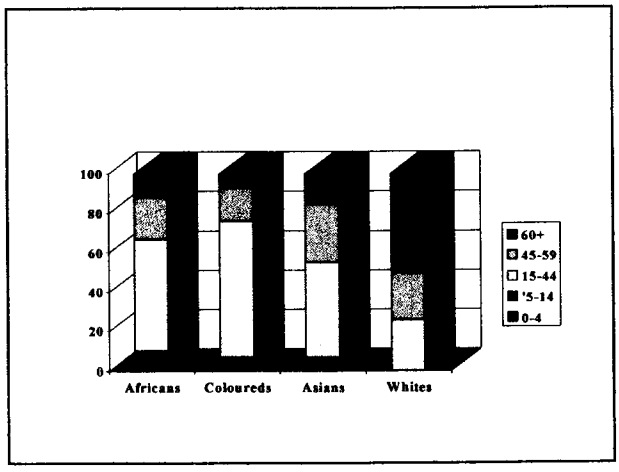



**Figure 13: Tuberculosis DALY, YLD and YLL rates by population group, SA 1990**

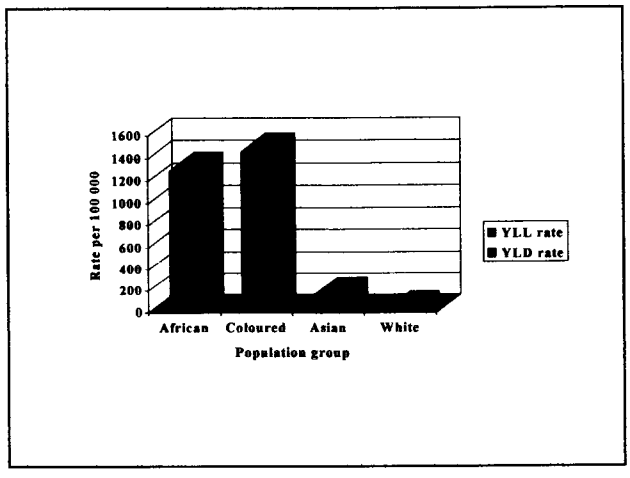



**Figure 14: Tuberculosis DALY rate by population group, age and sex**

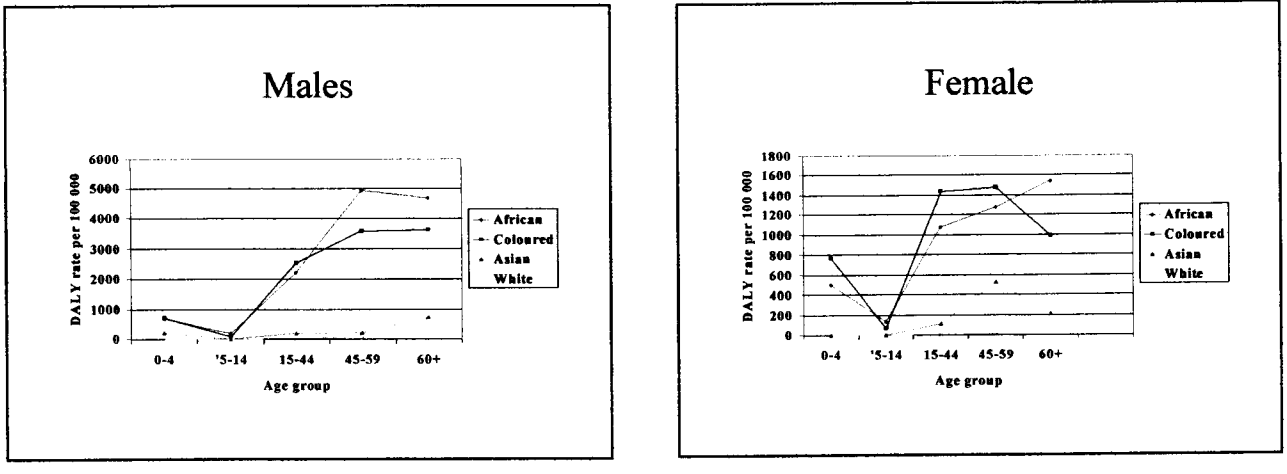


**Figure 15: Male to Female ratio of tuberculosis YLD and YLL rates by population group, South Africa 1990**

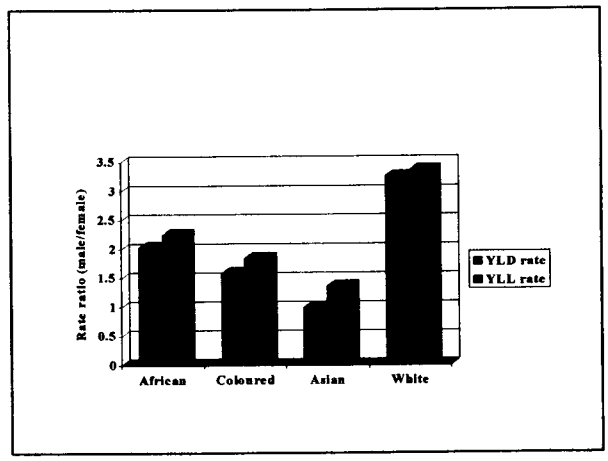
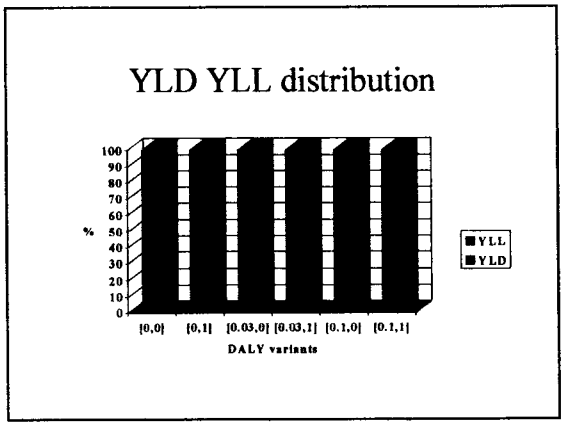
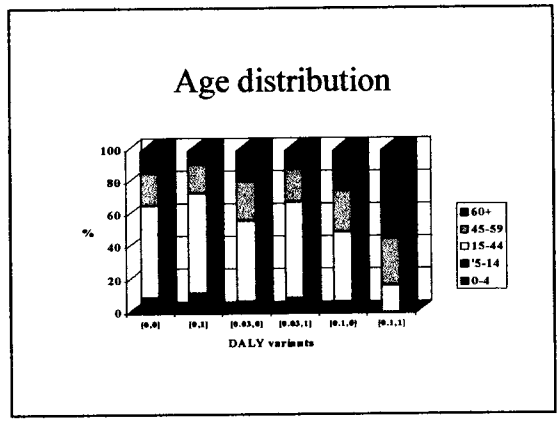



**Figure 16: Comparison of the effects of changing the discount rate *r* and age weighting modulation factor *K* on the composition of the DALY due to tuberculosis (percentages)**



**Appendix 1: Medical Research Council Ethics Committee Approval for study**

MRC

MEDICAL RESEARCH COUNCIL

MEDIESE NAVORSINGSRAAD

UMKHANDLU WOKUCWANINGA NGEZOKWELAPHA

LEKGOTLA LA PHUPUTSO HO TSA KALAFO

**Office of the President**

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Tel: +27 21 938-0211/938-0911 • Fax: +27 21 938-0201
E-mail: OWPROZES@EAGLE.MRC.AC.ZA.

17 June 1998

Dr Debbie Bradshaw
CERSA: Burden of Disease
MRC
P O Box 19070
**7505 TYGERBERG**

Dear Dr Bradshaw,

**Measuring the burden of disease.**
**Case Study: Estimation of the DALY for Tuberculosis in South Africa**

I am pleased to inform you that the above protocol has been ethically approved by the MRC Ethics committee.

Wishing you well with your research.

Yours sincerely,

**PROFESSOR PE CLEATON-JONES**
**ACTING CHAIRMAN: MRC ETHICS COMMITTEE**

## Appendix 2: Basis for tuberculosis CFR estimates for treated TB cases in South Africa, 1990

| REGION | YEAR | CASE FATALITY | | REFERENCE | COMMENTS |
|---|---|---|---|---|---|
| | | New cases | All cases | | |
| RSA | 1980 | | Afr: 3.2%<br>Col: 5.9%<br>Asi: 4.4%<br>Whi: 4.5% | Yach (1987) | Notified TB deaths/notified cases<br>Assumes similar levels of undernotification |
| RSA | 1987 | | Afr: 3.7%<br>Col: 5.9%<br>Asi: 4.5%<br>Whi: 3.5% | Weyer and Fourie (1989) | Notified TB deaths/ notified cases<br>Undernotification of deaths suspected |
| Mpumalanga | 1995 | 3.5 –4.4% | 5.8-9.5% | Weyer and Fourie (1996) | Assume mainly African |
| Kwazulu | 1995 | 3% | | Dept of Health (1996) | Assume mainly African |
| North west | 1995 | 3% | | Dept of Health (1996) | Assume mainly African |
| Northern Province | 1995 | 7% | | Dept of Health (1996) | Assume mainly African |
| Ravensmead Western Cape | 1988 | | 5.3% | Youngleson and Joubert (1989) | Assume mainly Coloured |
| West Coast Western Cape | 1994 | 1.2 – 1.6% | 1.3 – 2.4% | Weyer et al (1996) | Assume mainly Coloured CFR at 6 months |
| Chapel Street Western Cape | 1995 | | 2.2% | Dick J – personal communication | Assume mainly Coloured CFR at 6 months |

**Appendix 3: Tuberculosis case fatality rates for world regions, GBD, 1990**

| Age | Case Fatality Rates for GBD World regions *(%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | EME | | FSE; LAC | | IND; SSA; OAI; MEC | | | |
| | Rx | Not Rx | Rx | Not Rx | Rx | | Not Rx | |
| | | | | | HIV - | HIV+ SSA; LAC | HIV – | HIV + SSA ; LAC |
| 0 – 4 | 5 | 43 | 7 | 43 | 10 | 30 | 43 | 100 |
| 5 – 14 | 5 | 16 | 7 | 16 | 10 | 30 | 16 | 100 |
| 15 – 44 | 5 | 41 | 10 | 41 | 15 | 40 | 41 | 100 |
| 45 – 59 | 7.5 | 66 | 15 | 66 | 20 | 50 | 66 | 100 |
| 60+ | 20 | 80 | 30 | 80 | 40 | 60 | 80 | 100 |

- **Global Burden of Disease Study (Kumaresan et al. 1994)**

## Appendix 4: Basis for tuberculosis remission rate estimates for treated TB cases, South Africa, 1990

| Region | Year | Remission rate* | Reference | Comments |
|---|---|---|---|---|
| Mpumalanga | 1995 | 83-87% | Weyer and Fourie (1996) | Assume mainly African |
| Kwazulu | 1995 | 64% | Dept of Health (1996) | Assume mainly African |
| North west | 1995 | 65% | Dept of Health (1996) | Assume mainly African |
| Northern Province | 1995 | 71% | Dept of Health (1996) | Assume mainly African |
| Ravensmead Western Cape | 1988 | 65% | Youngleson and Joubert (1989) | Assume mainly Coloured |
| West Coast Western Cape | 1994 | 69.5 – 80% | Weyer et al. (1996) | Assume mainly Coloured |
| Chapel Street Western Cape | 1995 | 78% | Dick J –personal communication | Assume mainly Coloured |

* Remission rate includes both tuberculosis patients reported 'cured' and 'completed treatment' according to TB register definitions

## Appendix 5: Tuberculosis disability weights for sub Saharan Africa, GBD*, 1990

| Untreated form *Age group (years)* | | | | | Treated form *Age group (years)* | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0-4 | 5-14 | 15-44 | 45-59 | 60+ | 0-4 | 5-14 | 15-44 | 45-59 | 60+ |
| 0.294 | 0.294 | 0.264 | 0.274 | 0.274 | 0.294 | 0.294 | 0.264 | 0.274 | 0.274 |

*Extracted from Murray and Lopez 1996

**Appendix 6: Population figures by population group age and sex, SA 1990.**

| Age group | Population figures | | | | |
|---|---|---|---|---|---|
| | African | Coloured | Asian | White | SA total population |
| **Male** | | | | | |
| 0-4 | 2033808 | 182379 | 49030 | 174897 | 2440114 |
| 5-14 | 3612756 | 357979 | 100088 | 388237 | 4459060 |
| 15-44 | 6298604 | 816000 | 245368 | 1216059 | 8576031 |
| 45-59 | 1191343 | 147884 | 60032 | 413586 | 1812845 |
| 60+ | 619198 | 70085 | 24846 | 282500 | 996629 |
| Total | 13755709 | 1574327 | 479364 | 2475279 | 18284679 |
| | | | | | |
| **Female** | | | | | |
| 0-4 | 2007934 | 180672 | 47399 | 166784 | 2402789 |
| 5-14 | 3569052 | 356612 | 98527 | 371835 | 4396026 |
| 15-44 | 6280458 | 845598 | 246630 | 1186133 | 8558819 |
| 45-59 | 1304943 | 165307 | 64168 | 403910 | 1938328 |
| 60+ | 867793 | 98780 | 31150 | 374558 | 1372281 |
| Total | 14030180 | 1646969 | 487874 | 2503220 | 18668243 |
| | | | | | |
| **Total** | 27785889 | 3221296 | 967238 | 4978499 | 36952922 |

**Appendix 7: South African Life Tables (SALT 1984-86), Central Statistical Services, 1987.**

| AGE | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | Whites | Asians | Coloureds | Africans | Whites | Asians | Coloureds | Africans |
| 0 | 0.01060 | 0.01728 | 0.051134 | 0.079687 | 0.007433 | 0.01456 | 0.045408 | 0.073858 |
| 1 | 0.00101 | 0.001244 | 0.004464 | 0.007395 | 0.000754 | 0.001303 | 0.003944 | 0.007471 |
| 5 | 0.00036 | 0.000439 | 0.000892 | 0.001262 | 0.000272 | 0.000504 | 0.000739 | 0.000943 |
| 10 | 0.00038 | 0.000411 | 0.000661 | 0.001052 | 0.000243 | 0.000383 | 0.000528 | 0.000687 |
| 15 | 0.00137 | 0.00143 | 0.002335 | 0.002727 | 0.000489 | 0.000659 | 0.000943 | 0.00129 |
| 20 | 0.00226 | 0.002457 | 0.00436 | 0.004949 | 0.000668 | 0.00084 | 0.001596 | 0.002128 |
| 25 | 0.00225 | 0.002742 | 0.005445 | 0.006085 | 0.000776 | 0.001049 | 0.002232 | 0.002905 |
| 30 | 0.00226 | 0.002907 | 0.005909 | 0.006899 | 0.000947 | 0.001233 | 0.002916 | 0.003937 |
| 35 | 0.00280 | 0.004492 | 0.007545 | 0.008476 | 0.001332 | 0.001744 | 0.004274 | 0.005953 |
| 40 | 0.00402 | 0.007365 | 0.010188 | 0.011415 | 0.00215 | 0.002948 | 0.006407 | 0.008166 |
| 45 | 0.00632 | 0.010907 | 0.01455 | 0.015844 | 0.003669 | 0.005051 | 0.009202 | 0.010722 |
| 50 | 0.01042 | 0.016893 | 0.021139 | 0.023336 | 0.005667 | 0.008867 | 0.012742 | 0.01462 |
| 55 | 0.01711 | 0.026771 | 0.029625 | 0.031013 | 0.008767 | 0.016024 | 0.017758 | 0.019701 |
| 60 | 0.02695 | 0.038496 | 0.040713 | 0.040734 | 0.014 | 0.024971 | 0.024453 | 0.027792 |
| 65 | 0.04058 | 0.055378 | 0.055298 | 0.055564 | 0.020964 | 0.039857 | 0.033116 | 0.038376 |
| 70 | 0.05957 | 0.073323 | 0.074063 | 0.074069 | 0.031855 | 0.05459 | 0.049196 | 0.052855 |
| 75 | 0.08684 | 0.094455 | 0.094469 | 0.099634 | 0.051704 | 0.075149 | 0.065189 | 0.072036 |
| 80 | 0.11870 | 0.117736 | 0.109907 | 0.132449 | 0.082006 | 0.091748 | 0.086043 | 0.108103 |
| 85 | 0.19135 | 0.151008 | 0.159704 | 0.156751 | 0.146171 | 0.131843 | 0.143936 | 0.12703 |

**Appendix 8: Tuberculosis incidence rate estimates by population group, sex and age in SA 1990**

| | Africans | | | | Coloureds | | | | Asians | | | | Whites | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Males** | IRE1 | IRE2 | IRE3 | IRE4 | IRE1 | IRE2 | IRE3 | IRE4 | IRE1 | IRE2 | IRE3 | IRE4 | IRE1 | IRE2 | IRE3 | IRE4 |
| 0 – 4yr | 208 | 357 | 162 | 168 | 1239 | 1096 | 299 | 299 | 18 | 43 | 1 | 1 | 21 | 31 | 1 | 1 |
| 5 – 14yr | 101 | 174 | 59 | 57 | 304 | 269 | 29 | 29 | 11 | 28 | 1 | 1 | 9 | 13 | 1 | 1 |
| 15 – 44yr | 273 | 470 | 319 | 320 | 802 | 709 | 691 | 691 | 80 | 195 | 70 | 70 | 18 | 26 | 9 | 9 |
| 45 – 59yr | 502 | 864 | 985 | 869 | 1169 | 1034 | 1454 | 1002 | 113 | 294 | 120 | 70 | 36 | 54 | 43 | 25 |
| 60+yr | 559 | 962 | 1599 | 1198 | 970 | 858 | 2659 | 1230 | 81 | 196 | 757 | 270 | 41 | 61 | 208 | 71 |
| Overall | 257 | 442 | 347 | 314 | 781 | 691 | 652 | 547 | 64 | 154 | 106 | 74 | 22 | 33 | 35 | 17 |
| | | | | | | | | | | | | | | | | |
| **Females** | | | | | | | | | | | | | | | | |
| 0 – 4yr | 181 | 290 | 119 | 123 | 1290 | 1150 | 329 | 329 | 20 | 48 | 1 | 1 | 23 | 36 | 1 | 1 |
| 5 – 14yr | 96 | 154 | 39 | 41 | 335 | 298 | 17 | 17 | 12 | 29 | 1 | 1 | 9 | 13 | 1 | 1 |
| 15 – 44yr | 143 | 230 | 154 | 161 | 614 | 548 | 390 | 434 | 46 | 110 | 38 | 45 | 13 | 20 | 2 | 2 |
| 45 – 59yr | 145 | 233 | 245 | 228 | 550 | 491 | 573 | 459 | 43 | 103 | 299 | 220 | 15 | 23 | 7 | 6 |
| 60+yr | 201 | 323 | 515 | 408 | 336 | 299 | 687 | 355 | 83 | 198 | 200 | 80 | 21 | 33 | 63 | 25 |
| Overall | 141 | 226 | 150 | 146 | 605 | 539 | 338 | 331 | 39 | 92 | 71 | 57 | 15 | 23 | 12 | 6 |
| | | | | | | | | | | | | | | | | |
| Total | 195 | 327 | 244 | 229 | 690 | 610 | 491 | 436 | 51 | 124 | 81 | 58 | 18 | 27 | 23 | 11 |

**Appendix 9: Tuberculosis incidence estimates by population group, age and sex in SA 1990**

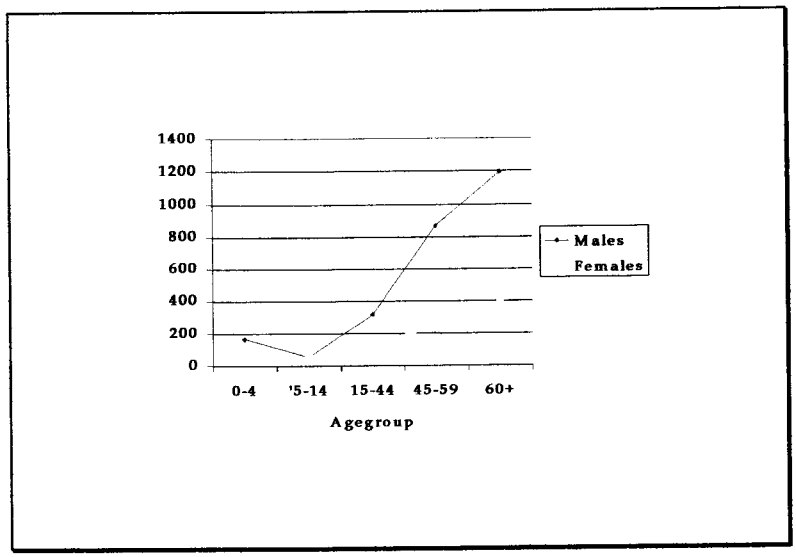
| | Africans | | | | Coloureds | | | | Asians | | | | Whites | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Males** | IRE1 | IRE2 | IRE3 | IRE4 | IRE1 | IRE2 | IRE3 | IRE4 | IRE1 | IRE2 | IRE3 | IRE4 | IRE1 | IRE2 | IRE3 | IRE4 |
| 0 – 4yr | 4230 | 7261 | 3292 | 3414 | 2260 | 1999 | 545 | 545 | 9 | 21 | 1 | 1 | 37 | 54 | 2 | 2 |
| 5 – 14yr | 3649 | 6286 | 1984 | 2058 | 1088 | 963 | 104 | 104 | 11 | 28 | 1 | 1 | 35 | 50 | 4 | 4 |
| 15 – 44yr | 17195 | 29603 | 20107 | 20122 | 6544 | 5785 | 5639 | 5639 | 196 | 478 | 171 | 171 | 219 | 316 | 109 | 109 |
| 45 – 59yr | 5981 | 10293 | 11734 | 10350 | 1729 | 1529 | 2152 | 1482 | 68 | 176 | 73 | 43 | 149 | 223 | 178 | 103 |
| 60+yr | 3461 | 5957 | 9688 | 7260 | 680 | 601 | 1808 | 837 | 20 | 49 | 189 | 68 | 116 | 172 | 579 | 197 |
| Total | 34516 | 59400 | 46805 | 43204 | 12301 | 10877 | 10248 | 8607 | 304 | 753 | 435 | 284 | 556 | 815 | 872 | 415 |
| | | | | | | | | | | | | | | | | |
| **Females** | | | | | | | | | | | | | | | | |
| 0 – 4yr | 3634 | 5823 | 2388 | 2468 | 2331 | 2078 | 596 | 596 | 9 | 23 | 0 | 0 | 38 | 60 | 2 | 2 |
| 5 – 14yr | 3426 | 5496 | 1392 | 1463 | 1195 | 1063 | 61 | 61 | 12 | 29 | 1 | 1 | 33 | 48 | 4 | 4 |
| 15 – 44yr | 8981 | 14445 | 9690 | 10103 | 5192 | 4634 | 3293 | 3687 | 113 | 271 | 95 | 112 | 154 | 237 | 24 | 24 |
| 45 – 59yr | 1892 | 3041 | 3192 | 2971 | 909 | 812 | 950 | 761 | 28 | 66 | 192 | 141 | 61 | 93 | 28 | 24 |
| 60+yr | 1744 | 2803 | 4402 | 3486 | 332 | 295 | 666 | 344 | 26 | 62 | 62 | 25 | 79 | 124 | 230 | 91 |
| Total | 19677 | 31608 | 21064 | 20491 | 9959 | 8882 | 5566 | 5449 | 188 | 451 | 350 | 279 | 365 | 562 | 288 | 145 |
| | | | | | | | | | | | | | | | | |
| Total | 54193 | 91008 | 67869 | 63695 | 22260 | 19759 | 15814 | 14056 | 492 | 1203 | 785 | 563 | 921 | 1377 | 1160 | 560 |

**Appendix 10: Estimates of total incident TB cases and rate per 100 000, by population group, SA 1990**

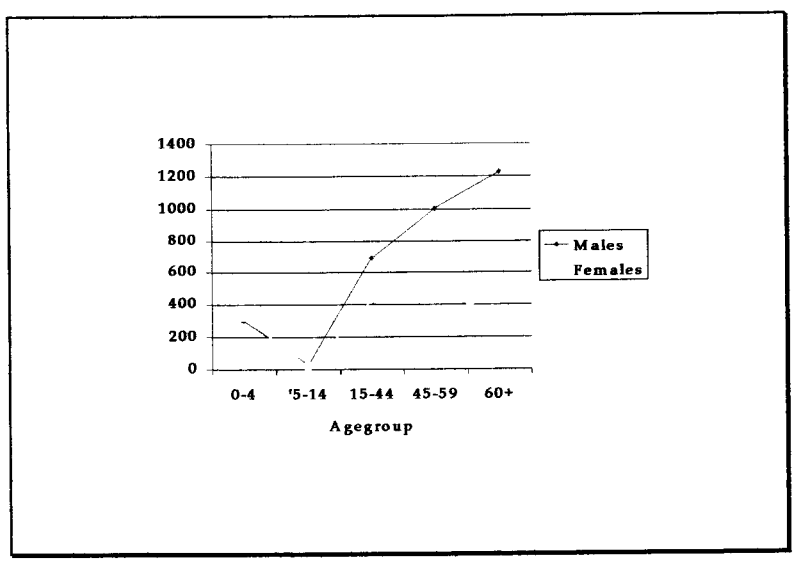
| Population group | Incident cases IRE1 (rate per 100000) | Incident cases IRE2 (rate per 100000) | Incident cases IRE3 (rate per 100000) | Incident cases IRE4 (rate per 100000) |
|---|---|---|---|---|
| **African** | 54193 (195) | 91008 (327) | 67869 (244) | 63695 (229) |
| **Coloured** | 22260 (690) | 19759 (610) | 15814 (491) | 14056 (436) |
| **Asian** | 492 (51) | 1203 (124) | 785 (81) | 563 (58) |
| **White** | 921 (18) | 1377 (27) | 1160 (23) | 560 (11) |
| **Total** | **77866 (211)** | **113347 (307)** | **85628 (232)** | **78874 (213)** |

## Appendix 11: Gender differences in tuberculosis incidence and notification rates, SA 1990

### DISMOD estimates of tuberculosis incidence rates by sex, SA 1990: Africans (per 100 000)

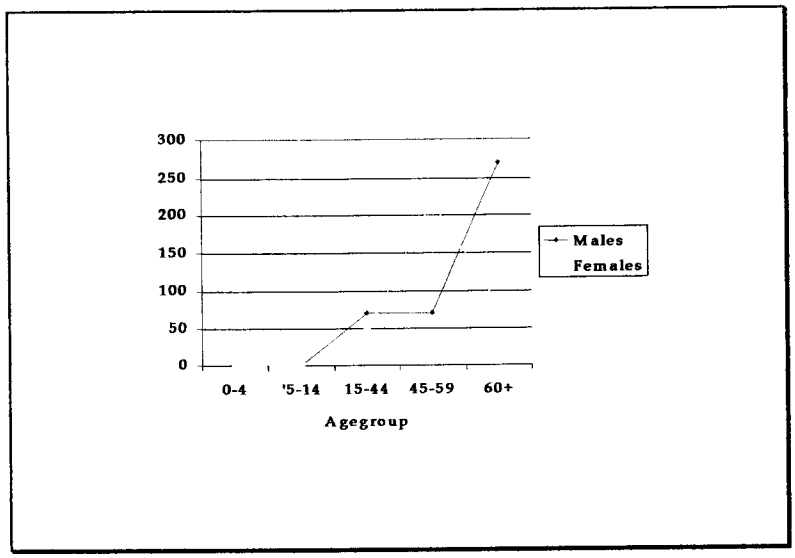



### DISMOD estimates of tuberculosis incidence rates by sex, SA 1990: Coloureds (per 100 000)

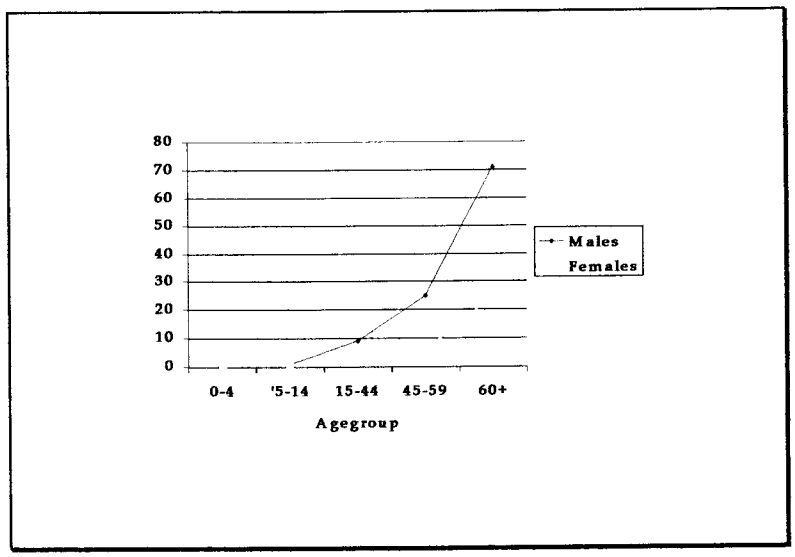


**Appendix 11 continued**

**DISMOD estimates of tuberculosis incidence rates by sex, SA 1990: Asians (per 100 000)**

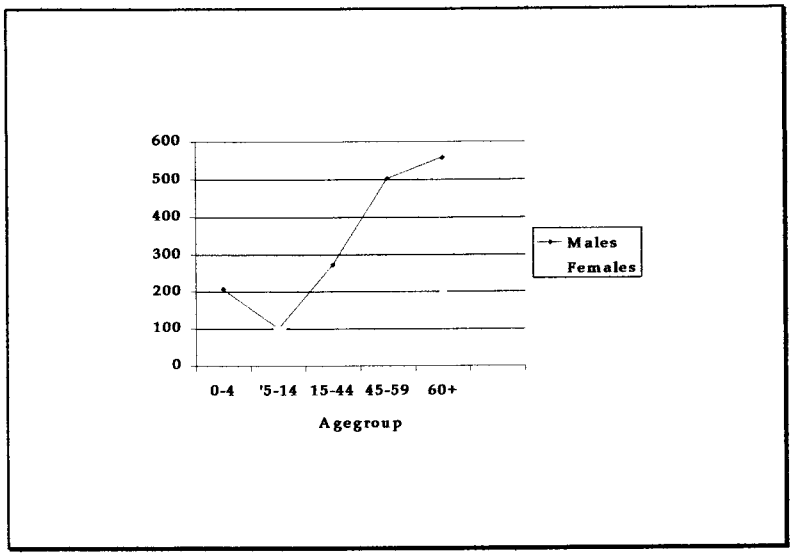



**DISMOD estimates of tuberculosis incidence rates by sex, SA 1990: Whites (per 100 000)**

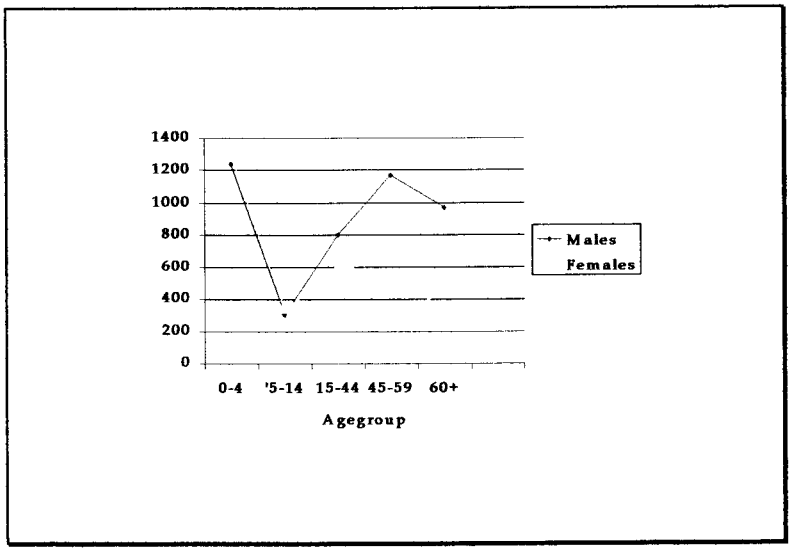


**Appendix 11 continued**

**Tuberculosis notification rates by sex, SA 1993: Africans (per 100 000)**




**Tuberculosis notification rates by sex, SA 1993: Coloureds (per 100 000)**



**Appendix 12: Estimates of the number of tuberculosis deaths in SA 1990, by population group, age and sex.**

| Age group | Number of tuberculosis deaths in SA 1990 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | African | | Coloured | | Asian | | White | | Total SA population | |
| Male | Reported * | Estimated | Reported * | Estimated | Reported * | Estimated | Reported * | Estimated | Reported * | Estimated |
| 0 – 4 | 136 | 389 | 28 | 35 | 2 | 3 | 0 | 0 | 166 | 427 |
| 5 – 14 | 63 | 162 | 4 | 8 | 0 | 0 | 0 | 0 | 67 | 170 |
| 15 – 44 | 2528 | 4356 | 352 | 614 | 9 | 14 | 5 | 9 | 2894 | 4993 |
| 45 – 59 | 2337 | 3403 | 258 | 300 | 4 | 7 | 10 | 17 | 2609 | 3727 |
| 60+ | 2197 | 3226 | 253 | 283 | 11 | 20 | 32 | 60 | 2493 | 3589 |
| **Total** | **7261** | **11536** | **895** | **1240** | **26** | **44** | **47** | **86** | **8229** | **12906** |
| **Female** | | | | | | | | | | |
| 0 – 4 | 102 | 282 | 30 | 38 | 0 | 0 | 0 | 0 | 132 | 319 |
| 5 – 14 | 65 | 116 | 3 | 6 | 0 | 0 | 0 | 0 | 68 | 122 |
| 15 – 44 | 1213 | 2108 | 256 | 359 | 4 | 8 | 1 | 2 | 1474 | 2477 |
| 45 – 59 | 632 | 943 | 123 | 134 | 11 | 18 | 2 | 3 | 768 | 1098 |
| 60+ | 917 | 1455 | 87 | 106 | 5 | 7 | 15 | 24 | 1024 | 1593 |
| **Total** | **2929** | **4904** | **499** | **643** | **20** | **33** | **18** | **29** | **3466** | **5609** |
| | | | | | | | | | | |
| **Overall total** | **10190** | **16440** | **1394** | **1883** | **46** | **77** | **65** | **115** | **11695** | **18515** |

* Central Statistical Services data for 1990

## Appendix 13: Tuberculosis case fatality rate and remission rate estimates for DISMOD, by age and population group, South Africa 1990

### African

| Age | Proportion treated (%) | Case fatality rate (%) Males (females in brackets) | | | Remission rate (%) | | |
|---|---|---|---|---|---|---|---|
| | | Rx* | Not Rx | Composite | Rx | Not Rx | Composite |
| 0 – 4 | 80 | 1 | 43 | 9.4 | 65 | 25 | 57 |
| 5 – 14 | 80 | 1 | 16 | 4 | 65 | 25 | 57 |
| 15 – 44 | 70 | 4 (3) | 41 | 15 (14.4) | 65 | 25 | 53 |
| 45 - 59 | 70 | 10 (7) | 66 | 26.8 (24.7) | 65 | 25 | 53 |
| 60+ | 70 | 25 (20) | 80 | 41.5 (38) | 65 | 25 | 53 |

* Treated

### Coloured

| Age | Proportion treated (%) | Case fatality rate (%) Males (females in brackets) | | | Remission rate (%) | | |
|---|---|---|---|---|---|---|---|
| | | Rx* | Not Rx | Composite | Rx | Not Rx | Composite |
| 0 – 4 | 90 | 1 | 43 | 5.2 | 65 | 25 | 61 |
| 5 – 14 | 90 | 1 | 16 | 2.5 | 65 | 25 | 61 |
| 15 – 44 | 90 | 4 (3) | 41 | 7.7 (6.8) | 65 | 25 | 61 |
| 45 - 59 | 90 | 10 (7) | 66 | 15.6 (12.9) | 65 | 25 | 61 |
| 60+ | 90 | 25 (20) | 80 | 30.5 (26) | 65 | 25 | 61 |

* Treated

### Asian

| Age | Proportion treated (%) | Case fatality rate (%) Males (females in brackets) | | | Remission rate (%) | | |
|---|---|---|---|---|---|---|---|
| | | Rx* | Not Rx | Composite | Rx | Not Rx | Composite |
| 0 – 4 | 95 | 1 | 43 | 3.1 | 65 | 25 | 63 |
| 5 – 14 | 95 | 1 | 16 | 1.75 | 65 | 25 | 63 |
| 15 – 44 | 95 | 4 (3) | 41 | 5.85 (4.9) | 65 | 25 | 63 |
| 45 - 59 | 95 | 10 (7) | 66 | 12.8 (9.9) | 65 | 25 | 63 |
| 60+ | 95 | 25 (20) | 80 | 27.8 (23) | 65 | 25 | 63 |

* Treated

### White

| Age | Proportion treated (%) | Case fatality rate (%) Males (females in brackets) | | | Remission rate (%) | | |
|---|---|---|---|---|---|---|---|
| | | Rx* | Not Rx | Composite | Rx | Not Rx | Composite |
| 0 – 4 | 95 | 1 | 43 | 3.1 | 65 | 25 | 63 |
| 5 – 14 | 95 | 1 | 16 | 1.75 | 65 | 25 | 63 |
| 15 – 44 | 95 | 4 (3) | 41 | 5.85 (4.9) | 65 | 25 | 63 |
| 45 - 59 | 95 | 10 (7) | 66 | 12.8 (9.9) | 65 | 25 | 63 |
| 60+ | 95 | 25 (20) | 80 | 27.8 (23) | 65 | 25 | 63 |

* Treated

**Appendix 14: Comparison of the effects of changing the discount rate (*r*) and age weighting modulating factor (*K*) on the composition of DALYs due to TB (as percentages of total DALYs)**

**Africans**

| | DALYs[*r*,*K*] | | | | | |
|---|---|---|---|---|---|---|
| | ***r*=0 *K*=0** | ***r*=0 *K*=1** | ***r*=0.03 *K*=0** | ***r*=0.03 *K*=1** | ***r*=0.1 *K*=0** | ***r*=0.1 *K*=1** |
| *By outcome* | | | | | | |
| Total YLD | **1.7** | 2.4 | 3.2 | **4.2** | 7.3 | 2.7 |
| Total YLL | **98.3** | 97.6 | 96.8 | **95.8** | 92.7 | 97.3 |
| | | | | | | |
| *By sex* | | | | | | |
| All males | **67.6** | 67.7 | 68.9 | **68.8** | 69.6 | 69.5 |
| All females | **32.4** | 32.3 | 31.1 | **31.2** | 30.4 | 30.5 |
| | | | | | | |
| *By age group* | | | | | | |
| 0 – 4 | **7.2** | 9.2 | 5.5 | **6.6** | 4.8 | 0.3 |
| 5 – 14 | **2.9** | 3.8 | 2.4 | **3.2** | 2.2 | 0.2 |
| 15 – 44 | **55.6** | 60.2 | 48.1 | **57.4** | 41.7 | 16.1 |
| 45 – 59 | **20.6** | 17.9 | 24.6 | **21** | 26.1 | 28.6 |
| 60+ | **13.8** | 8.9 | 19.5 | **11.8** | 25.2 | 54.8 |
| | | | | | | |

**Coloureds**

| | DALYs[*r*,*K*] | | | | | |
|---|---|---|---|---|---|---|
| | ***r*=0 *K*=0** | ***r*=0 *K*=1** | ***r*=0.03 *K*=0** | ***r*=0.03 *K*=1** | ***r*=0.1 *K*=0** | ***r*=0.1 *K*=1** |
| *By outcome* | | | | | | |
| Total YLD | 3.1 | 4.6 | 6 | 8 | 13.7 | 5.2 |
| Total YLL | 96.9 | 95.4 | 94 | 92 | 86.3 | 94.8 |
| | | | | | | |
| *By sex* | | | | | | |
| All males | 62.7 | 62.7 | 64 | 63.6 | 64.7 | 67.5 |
| All females | 37.3 | 37.3 | 36 | 36.4 | 35.3 | 32.5 |
| | | | | | | |
| *By age group* | | | | | | |
| 0 – 4 | 6.3 | 7.7 | 5.1 | 5.6 | 4.8 | 0.3 |
| 5 – 14 | 1.1 | 1.4 | 0.9 | 1.2 | 0.9 | 0.1 |
| 15 – 44 | 67.1 | 71.2 | 60.6 | 69.3 | 55.4 | 25.1 |
| 45 – 59 | 16.4 | 14 | 20.3 | 16.4 | 21.9 | 28.9 |
| 60+ | 9 | 5.6 | 13.1 | 7.5 | 17 | 45.5 |
| | | | | | | |

**Appendix 14 continued**

**Asians**

| | DALYs[r,K] | | | | | |
|---|---|---|---|---|---|---|
| | r=0 K=0 | r=0 K=1 | r=0.03 K=0 | r=0.03 K=1 | r=0.1 K=0 | r=0.1 K=1 |
| *By outcome* | | | | | | |
| Total YLD | **3.3** | 5.3 | 6 | **8.8** | 12.8 | 5.7 |
| Total YLL | **96.7** | 94.7 | 94 | **91.2** | 87.2 | 94.3 |
| | | | | | | |
| *By sex* | | | | | | |
| All males | **56.3** | 58.3 | 55.3 | **56.5** | 55.4 | 56.9 |
| All females | **43.7** | 41.7 | 44.7 | **43.5** | 44.6 | 43.1 |
| | | | | | | |
| *By age group* | | | | | | |
| 0 – 4 | **7.1** | 9.8 | 4.9 | **6.6** | 3.6 | 0.2 |
| 5 – 14 | **0** | 0 | 0 | **0** | 0 | 0 |
| 15 – 44 | **45.2** | 51.5 | 37.7 | **48.3** | 33.3 | 10.7 |
| 45 – 59 | **29.2** | 26.4 | 32.7 | **29.4** | 33.2 | 31.5 |
| 60+ | **18.4** | 12.4 | 24.6 | **15.6** | 29.9 | 57.6 |
| | | | | | | |

**Whites**

| | DALYs[r,K] | | | | | |
|---|---|---|---|---|---|---|
| | r=0 K=0 | r=0 K=1 | r=0.03 K=0 | r=0.03 K=1 | r=0.1 K=0 | r=0.1 K=1 |
| *By outcome* | | | | | | |
| Total YLD | **2.7** | 4.3 | 4.1 | **6.3** | 7.9 | 3.8 |
| Total YLL | **97.3** | 95.7 | 95.9 | **93.7** | 92.1 | 96.2 |
| | | | | | | |
| *By sex* | | | | | | |
| All males | **74.7** | 77.1 | 74.4 | **76.9** | 74.4 | 70.7 |
| All females | **25.3** | 22.9 | 25.6 | **23.2** | 25.6 | 29.3 |
| | | | | | | |
| *By age group* | | | | | | |
| 0 – 4 | **0.1** | 0.0 | 0.1 | **0.0** | 0.2 | 0.0 |
| 5 – 14 | **0.1** | 0.1 | 0.1 | **0.1** | 0.2 | 0.0 |
| 15 – 44 | **21.9** | 30.6 | 15.5 | **25.3** | 12 | 2.5 |
| 45 – 59 | **21.7** | 24.3 | 20.9 | **24.1** | 19 | 11.4 |
| 60+ | **56.3** | 45.1 | 63.4 | **50.4** | 68.6 | 86.1 |
| | | | | | | |