PhD THESIS

Title:

Cost Effectiveness Analysis of Tuberculosis Control Strategies among Migrants from Nigeria in the United Kingdom

Student:
Dr Nisser Ali Umar
(UEA Student Number: 3750167)

Supervisors:
Prof Richard Fordham (Primary Supervisor)
Prof Max Bachmann
Prof Ibrahim Abubakar

University of East Anglia
Norwich
United Kingdom

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ABSTRACT

Background: Tuberculosis is a leading cause of morbidity and mortality in several low- and middle income countries (LMICs). Despite a decline in the burden of tuberculosis (TB) over the last century in many high-income countries (HICs), including the United Kingdom, emerging evidence in the last 10 years reveals an increasing burden attributed mainly to immigration, particularly from countries with high TB incidence like Nigeria.

Methods: Based on Nigeria, this study explores the cost-effectiveness of three TB control strategies on reducing the potential burden of TB among Nigerian migrants to the United Kingdom. The three strategies explored were: *i)* Chest X Ray (CXR) Screening of Nigerian migrants at United Kingdom airports; *ii)* Interferon Gamma Release Assay (IGRA) Screening at airports; and *iii)* 'enlighten self-interest' investment of the UK government by supporting Nigeria to scale-up her country-based TB control programme. A decision analysis model was developed to estimate the cumulative probabilities of TB-related outcomes and the cost-effectiveness of each strategy. Quality Adjusted Life Years (QALYs) were used as the utility measure, and a 3% discount was applied to all future costs.

Results: Over 91,000 Nigerian migrants were estimated to come to the United Kingdom annually over the 20 years modelled. 21.62% of these migrants were likely to be screened for TB based on the current practice (or selection) of TB screening. The average cost of TB treatment in Nigeria was estimated at US $227. The median out-of-pocket patient cost for hospitalized cases was US$166.11, while ambulatory patients paid an estimated median cost of US$94.16, equivalent to about 9-38% of their average annual income. Delay in diagnosis of TB across various settings in Nigeria was attributable to the estimated high direct and indirect costs from TB. The mean cost, to the UK government, for investment (paying the whole funding gap)

in scaling up TB control in Nigeria was estimated at £253.78 (SD £25.84) per Nigerian migrant coming into the UK, CXR screening at £293.41 (£102.95), IGRA screening at £690.93 (£113.45), while not doing anything '*Nothing*' will still cost the UK government £70.29 (£31.52) per Nigerian migrant. The incremental cost-effectiveness ratio (ICER) for strategies – Investment in the Nigerian TB control, CXR, and IGRA – compared to strategy '*Nothing*' was estimated at £2,964/QALY, £15,712/QALY and £11,429/QALY, respectively.

Conclusions : Relative to the Nigerian GDP, this study reveals a high cost of TB treatment in Nigeria, suggesting a disproportionate expenditure on TB at the expense of other competing health needs in the Nigerian health sector. The study suggests, albeit with important limitations, a potential benefit to the United Kingdom when the WHO Stop TB Strategy program is fully scaled up in Nigeria. There is potential application of the findings of this study in other high-income countries that receive large numbers of migrants, and the low-income, but higher TB incidence, countries like Nigeria.

1. INTRODUCTION

1.1. OVERVIEW

This chapter presents the background information and approach to this thesis. It provides the general motivation, problem statement and justification of the research. The chapter also covers the research aim, objectives and anticipated outcomes. The thesis structure is also given in the concluding section of the chapter.

1.2. RESEARCH BACKGROUND

Tuberculosis (TB) has been among the top global health crisis for several decades (1). In the 2016 World Health Organization (WHO) global TB report (2), there were an estimated 10.4 million incident (new) cases and 1.4 million deaths from TB worldwide in 2015, with people living with HIV accounting for about 1.2 million (11%) of all new cases of TB globally. Currently, more than 2 billion people, about one-third of the world's population are infected with TB, with this accounting for almost 26% of all preventable deaths globally (1-3). Across world regions, the burden is unevenly distributed, with several regions disproportionately affected (3, 4). According to the WHO, six countries—India, Indonesia, China, Nigeria, Pakistan and South Africa—accounted for about 60% of the new cases of TB in 2015 (2). Africa has the highest TB incidence and mortality worldwide, with this accounting for about one-fourth of TB burden globally (1, 5). The response to the rising burden has also been a major challenge, especially in resource-constrained settings. Estimates suggest that in several world regions, about three million people were consistently not diagnosed, not treated, or possibly not officially covered by local or national TB programmes (6, 7). Indeed, many affected persons in this category will continue to be a source of infection to others, with this pointing to the need for a comprehensive global response (8).

One largely under-researched aspect of TB, especially in Africa, is the economic impact, given the size of the problem in the region (8, 9). Many affected persons are actually in the economically active and productive population age groups (10). In fact, the disease no longer affects only the poor, with many affected persons now having moderate education, and moderate incomes (10, 11). The direct costs to patient, family and several governments have been tremendously huge. In fact, one significant indirect cost of TB to a sick patient is income lost from the inability to go to work, with this estimated to about 20-30% income of a household yearly (12). Families and carers are also affected, especially among the inpatients (13). These all point to a large economic burden in settings with high TB incidence.

Tuberculosis (TB) is an infectious disease caused by a bacterium from the *Mycobacterium tuberculosis* complex. These comprise *M. tuberculosis, M. bovis, M. africanum* and *M. microti* (14). Depending on national guidelines for TB diagnosis and management, the case definition of TB varies slightly across countries (14). However, in most instances, it is necessary to isolate one of the *M. tuberculosis* complex organisms from the affected organ(s) for a case to be confirmed (15). *M. tuberculosis* complex is usually transmitted as an infectious aerosol, but also by ingestion of contaminated milk (usually *Mycobacterium bovis)*, or less commonly through direct inoculation (16). Humans, and rarely primates, are the primary reservoir (16). Sharing breathing space with an infectious (i.e. sputum smear-positive) person is the most important risk factor for acquiring infection (14). The transmission of a disease among persons depend on the clinical presentation of the TB, smear status, age of the infected person, proximity and duration of exposure to an infectious aerosol (from cough or sneeze), and if early diagnosis and prompt treatment were instituted (14). Except for rare conditions, for example a draining skin sinus, extra-pulmonary TB (other than laryngeal) is generally not communicable (16).

Generally, TB is a highly complex and poorly understood disease, having persistently infected people for several years, and even nowadays, despite the availability of antibiotics (17). There are many unanswered questions on the natural history, and impact of current interventions (17). This has prompted several debates among authors on the need to improve the understanding of the dynamic epidemiology of TB, especially regarding measures to control the spread of the disease across international borders (17, 18).

As already noted, TB disproportionately affects poor and marginalized populations, especially those who do not have access to health care and social support. This has been particularly observed in populations with high prevalence of HIV, which also shares links with poor socio-economic status (19). Evidence shows that HIV co-infection increases the risk of developing TB significantly (20). It specifically targets cell-mediated immunity, impairing its functions and processes (21). It can be understood that countries in sub-Saharan Africa with high prevalence of HIV, have continued to report an increasing trend in new TB cases over the last two decades (21, 22).

Although there has been a steady decline in the prevalence of TB in developed countries, recent evidence has shown a rise in both TB incidence and prevalence in these countries from the mid-1980s onward (23). This has been attributed mainly to immigration patterns (24). The lack of capacity of the health systems in developing countries to respond to the disease may have been an underlying factor. Hence, due to increasing migration from these settings with high TB incidence, high-income countries have now continued to witness a rising number of new TB cases (18).

Based on historical evidence, human migration has played important roles in the spread of TB worldwide (25, 26). In the seventeenth century, the first epidemic of TB—*White plague*—

occurred in Europe, with TB becoming the leading cause of death for several years (27). Subsequently, this spread to other continents, resulting in major TB epidemics across the world (28). With high-income countries tackling the disease, and substantial gaps existing in low-income settings, coupled with increased migration to high-incomes countries from low-income settings, increased TB prevalence has been reported in immigrants-receiving countries (29). Experts have estimated the proportion of TB patients that were foreign-born at 85% across low-incidence countries (29, 30). In the UK, TB notifications have increased over the last 30 years, increasing by about 50% to 9040 cases between 1998 and 2009 (31). Foreign-born individuals account for over 70% of TB notifications in the country, with a 22-fold increase in incidence rate at 89 cases per 100000, compared to 4 cases per 100000 in UK-born persons (31).

Reports show that several of these TB cases were due to reactivation of latent TB infection (LTBI) in the migrant population, which has been acquired before arriving the low-incidence countries, enhanced by high levels of migration from sub-Saharan Africa and India, which have high TB burdens (32). The International Union Against TB and Lung Diseases has already indicated a strong relationship between TB incidence and international migration, which need to be comprehensively reviewed to optimize control (29, 33).

In the last three decades, several developed countries have spent millions of United States Dollars (US$) annually for TB treatment in their respective countries (34). Despite the huge costs committed to the management of TB in these countries, more cases have continued to be imported by immigrants (28, 35). According to Pareek and colleagues, TB control in several high-income settings have historically targeted early identification and treatment of active TB cases with strict contact tracing (32). However, due to high TB loads in migrant populations, it still remains doubtful how best to identify (or contract-trace) TB in these groups (36).

Meanwhile, in developing countries, there is still a complex pathway required to be navigated by every patient to ensure effectiveness of TB control measures (37, 38). This involves presenting at local health centres, suspicion of TB by a clinician, ordering appropriate diagnostic investigations, making accurate diagnosis and commencement of the right medications (37). The loss of patients along this line can affect the epidemiological impact of a diagnostic intervention.

According to the WHO, population-wide improvements in the ability to detect TB, especially in resource-constrained settings, must be ensured (39). This is because TB is grossly under-diagnosed across world regions, with just about 67% of TB cases currently detected, and 57% with confirmed bacteriologic diagnosis (40). Insufficient laboratory capacity in several settings and relative costs of TB diagnosis, coupled with poor sensitivity and specificity of available diagnostic tools may have contributed to these challenges (41). It has been suggested that established market economies need to be carried along with new technological innovations to help address the cost of TB interventions, particularly because they eventually share in TB burden as a result of migration (42, 43). Besides, the current uncertainties surrounding the commitments of several governments also need to be addressed, possibly through a strong WHO backing of current and emerging interventions (44).

Largely, high-income countries have adopted two broad approaches to tackling TB—identifying active TB pre- or post-arrival in migrants, or identifying LTBI in migrants from TB endemic settings (45). Some observers have also stated that investments in TB control in high TB burden countries by providing targeted LTBI screening and treatment may be of huge benefits to migrants-receiving high-income countries, with this however requiring addressing inherent (country-based) challenges and barriers to successful implementation of these interventions (46,

47).

However, in the diagnosis of TB, an antecedent contact with a TB case has been found to be a significant clinical history in ensuring an accurate TB diagnosis, and also useful for contact tracing (48). A Chest X Ray (CXR) may be helpful but can also be misleading, as this requires other confirmatory tests and appropriate clinical history (49). A positive tuberculin skin test (TST) is useful, but a negative test does not exclude disease (48). However, many believe sputum microscopy for Acid Fast Bacilli (AFB) identification and culture remain the gold standard for detection of *Mycobacterium tuberculosis* (49). Some authors still suggest combination of these conventional methods with advanced diagnostic methods to enhance sensitivity and specificity, as detection of *Mycobacterium* specie may be sometimes difficult (50). In several advanced settings, multiplex polymerase chain reaction (PCR), or multiplex PCR- reverse cross blot hybridization is now being used as a confirmation assay, particularly for negative results from smear and culture (51-53).

A more recent diagnostic test, Interferon-Gamma Release Assays (IGRA), has several advantages over the TST and CXR (54). A two-step strategy is usually employed in LTBI-screening, with an initial TST, followed by IGRA if the TST is positive (55). One major advantage of IGRA over TST is the fact that it is an in-vitro test and does not require the subjective measurement of skin reactions, and only a single visit is necessary (56). These advantages therefore make IGRA an attractive alternative to replace the widely-adopted practice of CXR screening of migrants for TB at Port of Arrival (PoA) (56).

Over the years, migrants have been identified and screened through the PoA channels in the UK, but this system has been found to be relatively ineffective with only a small proportion of entrants screened annually, out of which only few have active TB at the time of entry (32, 57).

This has raised several debates on immigrant screening exercise. The UK National Institute for Health and Clinical Excellence (NICE) also noted that in addition to the use of CXR at points of arrival, the focus should be on adult immigrants from sub-Saharan Africa, with a combination of TST and a confirmatory IGRA (58). This guideline however received varying levels of adherence following reports suggesting the economic analyses on this guideline lacked relevant data on LTBI prevalence among migrants (29). There have been further reviews suggesting countries with TB incidence greater than 40 cases per 100000 should be screened with TST and a confirmatory IGRA (58). Again, these have also been debated by economists pointing out that the reviews were mainly based on scenarios rather than empirical data, with this failing to address the challenges on the preferred and cost-effective methods of TB screening among migrants (44, 45). Sanneh and colleagues did report that active PoA screening has significant benefits especially in identifying high risk groups, reducing periods of infectiousness and instituting early commencement of treatment (57). However due to high costs of some of the proposed interventions and challenges with implementation, it is still important to conduct a comprehensive assessment of the costs and associated benefits (45, 57). The next section gives insights into the main approaches to screening of TB in the UK.

1.3. APPROACH TO SCREENING OF TUBERCULOSIS IN THE UK

Tuberculosis screening for migrants before or when arriving developed countries started decades ago, particularly after the Second World War (59). CXR screening was the primary method adopted by these countries (60). At some time, general screening of the population was advocated but stopped when the burden of the disease significantly declined in these countries (59). In an 18-point questionnaire based survey to 31 member countries of the Or-

ganization for Economic Cooperation and Development, including the UK, 86% screened immigrants for active TB, and 55% screened for LTBI, with marked variations in populations covered (45). The report reveals most developed countries used TST (68%) and IGRA (38%) following a positive TST performed LTBI screening, mostly conducted with random selections and varying policies and guidelines (45).

In the UK, there is a '*Collaborative TB Strategy for England 2015-2020'*, which aims to achieve a yearly decrease in incidence of TB, address health inequalities occasioned by the disease, and ultimately eliminate TB as a public and global health problem in England (61). Targets have been set out in key areas to achieve this, including improving access to health services, ensuring early and high quality diagnostics, facilitating comprehensive contact tracing, and particularly systematically implementing immigrants' latent TB screening (61). There is growing evidence that active case detection, contact tracing and treatment of both active and latent cases are essential in effective control of TB (62). Migrants from high TB burden countries account for over 70% cases of TB in the UK (61, 63). Generally, immigrants planning to stay in the country for longer than 6 months undergo radiographic screening at international ports during first arrival, and if found or suspected to have active TB are referred to appropriate facilities for more investigations and care (64).

In the recently launched TB strategy in the UK, Latent TB infection (LTBI) screening is a key component. This is supported by the National Health Service (NHS) and Public Health England (61). Targeted population include all migrants aged 16-35 years entering the UK from a TB high incidence country (150 per 100,000 and over or from sub-Saharan Africa) within the last five years (46). The general approach is an Interferon Gamma Release Assay (IGRA) based screening, which will be conducted in a primary health centre, with positive individuals referred

to specialty infectious units (56). The programme may also provide opportunities for other health check initiatives. The launch of the strategy along with a clear vision and identified resources for a national LTBI screening programme would ensure that this intervention is properly implemented. The programme has a clear vision and identified needed resources, including a budget GB £10 million by NHS England for systematically implementing LTBI screening of new entrants (61). It is however still subject to further evaluation and economic analyses regarding the overall cost and effectiveness of the intervention. The next sections describe the three screening methods (CXR, TST and IGRA) in detail.

1.4. CHEST X-RAY (CXR) SCREENING

Legal immigrants and visitors planning to stay longer than 6 months in the UK undergo radiological screening for tuberculosis at least at the point of entry (64). However, adoption of other alternative screening methods, with treatment of latent tuberculosis infection, have been recommended by several experts (44, 65). Ideally, CXR can be suggestive of typical TB case with the classic unilateral lymphadenopathy, or lung field shadows (cavitations) indicating infiltration (66). However, there have been challenges in categorizing TB patients especially with the increase HIV prevalence and immunocompromised patients, with this subsequently increasing the number of atypical X-rays (67). It is important to note that the chance of any screening to diagnose a TB case is expressed by the sensitivity and specificity of the test, clinical presentation and severity of the disease, which in turn are influenced by a range of other factors (**Table 1.1**). Hence, the prevailing argument on the effectiveness of CXR screening is that it is limited by poor predictive value and several administrative and follow-up challenges (68). The specificity of CXR in detection of latent TB has been generally assumed to be very low (67). Other limitations include the fact that some migrants and visitors might not be screened based on the

screening eligibility guidelines that consider the 'migrant-declared' intended length of stay in the country (68), and exposure of foreign born residents who often visit their countries of birth (69).

Table 1.1. Sensitivity, specificity and predictive values of Chest X Ray (CXR) screening for pulmonary TB

	Sensitivity (95% CI)	***Specificity (95% CI)***	***PPV (95% CI)***	***NPV (95% CI)***
TB cases	91 (88–93)	67 (62–71)	0.78 (0.74–0.81)	0.84 (0.81–.088)
Any CXR pathology	92 (90–94)	63 (58–67)	0.76 (0.73–0.79)	0.86 (0.82–0.90)

Source: MRA van Cleeff et al. The role and performance of chest X-ray for the diagnosis of tuberculosis: A cost-effectiveness analysis in Nairobi, Kenya. BMC Infectious Diseases 2005, 5:111.(70)
PPV: Positive Predictive Value, NPV: Negative Predictive Value

1.5. TUBERCULIN SKIN TEST (TST)

As noted earlier, a CXR may be helpful but can also be misleading, as this requires other confirmatory tests and appropriate clinical history (49). A positive tuberculin skin test (TST) is useful, but a negative test does not exclude disease (48). Many have stated that an accurate diagnosis of LTBI depends on a positive TST, especially among contacts and groups likely to progress to active TB (71). But, TST may sometimes give false positive results due to a relatively poor specificity, owing to several antigens it shares with Bacille Calmette-Guerin (BCG) (72, 73). In fact, TST has been suggested as the most cost-effective diagnostic measure for preventing new cases of TB on a short-term basis (48).

1.6. INTERFERON GAMMA RELEASE ASSAYS (IGRA)

IGRA test is based on the detection of mycobacterium tuberculosis specific region of difference (RD1) antigen (56). It has been found to be effective in detecting latent TB, even in those that had BCG vaccine (73). IGRAs are whole-blood tests used in diagnosing *M. tuberculosis* infection (74). It specifically measures a person's immune response to *M. tuberculosis*. Fresh blood samples are obtained and mixed with antigens and controls. The principle for this test is based on the fact that T-cells (a class of white blood cells responsible for immunity against bacteria), once sensitized with tuberculosis antigens, produce immunoglobulin called interferon gamma (IFN-y) when in contact mycobacterial antigens (75). A significant elevation of this IFN-y is therefore presumed to be suggestive of TB (75, 76).

Recent systematic reviews show that in contrast to TST, IGRA has higher specificity and better correlation when exposed to M. tuberculosis (or active TB), and less cross-reactivity with BCG vaccine and other non-tuberculous mycobacterium (36, 37, 77, 78). In some clinical settings, Interferon Gamma Release Assays (IGRAs) have now been introduced, as it is broadly regarded as a more specific whole-blood tests in the diagnosis of LTBI (54, 76).

Largely, immigrant screening in the UK has been found to be useful in reducing the burden of TB in the country (29, 66). However, given several other factors that have affected the implementation of recommended strategies, especially with growing TB incidence in several low-income settings, it is important to comprehensively re-appraise the available options, and provide an evidence-based cost-effective strategy that meets contextual needs, and can be feasibly implemented across affected settings.

1.7. RESEARCH QUESTION

Although there have been several studies done to assess the cost effectiveness of contact tracing

and TST for detecting TB among migrants over the conventional CXR screening. To the best of the author's knowledge, no study has yet compared the cost effectiveness of a proactive approach of reducing TB burden among migrants coming into the UK from high TB incidence country as against the cost-effectiveness of the conventional CXR screening, nor with the cost-effectiveness of IGRA screenings for TB among migrants entering the UK from these high TB incidence countries.

In view of the aforementioned, this study seeks to answer the question:

What is the relative cost-effectiveness of '*doing nothing*' as an alternative TB control strategy by the UK government to some selected alternative interventions. The selected alternatives are: *i*) Investment in scale-up of TB control programmes in high TB incidence country like Nigeria (as a proactive approach to reduce influx of TB cases from the country); *ii*) IGRA for screening of all migrants entering the UK from the high incidence country, or *iii*) CXR screening for migrants at points of entry.

1.8. RESEARCH JUSTIFICATION

Nigeria is the most populous country in Africa, and with high incidence and overall burden of TB. The influx of Nigerians to the UK has increased in the last three decades, as many are in pursuit of higher degrees, employment, seeking asylum, or in search better opportunities. Hence, there is a relative chance for decrease in TB incidence in the UK with a potential reduction in TB imports from Nigeria if appropriate control measures are applied. Implementation of the WHO strategy is a proven approach to limit the incidence and prevalence of TB in countries with a high prevalence of the disease (79, 80); thus, reducing the burden amongst entrants coming to UK from those countries. However, due to reasons primarily attributed to inadequate funding and a host of contextual factors, the implementations of these

strategies in those countries remain far from complete (81). These countries, therefore, act as reservoirs for TB, and adding burden to countries where the disease has hither-to been controlled. This is particularly due to significant international travels and migrations from high incidence to low incidence countries. It is therefore worthwhile to compare control strategies with regards to the cost of these interventions and their effectiveness, towards providing evidence-based options that can be implemented in affected settings. The research has been largely motivated by the relative knowledge gap on the potential returns in donor countries (i.e. anticipated accrued savings from cases and deaths averted in donor countries) obtainable from investments in disease control programmes in low-income countries.

1.9. AIM AND OBJECTIVES

The main aim of this research is to evaluate the cost-effectiveness of 'doing nothing' as an alternative TB control strategy by the UK government to some selected alternative interventions. These alternatives are: *i*) Investment in scale-up of TB control programmes in high TB incidence country like Nigeria (as a proactive approach to reduce influx of TB cases from the country); *ii*) IGRA for screening of all migrants entering the UK from the high incidence country, or *iii*) CXR screening for migrants at points of entry.

However, to quantify the cost of the 'enlighten self interest spending' in scaling up the TB control program in Nigeria it is necessary to also evaluate the cost of TB detection and treatment in Nigeria, the burden of TB in the country and the funding deficit (gap) that when provided the country will able detect and treat target cases of TB over a period of time.

Thus, the first 6 objectives of this research aims to evaluate the cost, burden and funding gap for TB detection, treatment and care in Nigeria while the 7th objective aims to address the primary study goal of evaluating the cost effectiveness of the alternatives under consideration.

These objectives are as follows:

- To estimate the provider cost for the treatment of TB in Nigeria.
- To estimate the patient (direct and indirect) cost associated with TB treatment in Nigeria.
- To estimate the total cost attributable to TB control programme in Nigeria.
- To estimate the total cost that will be required to scale up TB control programme in Nigeria from the present level to a coverage rate of 100%, case detection rate of 80% and treatment success rate of 80%.
- To estimate the funding gap for scaling up TB control programme in Nigeria
- To estimate the impact of scaling up TB control programme in terms of number of latent and active TB cases averted in Nigeria and amongst migrants coming to the UK.
- To compare the cost-effectiveness of 'doing nothing' to the three (3) proposed alternatives interventions (Investment to scale up TB control programme in Nigeria, IGRA screening, or CXR screenings for migrants at points of entry).

1.10. STUDY EXPECTATIONS

It is intended that this research will provide a guide for policy makers and other stakeholders in Nigeria and internationally on the cost attributable to TB burden and overall management in Nigeria. It will also provide evidence for or against investment in TB control interventions in

high TB incidence countries (as a cost- effective approach) to mitigate influx of TB cases from these countries to low incidence countries.

1.11. THESIS STRUCTURE

This thesis is presented in 7 distinct but interrelated chapters.

A literature search was conducted to aid the discussion of findings in the thesis. As this was not a systematic review, there were no distinct inclusion or exclusion criteria, and no systematic extraction or synthesis of findings obtained in the literature. Studies were mainly scoped for three key words (*cost-effectiveness/ economic analysis*; *Tuberculosis*; and *Developing countries*). The **Table 1.2** gives a summary of the search terms and results of the searches conducted in MEDLINE and EMBASE. Searches were conducted in December 2016, and related findings have been included under relevant chapters and sections of the thesis.

Table 1.2. Literature search terms and results

#	***Searches***	***MEDLINE Results***	***EMBASE Results***
1	((Low- and middle-income countr*) or Developing Countr* or Developing Nation* or Least Developed Countr* or Less-Developed Countr* or Less-Developed Nation* or Third-World Countr* or Third-World Nation* or Under-Developed Countr* or Under-Developed Nation* or resource limited setting*).af.	122905	134501
2	(Costs or Cost analysis or Cost Benefit Analysis or Cost Effectiveness or Cost-Benefit Data or Cost-Effectiveness Analysis or Cost-Utility Analysis or (Costs and Benefits) or Economic Evaluation or Marginal Analysis or Incremental cost-effectiveness ratio or Economic analysis or Quality-adjusted life years or Disability-adjusted life years or Adjusted Life Years).af.	286548	389837

3	(Tuberculosis or TB or Mycobacterium tuberculosis).af.	253847	268453
4	1 and 2 and 3	399	536

- *Chapter 1* describes the problem background, research justification, aim and objectives of the study and the study expectations;

- *Chapter 2* (addresses the 1st Objective of the study) describes the method, assumptions, descriptions and evaluation of the provider cost of TB treatment in Nigeria;

- *Chapter 3* (addresses the 2nd Objective of the study) describes the method, assumptions, descriptions and evaluation of the direct cost incurred by TB patients in Nigeria attributable to TB treatment;

- *Chapter 4* (also addresses the 2nd Objective of the study) describes the method, assumptions, descriptions and evaluation of the indirect cost (valued time lost and productivity lost) incurred by TB patients in Nigeria attributable to TB disease and treatment; (NB: although both the 'direct' and 'indirect' patient costs due to TB are estimated in Chapters 3 and 4 respectively, these estimates have not been factored in the CEA model in Chapter 7 primarily because the perspective of the CEA is for the UK Government and only captured the provider cost of treatment of TB in Nigeria. However, this analysis is included in the thesis to highlight some of the positive externalities (humanitarian) of the 'Investment in Nigerian TB Control" as an alternative.

- *Chapter 5* (address the 3rd, 4th, 5th and 6th Objectives of the study) describes the method, assumptions, descriptions and evaluation of the total cost of TB control programme in Nigeria and the cost of scaling up the programme as well as impact and the required funding gap for the scale up;

- *Chapter 6* (addresses the 7th Objective of the study) describes the method, assumptions, descriptions and evaluation of the cost effectiveness analysis model comparing three alternative strategies for TB control among migrants from Nigeria to the UK; and

- *Chapter 7* covers the thesis synthesis, contribution to body of knowledge and recommendations for further research.

2. PROVIDER COST OF TUBERCULOSIS TREATMENT IN NIGERIA

Acknowledgement

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http://www.publichealthinafrica.org/index.php/jphia/article/view/jphia.2011.e19.

Authors' Contributions: NU designed the study, collected and analyzed the data, and drafted the manuscript. RF, MB and IA provided supervisory support, vetted and approved the manuscript as part of the PhD work.

2.1. BACKGROUND

Nigeria, like most third world countries, is severely resource constrained in the provision of health care services (51). Nigeria has the fourth highest burden of tuberculosis (TB) in the world after India, Indonesia, and China, with an incidence rate of 322 per 100,000, prevalence at 521 per 100,000, and mortality at 99 per 100,000 populations, respectively in 2015 (2). Despite Nigeria's gross domestic product (GDP) per capita at US$ 1376 in 2008 (53), only about 6.6% of GDP per capita was spent on health in that year (82), most of which was spent on staff wages (83).

Underfunding, resource leakage and wastage due to corruption and incompetence were seen by several experts as the main reasons behind the prevalent misdiagnosis and low case detection rates of TB in the country over past decades despite the enormous resources invested by both the government and international development partners (84, 85).

The complexity and cost of treating TB has increased in recent years due to emergence of multi drug resistant TB (MDR-TB) strains, significant proportion of TB patients co-infected with HIV, high rates of both TB and HIV infections in difficult-to-reach populations, and the delays in diagnosis (86).

Walker and colleagues noted that the role of the provider of care is to ensure accurate diagnosis and correct treatment of TB in the population within the limited resources available (66). However, incorrect diagnosis, among several other factors, has contributed to high overall cost of provider care in many low-income settings (43). For instance, under-diagnosis of TB may likely aid further spread of the disease, as several people remain undiagnosed and are at risk of spreading the disease to others (66). Over-diagnosis leads to a waste of limited resources in these settings due to commencement of inappropriate medications (43, 66).

Although significant work has been done in evaluating the economic burden of TB among patients, society and providers in several developed and developing countries, some methodological challenges have been reported during these appraisals (87). Essentially, the specifications of appropriate alternative interventions, the need to measure and consider relevant costs that need to be avoided, and the difficulties of measuring and comparing outcomes across populations, are among the main challenges towards estimating provider cost of TB treatment in developing countries (87).

Moreover, these challenges may have contributed to a paucity of comprehensive studies on provide costs evaluation in sub-Saharan Africa (sSA) (88). Besides, experts have noted it is worthwhile to identify newer provider-based approaches to tuberculosis treatment that are effective, contextually adaptable, and put less demand on limited health resources in developing countries (89). There is a clear need for such provider data and research for evidence-based

planning and efficient management of TB control programs in Nigeria. To address this and contribute to existing knowledge, this study aimed to evaluate the provider cost of TB diagnostic and treatment services in Bauchi State, Nigeria.

2.2. STUDY AREA AND SETTING

Bauchi State is in the North-Eastern region of Nigeria and is the 7th most populous state in the country. It occupies a land mass area of 49,259 sq. Km with a total population of 4,676,465 inhabitants (90). The population of the State are served by about 950 government health facilities (two tertiary hospitals, 19 secondary hospitals, 81 primary health care centers, 213 maternity and child health centers, 636 dispensaries/health posts) (91). However, only 67 of these government facilities provide tuberculosis care facilities. These include the two tertiary hospitals, 18 general hospitals, one infectious diseases hospital, 14 primary healthcare with diagnostic (smear microscopy) capacity, 25 treatment centers (also primary healthcare centers. Three privately owned clinics in the state provide tuberculosis services (91).

Nigeria also run a National Tuberculosis Control Programme, which is based on the internationally recommended WHO Stop TB strategy. It provides free investigations quality drugs to aid diagnosis and treatment of TB. The programme also allows decentralized treatment services to be offered close to patients' residence under direct observation with the help of government health workers and community volunteers (92).

In health facilities, clinicians, community health officers, nurses and other hospital staff attend to these patients in either outpatient department, where suspected TB patients are initially seen, diagnosed or followed up, or in general medical wards, where inpatient care is provided to patients with serious conditions requiring closer clinical attention. Patients suspected of having TB are usually asked to submit three early morning sputum for acid-fast bacilli tests in three

consecutive days. Diagnosis is either based on sputum positive smear or clinical and radiological judgment when the sputum result is negative (92).

Directly observed therapy (DOT) is carried out in the first two months of treatment for those patients who live close to the clinics. However, family members and friends are usually relied on to give or make sure patients take medications in those that live far from the clinic or are stable but too weak to reach the clinic. Generally, during the remaining six months of treatment, patients only come in once every two weeks for refills. The DOT clinics are designated rooms in the hospitals for patients coming in to be weighed, reviewed, and receive treatment or pick their refills. The DOT clinic is also the place where the TB register is kept and TB notifications are made. A nurse or a community health officer usually oversees these clinics. Any patient diagnosed with TB is usually referred for HIV voluntary testing and counselling, and if positive is referred to the nearest anti-retro viral therapy (ART) clinic where free HIV treatment is usually available.

2.3. STUDY DESIGN

This is a cross sectional study where a questionnaire was used to assess the provider cost of TB diagnosis and treatment. The questionnaire used was developed using the WHO cost analysis guidelines (93). The methodology used in estimating this cost is primarily a 'Bottom-up estimation approach' breaking down composite services into different cost dimensions which are then summarized or "rolled up" to determine an overall cost estimate for the cost of care per patient. This type of estimate is generally more accurate than other methods (parametric, analogous or expert judgement estimations) since it is looking at costs from a more granular perspective.

Questionnaire was piloted in 2 facilities in May 2008, and was found to be practical and reliable.

Between June and August 2008, a total of 27 facilities were stratified and randomly sampled out of the 67 facilities providing TB services in the state.

Ethical approval was sought and granted for this research from the Bauchi State Ministry of Health.

2.4. DATA COLLECTION

All sampled facilities were visited and questionnaires administered with the help of relevant members of staff. There were no outpatient attendance records, or reliable inpatient registers or patient records in all the facilities. However, the records from the TB notification and DOT register showed no pattern in weekly, monthly or annual incidence or proportion of TB cases in all except one treatment center that reportedly sees fewer patients in rainy season due to bad road conditions. Based on this information, and in the absence of a reference proportion of TB patient population, this study assumed the average patient counts done on the 3 randomly selected days in 12 consecutive clinic days, considered to represent the daily patient population in the hospital. However, Mondays were excluded because of possible bias resulting from higher patients coming in following weekend closure. Based on the number of both TB and total populations on these days, the proportions of TB patients receiving inpatient and outpatient care were calculated and used to allocate weigh costs for inpatient and outpatient services per patient receiving TB service in the facility. Overhead and general cost was also allocated based on proportion of TB patient in the overall facility patients' population from the total overhead spent in the facility.

Staff costs were mostly shared; hence, costs were calculated using proportional time allocation (proportion of staff time). Additional 29% fringe was added to staff cost based on the rate used by the state Ministry of Budget and Planning. Building cost was estimated from a cost per square

meter estimation made from recently built facilities in the state. The average lifespan of buildings was assumed to be 30 years based on an unpublished report from the Ministry of Works.

The annual inflation rate in the country was 10.9% in 2008 and 12.6% in 2009 (94). Real time deposit interest rate was 9.87% in 2008 and 12 months' deposit rate was 12.6% in 2008 and 13.6% in 2009 (95). Based on these economic indices, depreciation method of discounting was applied on the assumption that the net effect of both inflation and interest rates will be minimal. Thus, the annual discount rates for buildings was assumed to be 3.5% based on a 30-year lifespan, and 10% for general office and medical equipment based on a 10-year lifespan. The replacement cost of equipment was also estimated from contract documents for supplies of equipment made for the government for the facilities in the state. All currency value reported in the study was based on the US $ PPP as at November 2008 value. Amounts quoted in UK Pound Sterling (£) is a based-on November 2008 $/£/Naira exchange rate.

The drug cost for 2 months' treatment with Rifampicin, Isoniazid, Ethambutol Pyrazinamide and 6 months of Ethambutol and Isoniazid (2RHZE/6EH) as first line TB drugs per patient was assumed to be (in 2008) US$ 19. The second line drugs treatment with 2 months of Streptomycin, Rifampicin, Isoniazid, Ethambutol, Pyrazinamide and a month of Rifampicin, Isoniazid, Ethambutol Pyrazinamide followed by 5 months of Rifampicin, Isoniazid, Ethambutol (2SRHZE/1RHZE/5RHE) per patient was estimated at (in 2008) US$ 46, all based on WHO estimates (96).

To estimate the cost of a sputum acid fast bacilli (AFB) test, the average cost was estimated from the market prices rates in 4 independent laboratories across the state, less by 35% (assumed profit margin). Another assumption made was that each TB patient would have at least 3 sputum

AFB tests during diagnosis and treatment. Each TB patient was also assumed to be screened for HIV at the point of TB diagnosis or while on treatment, and the cost of HIV screening was also by same method from 4 independent laboratories across the state. Another assumption made in the study is that only patients that are sputum negative get CXR, at least once during TB diagnosis and treatment. This assumption is based on the practice reported in all the diagnostic centers. The cost of CXR was also estimated from the average, less by 35%, of price quotations from 4 independent x-ray facilities across the state.

2.5. ANALYSIS

The Nigerian Naira amounts were subsequently converted to US dollar based on the currency exchange rate (Official rate from Central Bank of Nigeria in November, 2008) of NGR 118.5 to 1 US in 2008 (95). The estimated cost attributable to TB treatments per facility was calculated from the summation of all TB attributable to the cost elements in each center.

The average proportions of TB patients in outpatient, inpatients and general patient populations were estimated and dispersion of the measurement described. The WHO Choice programme (service delivery) costs template was adopted (including administrative support, training, building costs, electricity, water etc). Differences in costs between levels of service provision and urban rural divide were assessed and reported. Diagrams were also drawn to appreciate these differences. Student t-test was done to test the significance of the differences of mean.

2.6. RESULTS

Seventeen out of 50 Primary care centers TB services in the state were randomly sampled. Out of these 17 facilities, 11 provide treatment services only, while the remaining 6 treatment centers sampled provide both diagnostics and treatment services. Nine facilities are secondary care providers and one is a tertiary service provider. Four treatment centers sampled have less than

10 bed capacities, 5 other treatment centers have between 10 and 20 bed capacities, the remaining two treatment centers and six of the diagnostics primary care centers have between 20 and 50 bed capacities. All secondary care providers have between 100 and 180 bed capacities and the tertiary care Centre has about 600 bed capacity.

2.6.1. Proportions of tuberculosis patients in facilities

The proportion of TB patients in the total patient population on the day of the research visit varied slightly between facilities. The mean of proportions for the total TB patient population within the patient populations in the facilities was 0.034 (SD 0.016; 95% CI 0.028-0.041). Non-parametric one-way ANOVA (Kruskal-Wallis Test) showed no significant (P=0.2578) deviation in the ratio TB patients/total patient population among the facilities sample in the study.

The proportion of TB inpatients in inpatient population in all the facilities was estimated at 0.33 (SD 0.037; 95% CI 0.019-0.048) and the proportion of TB outpatients in outpatient population was 0.03 1 (SD 0.013; 95% CI 0.026-0.036). Kruskal-Wallis Test showed significant (P=0.0036) difference in the ratio of hospitalized TB patients to the total hospitalized patient population among the facilities sample in the study.

However, by taking out the ‘infectious diseases hospital’, a hospital designated as a referral hospital to treat infectious diseases with much higher proportion of TB patients, the variability became statistically insignificant (P=0.3212).

The ratio TB cases to total outpatient population in all the facilities was 0.031, and the variation among facilities, tested by Kruskal-Wallis Test in the sample was not significant (P=0.3948) (**Table 2.1; Figures 2.1, 2.2 and 2.3**).

Table 2.1. The proportions of TB patients in the whole facility patient population as well as in outpatients and inpatients population by facility level

Facility Level	***Prop. of all TB patients in facility patient population (SD)***	***Av. Prop. of TB inpatients in facility inpatient population (SD)***	***Av. Prop. of TB outpatients in facility outpatient population (SD)***
Tertiary Hospital	0.03 (0)	0.03 (0)	0.03 (0)
Infectious Disease Hospital	0.11 (0)	0.19 (0)	0.08 (0)
General Hospitals	0.036 (0.011)	0.041 (0.014)	0.03 (0.08)
PHC (D)	0.04 (0.02)	0.038 (0.0147)	0.027 (0.01)
PHC (T)	0.029 (0.009)	0.015 (0.013)	0.032 (0.014)
For all facilities	0.034 (0.019)	0.033 (0.037)	0.031 (0.013)

PHC: primary health centre

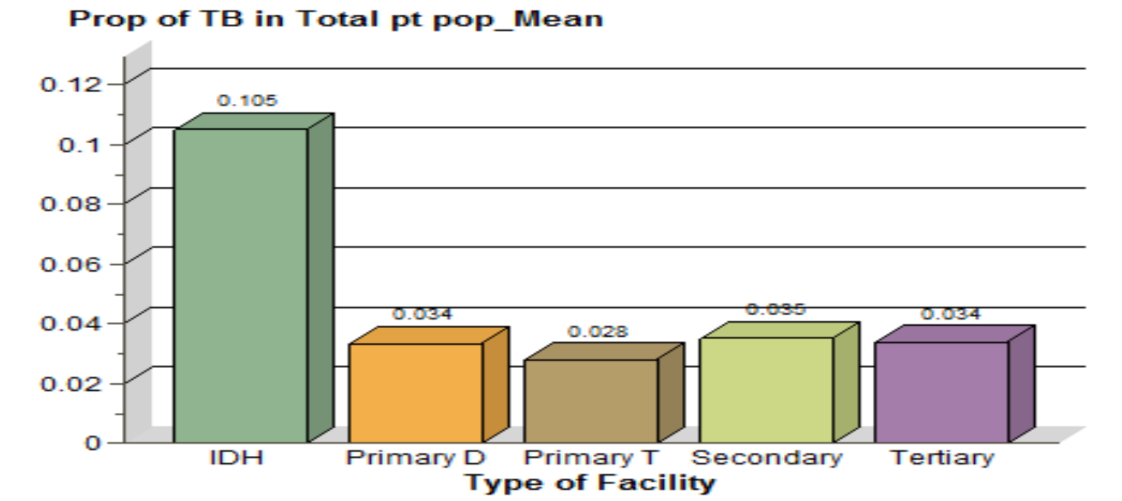

Figure 2.1. Histogram showing the (total) proportion of TB patients by facility types

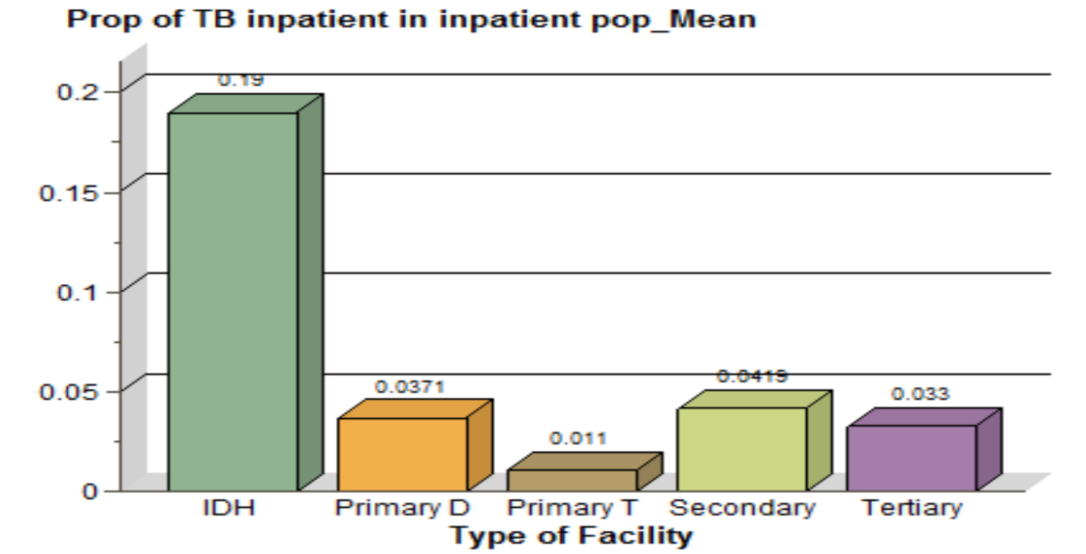

Figure 2.2. Histogram showing the (inpatient) proportion of TB patients by facility types

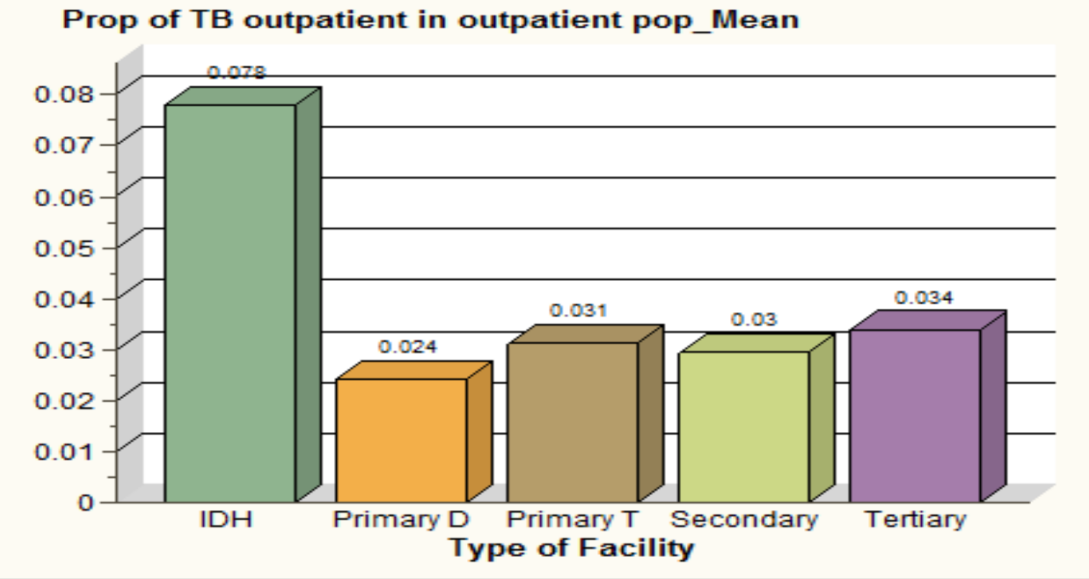

Figure 2.3. Histogram showing the (outpatient) proportion of TB patients by facility types

2.6.2. The cost of tuberculosis treatment per patient

The average provider cost attributable to TB diagnosis and treatment in Bauchi State was estimated at US $206.22 per patient treated. These total and all cost elements, except for DOT services, were observed to be highest in the tertiary center and least expensive in the infectious diseases hospital. However, the variation between facility type in the cost per patient, using Kruskal-Wallis method, was not significant (P=0.1407).

Of all the cost elements estimated, the costs of providing DOT services contribute highest in all the facilities, ranging from US$ 148 (61% of the total cost) in Primary Healthcare treatment centers to US$ 21 (23% of total cost) in the Infectious Diseases hospital. This could be due to the lower number of patients in those facilities despite the human and other resources stationed to provide the DOT. The difference in the cost of DOT services between facilities was found to be statistically not significant, with a P value of 0.1407 (Kruskal-Wallis χ2-test).

The average overhead cost estimate for all the centers in this study was US$ 30.89 per TB patient

(SD 16.55; 95% CI 24.35- 37.44). The estimated overhead cost was only about US$ 11 (12% of the total cost) in the 'infectious diseases' hospital, but as high as US$ 74 (29% of total cost) in the 'tertiary hospital' though these observed differences between the centers was also found to be statistically not significant (P=0.1281) by Kruskal-Wallis χ-test. Sensitivity analysis may not be necessary to explore the robustness of the analysis, and reasons behind the high differential in costs between different institutions in Nigeria, because the cost drivers are very predictable. For instance, the low overhead cost, high patients' turnover and high proportion of TB patients in 'infectious disease' hospital makes the attributable cost of TB care in infectious disease hospital very low contrary to what was observed in 'tertiary hospital'.

The average cost of hospitalization for TB patients was estimated at US$ 16.95 per TB patient (SD 13.99; 95% CI 11.41- 22.48). The average cost of follow-up visits was estimated at US$ 6.26 (SD US$ 4.02; 95% CI US$ 4.67- $7.85) and the cost of DOT services estimated at $119.27 (SD US$ 67.81; 95% CI US$ 92.45- US$ 146.10). There is significant variance in the cost of DOT services per patient between by facility type, P value of 0.0273 (Kruskal-Wallis χ-test).

Ninety-one percent of patients in all the facilities were assumed to be on first line drugs and 9% on second lines based on the reported prevalence resistance to first line anti TB drugs resistance. A weighted estimation of the cost of anti TB drugs was US$ 21.43 per patient treated in any facility and the cost estimate for AFB sputum tests, HIV screening and chest X-rays for sputum negative patients was US$ 23.20 per TB patient (**Table 2.2; Figures 2.4, 2.5, 2.6 and 2.7**).

Table 2.2. The average cost of TB services per patient by facility type

Facility Level	***Average Overhead cost/Pt (SD) in US $***	***Inpatient services cost/Pt (SD) in US $***	***Outpatient services cost/Pt (SD) in US $***	***Total cost of TB care/pt (inc drugs and tests) (SD) in US $***
Tertiary Hospital	$74 (0)	$25 (0)	$111 (0)	$256 (0)
Infectious Disease Hospital	$11 (0)	$13 (0)	$24 (0)	$93 (0)
General Hospitals	$32 (14.2)	$22.88 (12.8)	$96.38 (63.42)	$197 (83.75)
PHC (Diagnostic)	$22.67 (7.26)	$22 (15.84)	$134.5 (30.65)	$225.67 (43.42)
PHC (Treatment)	$32.45 (16.76)	$9.45 (12.27)	$171.55 (80.99)	$259.45 (84.82)
For all facility	**$30.89 (16.55)**	**$16.95 (13.99)**	**$133.34 (72.92)**	**$227.14 (80.34)**

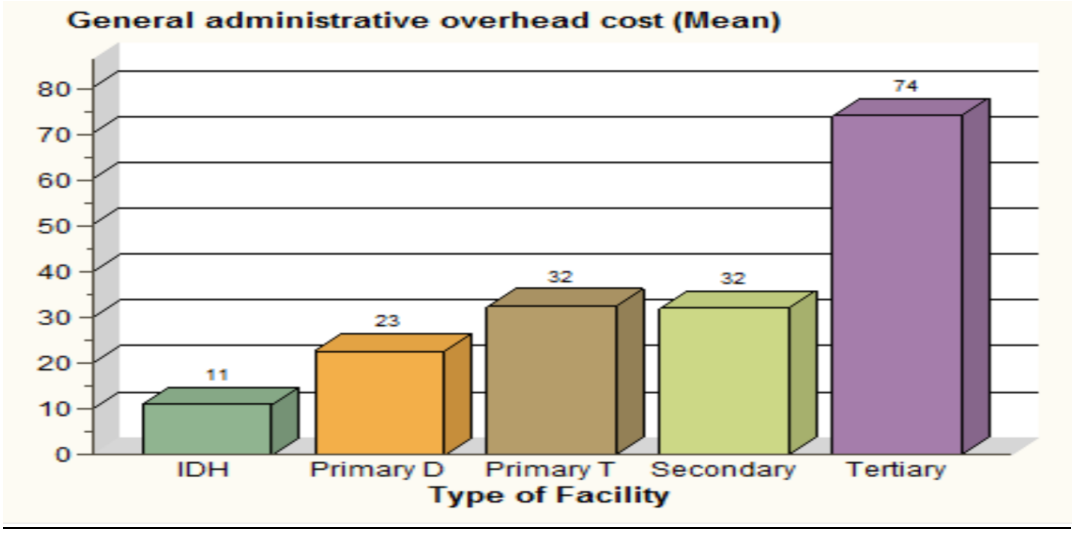

Figure 2.4. Histogram showing the general administrative overhead cost/patient by facility types

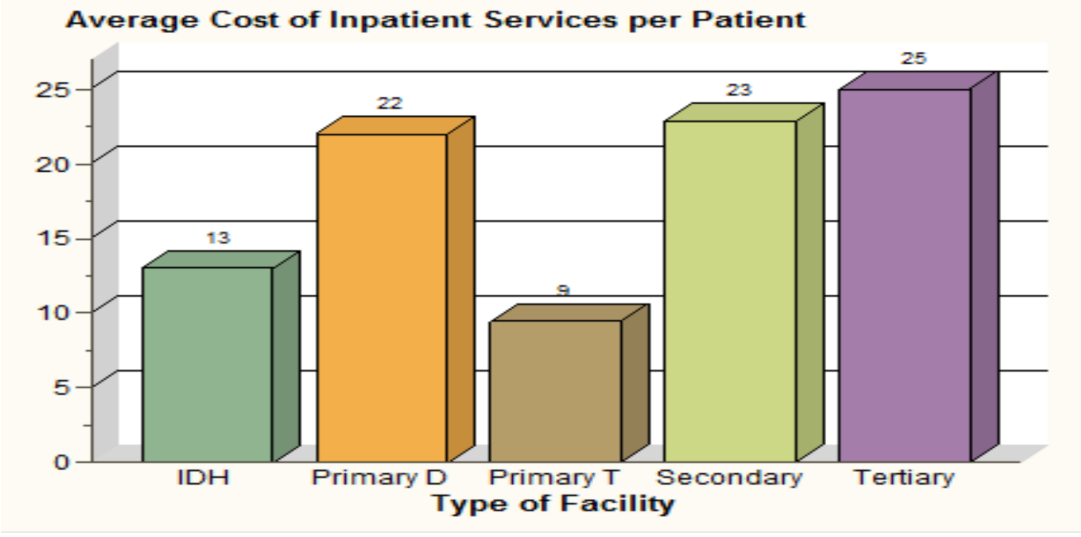

Figure 2.5. Histogram showing the average inpatient cost/patient by facility types

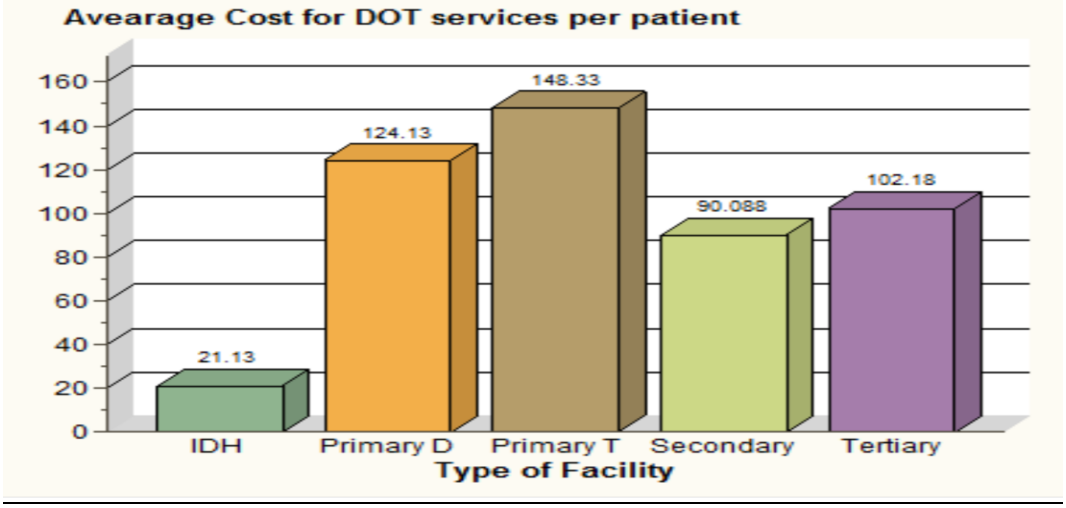

Figure 2.6. Histogram showing the average DOT services cost/patient by facility types

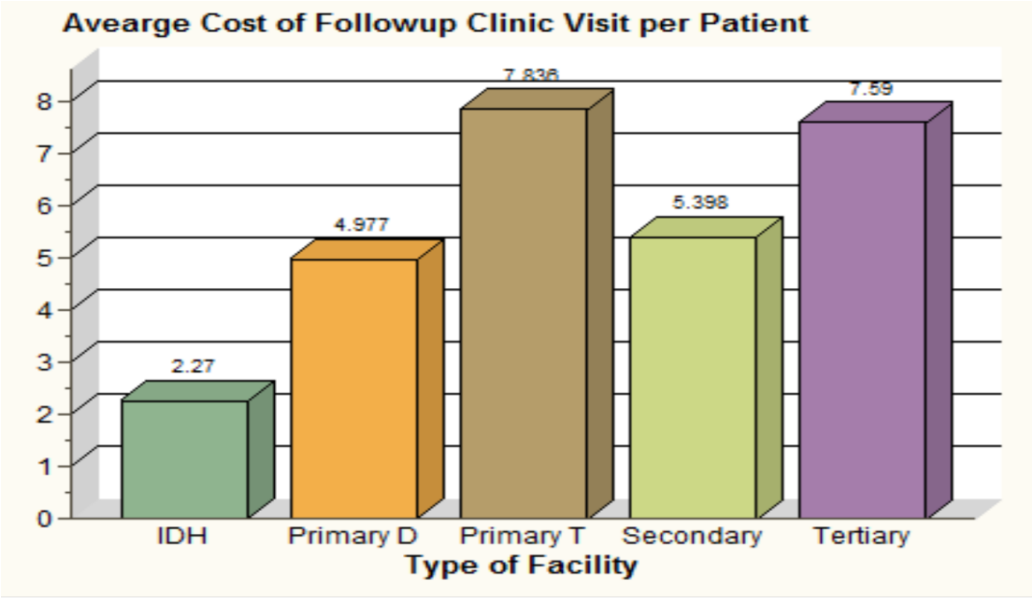

Figure 2.7. Histogram showing the average follow-up visits cost/patient by facility types

2.7. DISCUSSION

Tuberculosis cases constitute about 3.4% of all patients, 3.3% of all inpatients and 3.1% of all outpatients receiving care in government health care facilities across Bauchi State, Nigeria. The average cost for treating a patient with TB was estimated at US $206.22, with inpatient cost

estimated at US $16.95/patient, outpatient cost including the direct observed therapy short-course (DOTS) services at US $133.34/patient, and average overhead cost per patient estimated at US $30.89/patient treated.

The high cost of DOTS (and outpatient management) has been observed by some authors, possibly due to the longer periods of treatment and monitoring involved (97). But, on the long-term, DOTS has been adjudged cost-effective and was relatively linked to the achievement of the then millennium development goals in developing countries (before it was abolished in 2015) (98). DOTS is particularly cost-effective in the treatment of smear-negative, extra-pulmonary and multidrug resistant TB cases (98). In Tanzania, Wandwalo et al. also noted that from all perspectives, including providers', patients' and supervisors', community-based approach to delivery of DOTS was more cost-effective compared to other facility-based treatment options (4). It was estimated to reduce the cost of treating a patient by over 33% in the settings (4).

Primary health care diagnostic centers were observed to spend less overhead cost per patient than that the general hospitals and primary health care treatment centers. This is probably due to inadequate staffing and lower budget for recurrent spending in primary health care diagnostic centers with higher proportion of TB patients and higher patient population. While a higher overhead cost per patient in general hospitals and primary health care treatment centers with lower proportion of TB patients and lower patient population is due to more staffing and recurrent spending.

The 'Infectious Diseases' hospital had the lowest cost of all cost components per patient treated, probably due to a lower marginal cost that result from economies of scale. The inpatients services cost per patient was slightly higher in the tertiary hospital probably because of the

higher cost of staff and more recurrent spending.

The study also showed that the cost of inpatient service care per patient in the primary health care treatment centers was much less than in general hospitals and primary health care diagnostic centers. Inadequate staffing and low inpatient capacity or lower recurrent spending in primary health care treatment centers with higher proportion of TB patients may also be responsible for this. It may also be attributed to more staffing and higher recurrent spending in general hospitals and primary health care diagnostic centers with lower proportion of TB patients.

Contrary to the inpatient cost, the outpatients' services cost per patient was highest in both primary health care treatment and diagnostic centers. This is probably because of higher proportion of TB patients in a low outpatient population. However, 'Infectious Diseases' hospital spent least compared to general hospitals and tertiary centers. This could be due to inadequate staffing and recurrent spending in the infectious disease hospital with higher proportion of TB patients and higher patient population. As noted earlier, it may also be due to more staffing and recurrent spending in general hospitals and tertiary centers with lower proportion of TB patients and lower patient population.

In a country where the GDP per capita is only US$ 1370 (83), government total expenditure on social amenities at US$50 per capita, and government total expenditure on health constituting only 4.1% of GDP (84), the cost of tuberculosis treatment reported in this study could be described as relatively high and probably one of the major reasons for the low case detection rate for TB in the country. In such instances, many would prefer to visit cheaper alternative (non-medical) sources of care when they are sick, meaning that several TB cases visiting such services may remain undiagnosed (99). Besides, due to low levels of diagnosis and delays in treatment, there is higher morbidity and mortality from the disease, with many eventually

presenting at government health facilities with severe advanced TB, which is particularly more difficult and expensive to manage (100).

In some other studies, varying estimates and conclusions on the cost of treating TB in different countries were reported. In the Tanzanian study, the authors concluded that Community based DOTs provides an economically attractive option to complement health facility based DOTs, especially in resource-poor settings where provider TB clinics are working at extreme capacity under limited resources (4). Using cost inputs from South Africa, Abimbola and colleagues reported higher provider costs in South Africa, estimated at US $850 per TB patient (101). However, this was relatively higher that the reported estimate ($206.22) in this study possibly because the provider cost covers diagnostics, treatment and anti-retrovirals (ART). Variations have however been observed in reported estimates across studies owing differing models, assumptions, study periods, and the overall economic situation of the study location. For instance, a study conducted in Thailand estimated the provider cost for treating tuberculosis at US $373 in 1995 (102), while another study from India reported lower mean cost at Rupees 1587 (92), which was equivalent to US $35.98 in 2006. These explains the difficulties in arriving at estimates that are representative of the population. There is definitely a need for improved approach and guidelines to estimating the economic burden from TB across countries.

2.8. STUDY LIMITATIONS

This study has several limitations arising from the methods and the actual conduct of the study. The following are the limitations noted.

1. Exclusion of some staff under the government payroll but were not accounted for in the analysis because there were never available at the facilities. There engagements was seen more as a ‘favor to them’ rather than call to serve. These unaccounted costs makes the

estimates in this study an underestimation.

The assumption used in the estimation of the proportions of TB patients based on 3 days' patient turnover was a major limitation, as the patients' daily turnover was neither consistent nor predictable. However, because there were no patient records in any of the facilities, this assumption was necessary. Besides, averaging the daily turnover from 3 randomly selected days over a period of 3 weeks was considered to provide reasonable estimation.

2. Another major limitation of this study also from the fact that in this study it was assumed that where there was no TB patient in a clinic or facility on all the three days selected, but at least between 1 and 3 TB patients were said to be seen in the facilities every week, a proportion of 0.005 for TB service burden was used. This could also account for some considerable degree of costs underestimation or over estimation.
3. Other assumptions were also made in estimating the replacement costs and life spans of buildings and equipment, and in estimating other cost components based on personal experience of some technical persons working in the field. There could be significant bia in reporting these estimates.
4. Selection bias: although the study sample was randomly selected but the fact that the selection and implementation was done solely by the investigator could have led to bias and preferential selection of health facilities. Effort were made during the selection to blind names of the facilities during the random selection process.
5. Observational bias: there could observational bias and errors in measurements or estimates during the data collection due to the imperfection of the observer and the subjective human judgement. Efforts were made standardize the procedure for collection of the data.
6. Generalization: A major limitation of this study is the fact that although significant number

of health facilities were sampled, due to the heterogeneity of the settings and other factors in Nigeria, and financial limitations of the investigator, it was difficult to sample as much health facilities across the country.

7. Sensitivity analysis was not done to assess the effect of these assumptions in the study. However, because all major parameters had normal distribution curves, these assumptions were accepted as reasonable estimates of the real values.

2.9. CONCLUSION

The result of this study is suggestive of wide differential costs in overall provider cost per patient attributable to TB treatment across facilities in Nigeria. Relative to the national health expenditure in Nigeria over the years (less than 5% of total budget), it is uncertain if efforts will be directed towards addressing the basic challenges across centres. Based on the current finding, there is a need to improve the local capacity (financial, health workforce and infrastructural) of several health or designated infectious diseases (or TB) centres in the country to receive and adequately cater for more TB cases. This may also help to address the relative low turnout of TB patients in the specialized (infectious diseases) centres. It is hoped that this study may contribute to improved policy and public health response to TB in the country.

The next chapter provides the direct patient cost on TB treatment in Nigeria.

3. PATIENT (DIRECT) COST OF TB TREATMENT IN NIGERIA

Acknowledgement

This chapter has been published in International Journal of TB and Lung Disease.

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http://www.ncbi.nlm.nih.gov/pubmed/22613686.

Authors' Contributions: NU designed the study, collected and analyzed the data, and drafted the manuscript. RF, MB and IA provided supervisory support, vetted and approved the manuscript as part of my PhD work.

3.1. BACKGROUND

Estimates show that over 25% of TB cases and 31% of TB related deaths occur in sub-Saharan Africa, a region with only about 11% of the world's population (103). Nigeria, the most populous country in Africa, has the fourth largest burden of tuberculosis (TB) worldwide (after India, Indonesia and China), with incidence rate at 322 per 100 000 population, prevalence of 521 per100 000 population, and 99 deaths per 100,000 in 2015 (2). The estimated adult (15–45 years) human immuno-deficiency virus (HIV) prevalence rate in Nigeria is 3.6%, a condition that has contributed to increased incidence of TB in the country (104). It has been estimated that about 26% of notified TB patients are HIV-positive, which is one of the highest TB/HIV co-infection rates in the world (105). Over the years, this has contributed to a considerably high economic burden from TB in Nigeria (106, 107).

The health care system in Nigeria, which also fully integrates TB control, is constrained by several factors including finances, health workforce, access to health care, and difficulties in rendering TB outreach services particularly in rural area (105). There are also challenges with integrating the private health sector into the TB services, due to poor regulation, high costs and inconsistencies in the quality of care provided by this sector (105). Hence, Nigeria still has the 4th largest burden of TB globally, despite a reported 99%, albeit debatable, coverage of DOTs (39). Besides, direct medical costs, and indirect costs from lost income, productivity and time spent in hospital have been other major individual and household economic barriers limiting the response to TB in Nigeria (108). The WHO, in its Stop TB Strategy, recommended universal access to care and reduction in socio-economic related burden from TB as key objectives toward global control of TB (96). There is no social protection against cost of illness in Nigeria, which is an important policy objective of the post-2015 Global Strategy for Tuberculosis (10).

Nigeria has a per capita gross domestic product (GDP) of US$1376 (83), with about 50% of the population living below US$ 1.25 per day (109). Approximately 41% of women and 18% of men aged 15– 45 years are unemployed, and with over 50% living below the poverty index of $1.25 per day (83, 110). In fact, over 34% of people in the country do not obtain the required daily calorie intake, even if they spent all their income on food (109). Both TB and HIV have been associated with poverty (111, 112). Difficult financial circumstances are more likely to expose the poor to conditions favorable for infection with *M. tuberculosis* (113), and progression to a full-blown disease (114). The poor also face geographic and economic difficulties (barrier) in accessing TB services (12, 115), leading to delays in diagnosis, higher mortality and morbidity, and continued transmission of TB in the community (116). TB also has significant

socio-economic impact on patients, families and community, particularly due to a predominant infection of the most economically productive age groups (117, 118).

The Nigerian National Tuberculosis Control Programme (NTP) is based on the internationally recommended World Health Organization Stop TB strategy and provides free diagnostic testing as well as quality anti-tuberculosis drugs free of charge to all TB patients (119). This strategy also recommends decentralized treatment services and community TB care, thereby taking treatment closer to patients' homes under direct observation with the help of government health workers and community volunteers (119). However, for patients to access care, they must bear certain out-of-pocket expenditure or direct costs for transport, drugs and services that are not provided free (120, 121). Although anti-tuberculosis treatment is provided free of charge, considering the level of poverty in the country, and particularly among most TB patients, other associated costs and trade-offs could limit patients' access to TB services. Aspler and colleagues also noted that the level of cost patients incur are also indirectly a function of the health system structure (120). For example, significant delays have been reported in arriving at definitive TB diagnosis in health care settings in sub-Saharan Africa (122), with this leading to patients incurring costs from repeated misdiagnosis and indirect costs from hospital visits and time lost in the process.

There is need to understand the varying dimensions to economic burden and personal costs associated with the management of TB in Nigeria, as this is also central to planning and identifying appropriate control measures specific for different population settings (10). There is however limited understanding of the economic burden of TB in Nigeria, especially due to paucity of studies describing out-of-pocket costs of TB across Nigeria, even though such information is essential for improving case detection and treatment success rates in the country.

For the few studies that do exists in Africa (10, 123), a number of bottlenecks have been identified in the methods and approach employed that limited a detailed systematic synthesis of results. This study therefore aimed to review and describe out-of-pocket costs incurred by TB patients and their households in accessing TB-related diagnosis and treatment in Bauchi State, Nigeria.

3.2. MATERIAL AND METHODS

The study area and setting have been described in Chapter 2.

3.2.1. Study design and sampling

A cross-sectional study was conducted to assess the direct costs of TB on patients from the onset of the illness to end of the treatment. Sampling was randomly done, but stratified based on facility type, patients' HIV status and sex. A total of 255 TB patients were randomly sampled across 27 facilities in the state: 40 from the Infectious Disease Hospital, 40 from the Specialist Hospital (a tertiary centre), 10 each from nine selected General Hospitals, six each from five selected primary health care diagnostic centers, and five each from 11 selected PHCs. Only patients with an established TB diagnosis (based on sputum smear results and in some cases CXR with clinical judgment), who had completed at least 3 months of treatment, were included. Those with disabilities and other debilitating conditions, such as leprosy, were excluded from the study. In all the sampled facilities, standard first-line treatment consisted of 2RHZE/6EH, while second-line treatment consisted of 2SRHZE/1RHZE/5RHE.*

The methodology used in estimating this cost is the 'Bottom-up estimation approach' breaking down composite services into different cost dimensions which are then summarized or "rolled up" to determine an overall cost estimate for the cost of care per patient. This type of estimate

is generally more accurate than other methods (parametric, analogous or expert judgement estimations) since it is looking at costs from a more granular perspective. All currency value reported in the study was based on the US $ PPP as at November 2008 value. Amounts quoted in UK Pound Sterling (£) is a based-on November 2008 $/£ exchange rate.

Its also important to note here that although both the 'direct' and 'indirect' patient costs due to TB are estimated in Chapter 3 and 4, these estimates have not been factored in the CEA model in Chapter 7 primarily because the perspective of the CEA is for the UK Government and only captured the provider cost of treatment of TB in Nigeria. However, this analysis is included in the thesis to highlight some of the positive externalities (humanitarian) of the 'Investment in Nigerian TB Control" alternative.

3.2.2. Questionnaire

A standardized questionnaire, similar to what was employed in a study in Zambia was used for this study (120), with permissions from the principal investigator. Through the questionnaire, the direct costs for patients in accessing TB diagnosis and treatment services during the pre-diagnostic, diagnostic and post-diagnostic period, as well as during hospitalization, where applicable, were estimated.

3.2.3. Defining direct patient cost of Tuberculosis

Direct costs (out-of-pocket) in this study refer to money spent by, or for, patients to access drugs, commodities, paid services and any other items used for TB care. Self-reported total annual income for both patients and their households (excluding patient's income) from the questionnaire was used to estimate patient and household income. For ease of recall, a table with columns for each month of a year, and rows for income elements captured in local currency value (cash, kind, other produce, e.g., farm produce) was used. For patients working on family

farms or businesses, the value of the business or farm produce was only included in their income if they were in the primary business or farm owners, otherwise it was added to the household income. Cost was captured in Nigerian Naira and converted to USD equivalent based on the Central Bank of Nigeria USD-Naira exchange rate as at 01 November 2008.

3.2.4. Data collection and analysis

Questionnaires were administered to each of the 255 patients individually. In most cases, information had to be sought or verified from relatives or friends who accompanied the patient to the clinic. All the patients sampled were in between months 3 and 8 of treatment. Based on the assumption that patients were treated for a total of 8 months, the monthly cost of the remaining treatment period was estimated from the number of monthly visits patients would have to make from the follow-up and re-fill schedules, and using the average patient expenditures for all the cost elements to extrapolate the expenditure in the remaining months.

The patient level costs of the WHO Choice costing templates (40)were employed including hospital bed days, health centre visits, diagnostic tests, and drugs. The study took place from May to December 2008. Data was analyzed using IBM SPSS version 19.0 software (Statistical Package for the Social Sciences Inc., Chicago, IL, USA).

3.3. RESULTS

Of the 255 patients, 112 (43.9%) were hospitalized within the period from 6 months before TB diagnosis to end of the second month of TB treatment, and the remaining 143 (56.1%) were never hospitalized during this period. One hundred and fifteen (45.1%) were female and 140 (54.9%) were male, 230 (90.2%) were new cases, 25 (9.8%) were retreatment cases. Twenty-one (84%) of the retreatment cases were relapses' 3 (12%) were due to default and 2 (8%) to

treatment failure. One hundred and fifteen (45.1%) of the sampled population were HIV-negative, 124 (48.6%) were HIV-positive, while 16 (6.3%) did not know or refused to declare their HIV status (**Table 3.1**).

Seventy-six (29.8%) were unemployed, 18 (7.1%) were students, 55 (21.6%) were small- scale businessmen and women, 42 (16.5%) farmers, 26 (10.2%) were drivers, laborers, security guards or menial workers, 10 (3.9%) were commercial sex workers, and 28 (11.6%) patients were civil servants and other professionals. The mean age of the sample population was 31.9 years (range 9–67).

Table 3.1. Characteristics of the sampled population

Description	***Number (%)***
History of hospitalization at least 6 months before diagnosis, during diagnosis and after diagnosis	
Hospitalized	112 (43.9%)
Not hospitalized	143 (56.1%)
Gender	
Female	115 (45.1%)
Male	140 (54.9%)
History of prior TB illness	
New TB cases,	230 (90.2%)
Retreatment	25 (9.8%)

Reasons for retreatment	
- Relapse	21 (81% of the retreated)
- Default	3 (11% of the retreated)
- Treatment failure	2 (8% of the retreated)
HIV status	
HIV negative	115 (45.1%)
HIV positive	124 (48.6%)
Unknown HIV status	16 (6.3%)
Employment	
Un-employed	76 (29.8%)
Students	18 (7.1%)
Small scale business men and women	55 (21.6%)
Farmers	42 (16.5%)
Drivers, Labourers, Security guards or Menial workers	26 (10.2%)
Commercial sex workers	10 (3.9%)
Mean annual income	
Female	$445/annum
Male	$942/annum
The mean age of the sample population	32 yr (min. 9 yrs, max. 67yrs)
Average number of facilities visited before diagnosis.	3 facilities

Patients visited an average of three facilities before diagnosis, and had completed on average 5 of 8 months of treatment at the time of the interview. There was a significant difference in median household income ($\chi 2$ P < 0.0001), but there was no statistically significant difference in the median patients' income between patients from different facility types (see **Table 3.2**).

Table 3.2. Median Patients' and Households' income by type of health facility attended

	Tertiary Hospital	***IDH***	***General hospital***	***PHC (Diagnostic)***	***PHC (Treatment)***
Patient income prior to diagnosis Median (IQR)	$281.88 ($161.07-604.04)	$604.03 ($281.88-1208.05)	$604.03 ($161.07-1208.05)	$281.88 ($161.07-604.03)	$281.88 ($161.07-604.03)
Household income prior to diagnosis Median (IQR)	$604.03* ($362.42-2818.79)	$2013.42* ($604.03-3020.12)	$604.03* ($604.03-1409.40)	$604.03* ($281.88-604.03)	$604.03* ($281.88-1208.05)

**Median test (Pearson's X^2), $p<0.05$*

3.3.1. Analysis based on hospitalization

Among patients hospitalized during the period at least 6 months before diagnosis or during treatment (the hospitalized group), median out-of-pocket expenditure was estimated at US$166.11 (range $33.52– 417.92). For patients who were never hospitalized during this period

(the 'non-hospitalized' group), the median out-of-pocket expenditure was estimated at $94.16 ($30.87–284.63).

3.3.2. Analysis based on HIV status

The median out-of-pocket expenditures did not vary significantly between HIV-positive and HIV-negative patients in both the hospitalized and non-hospitalized patient groups. Median test P values were respectively 0.849 and 0.933 for the non-hospitalized and hospitalized groups (see **Table 3.3**).

Table 3.3. Median Direct Cost based on patients' HIV status and hospitalization

	Hospitalized		***Not hospitalized***	
	HIV+	HIV-	HIV+	HIV-
Total (Median) out of pocket cost, US$	$166.48	$166.11	$82.95	$83.96
IQR	$127.25-$203.99)	$131.55-$207.30	$58.52-$114.36	$55.67-$111.21
Median test (Pearson's X^2)for difference based on HIV status	P value = 0.933		P value = 0.0.849	

3.3.3. Analysis based on sex

Non-hospitalized female patients spent a median 16% more on out-of-pocket expenses than their male counterparts, while among the hospitalized patient group, females incurred 11% less costs than male patients. However, these differences were not statistically significant (respectively P = 0.185 in non-hospitalized and 0.252 in hospitalized patient groups). Females spent a

statistically significantly higher proportion of their income than males in both the hospitalized and non-hospitalized groups ($\chi 2$ P both < 0.0001) (**Table 3.4**).

Table 3.4. Direct costs based on patients' sex and hospitalization

	Hospitalized		***Not hospitalized***	
	Female	Male	Female	Male
Total (Median) out of pocket cost, US$	$158.52	$178.58	$94.46	$79.80
IQR	$125.60-$213.12)	$137.25-$204.16	$55.54-$122.97	$59.93-$104.55
Median test (Pearson's X^2)for difference based on HIV status	P value = 0.253		P value = 0.185	
% of self-reported annual income	38%*	19%*	21%*	9%

**p<0.0001 (Z test for difference in proportion of income)*

3.3.4. Analysis based on period of illness (pre/post-diagnosis, diagnosis and hospitalization period)

The median out-of-pocket cost paid by and for patients before TB diagnosis was US$28.99. During diagnosis and during treatment, the estimated median cost for all patients was respectively US$31.01 and US$17.45. The median out-of-pocket cost incurred during hospitalization was US$73.83.

There were no significant differences between males and females in out-of-pocket costs incurred before, during and after TB diagnosis in both the HIV- positive and HIV-negative groups. The median out- of-pocket expenditure during hospitalization was 11% higher for HIV-positive

males than HIV-negative females, and 5% lower in HIV-positive males than for HIV-positive females (P > 0.05) (**Table 3.5**)

Table 3.5. Median direct cost based on period before, during or after diagnosis by HIV and gender of patients

	HIV Positives		***HIV Negatives***	
Period of illness	Male	Female	Male	Female
Pre-diagnosis/ care seeking* Median (IQR)	$33.56 ($16.29-$51.41)	$26.21 ($8.79-$46.43)	$35.57 ($17.35-$46.85)	$28.79 ($12.75-$55.96)
Diagnosis period* Median (IQR)	$31.61 ($23.58-$37.00)	$31.18 ($22.95-$43.29)	$29.66 ($22.05-$44.06)	$31.01 ($23.19-$45.00)
Post diagnosis/treatment period* Median (IQR)	$19.46 ($10.99-$32.92)	$22.49 ($11.41-$40.10)	$19.33 ($11.08-$34.03)	$16.78 ($9.67-$35.57)
Total out of pocket per patient not hospitalized* Median (IQR)	$79.06 ($58.82-$103.36)	$97.32 ($56.11-$124.83)	$88.12 ($61.81-$111.74)	$88.26 ($53.70-$117.07)
Hospitalization* Median (IQR)	$69.93 ($53.02-95.30)	$73.83 ($54.70-94.96)	$70.81 ($55.30-101.18)	$63.56 ($49.66-$83.89)
Total out of pocket per patient hospitalized* Median (IQR)	$178.52 (147.05-$204.16)	$158.52 ($120.57-$213.49)	$177.25 ($132.03-$209.27)	$157.09 ($131.28-$208.32)

**Median test (Pearson's X^2), p>0.05*

The median out-of-pocket expenditures incurred in the different periods of the disease also vary across the different types of facilities sampled. The pre- diagnosis median out-of-pocket costs range from US$23.02 for PHC patients to US$26.92 in general hospitals to $41.91 for patients at the infectious dis- eases hospital (median P = 0.008). The median out-of- pocket cost during diagnosis ranged from US$24.30 in infectious diseases hospital patients to US$37.72 in diagnostic PHCs (median test P < 0.05). Post-diagnosis (treatment) varied from US$10.74 in general hospital patients to US$32.2 in PHCs (median test P < 0.001). Out-of-pocket expenditures did not vary significantly between patients sampled from the different types of facilities. In both the hospitalized and the non-hospitalized patient groups, the median total out-of-pocket expenditures varied statistically significantly among patients from different types of health care facilities (median test P < 0.05) (**Table 3.6, Figure 3.1**).

Table 3.6. Median direct cost based on period before, during or after diagnosis by type of facility attended

Period of illness	***Tertiary Hospital***	***IDH***	***General Hospital***	***PHC (Diagnostic)***	***PHC (Treatment)***
Pre-diagnosis/ care seeking* Median (IQR)	$33.29 ($17.05-$51.45)	$41.91 ($28.39-$64.73)	$26.92 ($8.32-$45.10)	$29.87 ($14.83-$43.76)	$23.02 ($10.74-$47.85)
Diagnosis period* Median (IQR)	$28.99 ($20.57-$35.97)	$24.30 ($19.00-$32.69)	$32.62 ($24.83-$43.76)	$37.72 ($28.59-$41.01)	$31.68 ($24.97-$43.09)
Post diagnosis/treatment period* Median (IQR)	$15.57 ($11.41-$21.65)	$22.82 ($17.45-$38.25)	$10.74 ($7.79-$21.74)	$27.05 ($16.11-$53.69)	$32.20 ($18.79-$48.32)

Total out of pocket per patient not hospitalized* Median (IQR)	$72.68 ($58.52-$93.42)	$104.73 ($88.26-$128.76)	$67.53 ($51.61-$87.49)	$101.34 ($67.85-$163.29)	$86.78 ($63.49-$109.46)
Hospitalization* Median (IQR)	$63.09 ($48.99-$75.84)	$74.19 ($56.72-$116.28)	$73.83 ($60.40-$91.95)	$83.22 ($51.68-$93.96)	$70.47 ($53.69-$94.63)
Total out of pocket per patient hospitalized* **Median (IQR)**	$149.87 ($123.56-$289.85)	$176.58 ($147.72-$201.04)	$70.54 ($121.48-211.95)	$153.96 ($127.65-$204.16)	$196.10 ($158.52-225.77)

**Median test (Pearson's X^2), $p>0.05$*

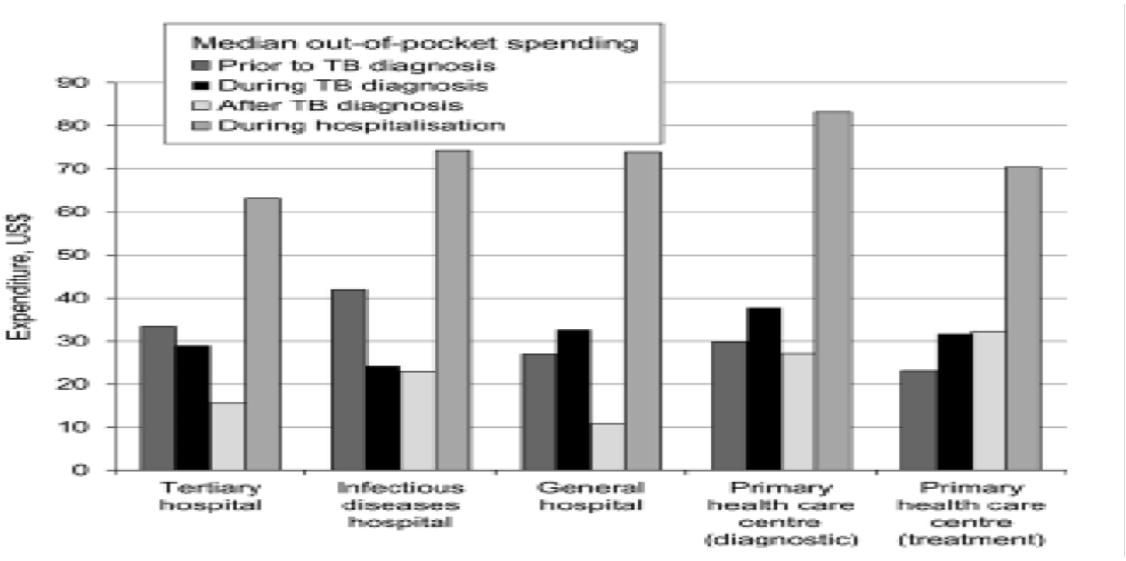

Figure 3.1. Total mean out-of-pocket spending during the prediagnosis, diagnosis and post diagnosis periods (all in US dollars) grouped by type of health care facility

3.3.5. Analysis based on cost elements

In both the hospitalized and the non-hospitalized groups, there was no significant difference between HIV-negative and HIV-positive patients in median costs of transportation, registration/consultation fees, medications, tests/X-rays and food (median test P > 0.05) (see **Table 3.7**).

Table 3.7. Cost elements (Median) by hospitalization and HIV status

	Hospitalised		***Non-Hospitalised***	
Cost elements	HIV negatives	HIV positives	HIV negatives	HIV positives
Travel* Median (IQR)	$24.03 ($15.44-$35.57)	$24.83 ($14.93-$35.57)	$8.05 ($3.89-$16.11)	$9.40 ($4.30-$17.58)

Registration/consultation* Median (IQR)	$0.81 ($0.20-$5.17)	$0.87 ($0.27-$1.85)	$0.34 ($0.13-$0.67)	$0.40 ($0.13-$0.67)
Medications* Median (IQR)	$72.15 ($1.34-$92.28)	$71.74 ($54.03-$89.77)	$38.07 ($23.49-$47.65)	$37.58 ($24.16-$45.64)
Investigations including X-Rays* Median (IQR)	$24.30 ($18.12-$32.89)	$25.50 ($16.61-$33.22)	$16.11 ($12.08-$20.13)	$16.11 ($11.07-$22.15)
Food/drinks while at facility* Median (IQR)	$20.13 ($12.42-$25.17)	$20.13 ($10.74-31.54)	$0 ($0-$0.67)	$0 ($0-$1.34)
Food supplements and paid help* **Median (IQR)**	$12.75 ($5.37-$26.17)	$13.42 ($6.71-28.86)	$6.71 ($0-$22.82)	$10.74 ($0.$21.48)

**Median test (Pearson's X2), p>0.05*

However, there were statistically significant differences in the amount spent on transport and registration/consultation by patients' facility types (median test $P < 0.05$). The out-of-pocket expenditure on food, tests/X-rays and registration/ consultations did vary slightly; however, these differences were not statistically significant (median test $P > 0.05$) (see **Table 3.8, Figure 3.2**).

Table 3.8. Cost elements (Median) by type of facility attended

Cost elements	***Tertiary Hospital***	***IDH***	***General Hospital***	***PHC (Diagnostic)***	***PHC (Treatment)***
Travel* Median (IQR)	$12.21 ($5.10-$20.47)	$23.22 ($10.87-$36.24)	$12.08 ($5.37-$21.21)	$18.79 ($13.42-$30.87)	$19.80 ($8.02-$36.51)
Registration/consultation* Median (IQR)	$0.80 ($0.20-$2.21)	$0.60 ($0.27-$2.92)	$0.27 ($0.13-$0.87)	$0.37 ($0.13-$0.87)	$0.70 ($0.27-$1.01)
Medications* Median (IQR)	$52.18 ($38.73-$81.54)	$57.38 ($44.46-$79.53)	$42.95 ($29.53-$69.13)	$43.62 ($32.21-$53.02)	$43.49 ($30.54-$71.14)
Investigations including X-Rays* Median (IQR)	$21.31 ($15.10-$28.54)	$15.50 ($11.41-$22.82)	$18.79 ($14.77-$26.85)	$20.81 ($12.75-$26.84)	$18.12 ($12.75-$24.83)
Food/drinks while at facility* Median (IQR)	$3.36 ($0-$12.08)	$6.71 ($0-$25.13)	$3.36 ($0-$20.13)	$3.02 ($0-$13.43)	$3.69 ($0-$22.15)
Food supplements and paid help* **Median (IQR)**	$10.74 ($5.37-$22.82)	$15.44 ($10.74-$28.19)	$12.08 ($4.08-$29.53)	$8.72 ($0.0-$20.13)	$6.71 ($0-$23.49)

**Median test (Pearson's X2), p>0.05*

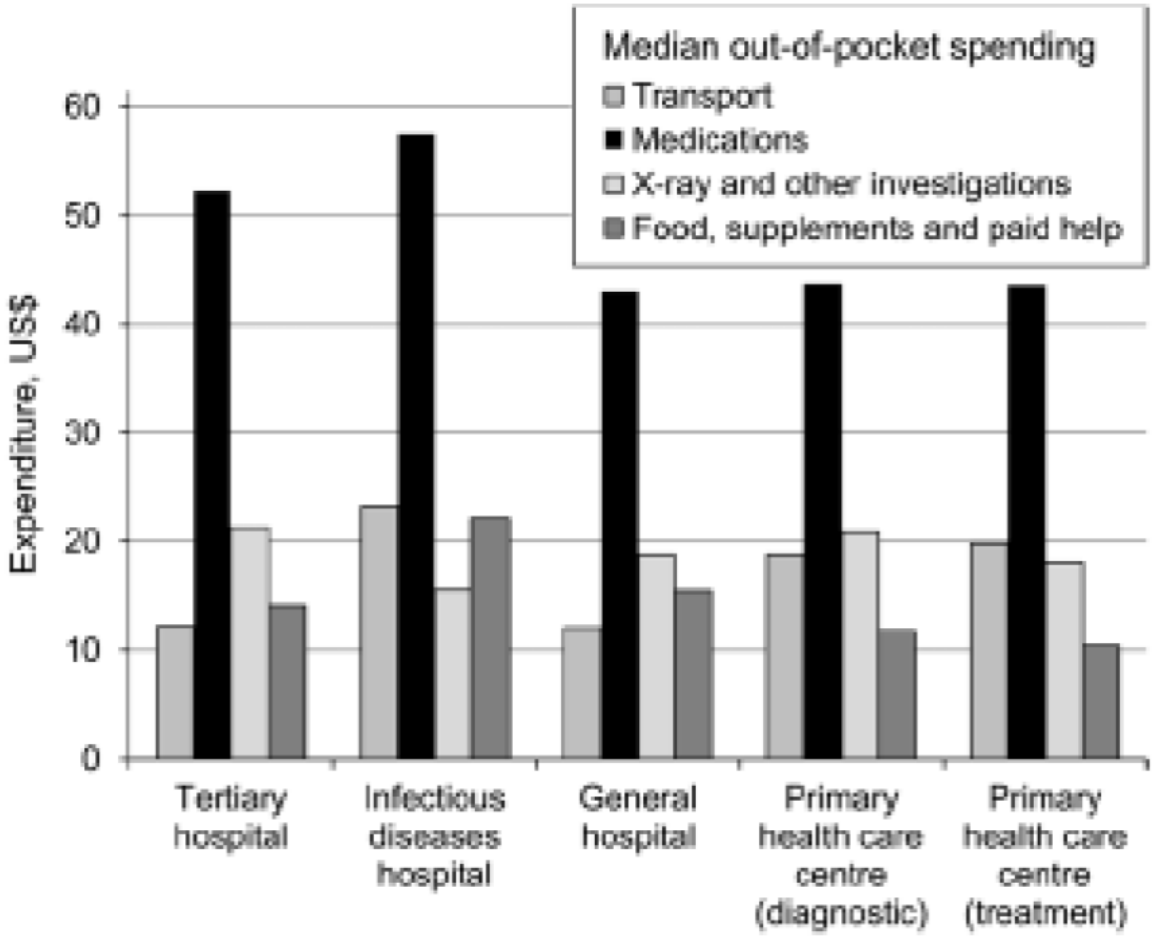

Figure 3.2. Median expenditure on travel, registration, clinical tests and food

3.4. DISCUSSION

The median total out-of-pocket spending by patients for seeking TB diagnosis and treatment in Bauchi State Nigeria was respectively US$166.11 and US$94.16 for hospitalized and non-hospitalized patients during their illness.

The study also found that, among patients hospitalized for TB, median out-of-pocket expenditure was US$166.48 and US$166.11 for HIV-positive and HIV-negative patients, respectively. Among non-hospitalized patients, it was respectively US$82.95 and $83.96 for HIV-positive and HIV-negative patients.

The median total out-of-pocket expenditure for hospitalized female and male patients during their illness was respectively US$158.52 and US$178.52. That of non-hospitalized female and male patients during their illness was respectively US$94.46 and US$79.80.

Females were found to spend significantly higher proportions of their income in seeking diagnosis and treatment. This could be due to delayed health seeking behavior among females. Generally, in an African setting a woman may not be able to seek medical attention even in emergencies, unless approved by her husband (116, 124). Even after such, she still depends on her husband for the cost of medical expenses, which she may not even get on the long-run (124). Hence, female patients tend to present late at health facilities, with an advanced disease and widespread complications, usually abandoned and requiring more of their personal income to offset hospital bills (125). However, the differences in out-of-pocket expenditure based on sex and HIV status were not statistically significant.

Similar studies have been published in sub-Saharan African and other resource limited developing countries (99, 126). These studies reported relatively lower overall costs than observed in this study. For instance, in Zambia, $7 was reported as the median direct cost of anti-tuberculosis treatment per patient in 2006, which was implausibly low, suggesting some inaccuracies with the costing methods employed (120). Another study conducted in 2002 reported the average direct cost for TB patients in Dar es Salaam, Tanzania, at $22 per patient, which is also low (4). While in Bangladesh and India, the estimates were slightly higher but still lower than the estimate in this study at US$ 130 and US$ 100, respectively (126). These differences could partly be explained by the differences in the purchasing powers of the US dollar between these countries and/or due to omission of some cost elements in these studies and/or due to bias resulting from inflation of self-reported expenditure, possibly in expectation

of refunds or compensation. Another major reason for these low estimates is because direct TB costs are often related to only health system costs, hence leading to an underestimation in most cases (100). Indeed, health system costs may be the smallest component of treatment costs in most settings, as observed in rural Uganda (99). Across most developing countries, many patients with tuberculosis would have sought assistance from traditional/herbal healers or alternative health care providers, incurring some costs in the process (99). A report in Malawi revealed that TB patients patronized traditional healers for an average of four weeks before presenting at standard health facilities (99). Initially the costs may be low, but due to repeated visits, the cumulative expenses incurred may eventually be high (126). This direct health cost is quite difficult to measure and often not included in several TB cost estimates (9, 96).

As noted in *Chapter 2*, one of the major reasons for the high cost of care in Nigeria as observed in this study may be due to delayed diagnosis, as it generally takes above four weeks before a definitive diagnosis is made. In the process, several expenses would have been incurred on irrelevant investigations, palliative drugs and expensive nutritional supplements (100). Foster and colleagues also affirmed this, describing the period of delays (prior to commencing treatment) as contributing the greatest to TB treatment costs Aspler et al. also explained that the three major predictors of patient costs in Zambia included patient delays in seeking care, an over-bearing male gender which affects the choice of seeking health care, and the DOTs supervision approach (120, 126).

Another important finding of this study is the fact that although anti-tuberculosis drugs are provided to patients free of charge in Nigeria, HIV-negative and -positive patients respectively spent a median of US$38.07 and US$37.58 (non-hospitalized patient group) and US$72.15 and US$71.74 (hospitalized group) for other medications from the period before diagnosis and up

to the end of treatment. Although several studies have reported that HIV co-morbidity increased the cost of TB (121, 127, 128). However, in this study HIV co-morbidity did not affect costs.

Some disparities were also observed between cost elements in expenditures incurred by patients in the different facility types. Expenditure on non-TB medication was higher in patients attending the tertiary hospital and the infectious disease hospital, whereas these facilities have the highest physician/patient ratio. These are mostly specialty physicians who are expected to give appropriate medications for TB. This raises a fundamental question as to whether physicians are over-prescribing non-TB medications in these facilities, possibly due to incorrect or delayed diagnosis. In addition, patients attending the infectious diseases hospital spent more on transportation than those attending other types of facilities, while those that attend to the primary health care treatment centers incurred higher transportation expenditure than those in the diagnostic PHCs. The higher travel costs among patients attending the infectious disease hospital could be due to the fact that there is only one such hospital in the whole State, and patients travel long distances to this hospital, which is known to provide the best TB services in the State. The higher travel costs among patients from the primary health care treatment centres may be due to the fact that such patients have to travel to other facilities not only for diagnostic services and follow-up visits but also for emergency and other 'non-treatment' services throughout the duration of their illness.

As already identified in this study that delay in diagnosis of TB is a major determinant of patient costs, interventions that bring diagnosis of TB closer to patients where they live, like community-based enhanced case finding, have been recommended (120). This may involve promoting TB symptom awareness in communities, encouraging early presentations, and an expert guided sputum collection form suspected TB cases in the communities (100, 120). This

possibly may address the high economic costs on patients currently experienced before diagnosis.

3.5. STUDY LIMITATIONS

The cost estimate in this study was based on self-reported expenditure by patients, which may have been biased. Besides, it could have been underestimated due to failure to recall certain expenditures by patients or informants, or overestimated from inflated self-reported expenditure. Another major limitation is the estimation of future expenditures by extrapolation for patients yet to complete treatment. Every effort was made to minimize bias and ensure projection of future costs.

Other limitations are:-

1. Selection bias: although the study sample was randomly selected but the fact that the selection and implementation was done solely by the investigator could have led to bias and preferential selection of participants. Effort were made during the selection to blind names of the facilities during the random selection process.
2. Observational bias: there could observational bias and errors in measurements or estimates during the data collection due to the imperfection of the observer and the subjective human judgement. Efforts were made standardize the procedure for collection of the data.
3. Sensitivity analysis was not done to assess the effect of these assumptions in the study. However, because all major parameters had normal distribution curves, these assumptions were accepted as reasonable estimates of the real values.

3.6. CONCLUSION

This study reveals the relatively high economic burden faced by TB patients in Nigeria, particularly due to delayed diagnosis of TB cases in these settings. Yet, worrying is the fact that patients have to pay out-of-pocket costs to get drugs, though anti-tuberculosis treatment is supposedly free in Nigeria. In a country where the per capita GDP is only US$1376, the per capita gross national income is only US$1160, and about 46% of the urban population lives below the poverty line, patient expenditure of 9–39% of annual income on TB diagnosis and treatment could be described as too expensive and potentially catastrophic for many patients and their families. The high cost of TB diagnosis and treatment poses significant barrier to care, resulting in further delays in diagnosis, poor treatment outcomes, and poor TB case detection rates, leading to continued spread of the infection in the community. The poorest group of patients have incurred higher costs due to delayed diagnosis, poor awareness on TB and lack of government support, thus pushing these set of people further down the poverty line. It is important that appropriate measures are taken to address this economic challenge in Nigeria, sub-Saharan Africa and several low-income settings to ensure sustained control of TB burden globally. To give a broader perspective on the impact of direct patient out-of-pocket expenditure, an insight into the indirect patient expenditure in the country is worthwhile. The next chapter describes this in detail.

4. PATIENT (INDIRECT) COST OF TUBERCULOSIS TREATMENT IN NIGERIA

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http://www.resource-allocation.com/content/pdf/1478-7547-10-6.pdf

Authors' Contributions: NU designed the study, collected and analyzed the data, and drafted the manuscript. RF, MB and IA provided supervisory support, vetted and approved the manuscript as part of my PhD work.

4.1. BACKGROUND

As already described in Chapter One, about one-third of the world's population are currently infected with *Mycobacterium Tuberculosis*, with 1.4 million deaths attributable to tuberculosis each year despite the availability of effective antibiotics {WHO, 2016 #2106}. Experts believe efforts to control TB globally is facing great opportunities, as well as, great challenges worldwide (129). Widespread opportunities have been reported owing to relatively better commitments of the governments of many developing countries, and the support they get from international donors and funding agencies (130). This has also led to a situation where many of these governments are unable to increase their local capacity to sustain the increasing opportunities they receive (68). Hence, many governments and international donors are finding it difficult to direct resources to the most pressing needs in developing countries, despite the

rising burden of TB in these settings (130). Consequently, this has translated into several indirect costs borne by patients, families and their carers.

Indirect costs constitute major health costs attributable to TB in any settings. Most economic analyses of TB burden have traditionally focused on direct out-of-pocket expenditure (foster). Across Africa and low- and middle-income countries (LMICs), patient and house-hold out-of-pocket costs of TB have been assessed, including cost-effectiveness analyses of different approaches to TB treatment in many countries (4, 12, 120). While this is important (as noted in Chapter Three), it has quite a number of limitations, in that there is little insight on the social impact of the illness, jobs lost, opportunities missed, time spent in hospital, and national economic loss, especially because TB predominantly affects the productive age groups (114). TB care and services are increasingly becoming reliant on informal care, with associated costs shifted from the health care sector to the communities through early discharge programmes (114). Besides, substitution of inpatient care with ambulatory care and the move toward community care of tuberculosis have been widely reported in several communities (119). This clearly demonstrates that the social networks of a TB patient play important economic roles, which become affected as a result of an illness. An appropriate understanding of this may be helpful for experts and policy makers working on TB control and prevention. Generally, it is quite difficult to describe with certainty time lost by patients or being unable to work due to sickness. This thus makes the estimation of indirect costs quite difficult, with this resulting in the paucity of related data and information across world regions (10). This study therefore seeks to estimate the indirect costs to patients, households, and communities with tuberculosis, particularly in terms of hours spent by TB patients and/or their households, and the associated productivity lost.

4.2. METHODS

Study area and setting have been described in Chapter Two.

4.2.1. Study objective

This study aimed to estimate, based on the United States Dollar (US$) value, the indirect cost of TB regarding the time spent and productivity lost by patients, families and others due to TB illness in Bauchi State, Nigeria.

4.2.2. Study design and methods

This is a cross sectional study in which the time spent by patients and other household members for tuberculosis (TB) diagnosis and treatment was assessed as well as the income lost (both the patients and households) due to the illness.

A total of 242 (initially 255 but 13 were excluded based on age criteria of less than 15 years or older than 59 years of age) TB patients were sampled from 27 out of 67 facilities providing TB services in the state. The sample size was allocated based on facility type and patients were randomly selected in each facility. Selection was stratified based on patients' HIV status and gender. The stratification was done during the selection, and where randomly selected number of patients in a stratum got at least half of the allocated sample size, the subsequent random selections will only be valid if is for the other stratum. A total of 40 patients were selected from the Infectious Disease Hospital, 40 from the Specialist hospital (tertiary hospital), 10 patients each from 9 General Hospitals, 6 patients each from 5 PHC diagnostic centers, 5 patients each from PHC treatment centers.

Only patients with 'confirmed' TB diagnosis were included. Most of these patients had at least one sputum smear positive test and few had only sputum negative results but had CXRs strongly suggestive of TB with history of significant clinical improvement after initiation of TB treatment.

Ethical approval was sought and granted for this research by the Bauchi State Ministry of Health. The study was conducted between May and August, 2008.

The methodology used in estimating the cost in this Chapter is the 'Bottom-up estimation approach' breaking down composite services into different cost dimensions which are then summarized or "rolled up" to determine an overall cost estimate for the cost of care per patient. This type of estimate is generally more accurate than other methods (parametric, analogous or expert judgement estimations) since it is looking at costs from a more granular perspective.

Its also important reinstate here that although both the 'direct' and 'indirect' patient costs due to TB are estimated in Chapter 3 and 4, these estimates have not been factored in the CEA model in Chapter 7 primarily because the perspective of the CEA is for the UK Government and only captured the provider cost of treatment of TB in Nigeria. However, this analysis is included in the thesis to highlight some of the positive externalities (humanitarian) of the 'Investment in Nigerian TB Control" alternative.

4.2.3. Questionnaire

A standardized questionnaire (with the permission of the original developers (120)) was used to estimates the indirect costs of TB on patients, their families and other carers for seeking and accessing TB treatment during pre-diagnostic, diagnostic and post-diagnostic period, as well as during hospitalization where applicable. The questionnaires were administered to the all patients individually.

4.2.4. Defining indirect patient cost of Tuberculosis

The indirect cost in this study was estimated from:

i) The average time spent by patients, their relatives, friends and other unpaid carers on travel, waiting time for consultation, treatment and hospitalization by TB patients and persons who accompanied patients during the period (starting from the onset of

illness that lead to TB diagnosis to the time TB treatment was completed). The monetary value of the time was calculated from the hourly wage value estimated at US$0.56/hr based on the 2008 annual gross national income per capita in Nigeria, which is $1169 (68). Annual working hours per capita used in this estimate was 2080 hours (40 hours per week for 52 weeks);

And

ii) Income lost by TB patients and their households due to the period of TB illness or complication resulting from TB or treatment, as estimated from the difference in self-reported monthly patients and household income in the periods before and during TB illness.

4.2.5. Data analysis

Based on the definitions above, semi-structured questionnaire was employed (***Appendix 21***). Descriptive data analysis was conducted. A univariate general linear modeling for test of between subject effects of some demographic and socioeconomic variables on the total indirect cost was also conducted. All statistical analyses were conducted in IBM SPSS version 19 software.

4.3. RESULTS

About 104 (43.0%) of the patients in this study were hospitalized within the period from 6 months before TB diagnosis through the period of TB treatment (**Table 4.1**).

One hundred and thirty-two (54.5%) of the patients were male, average age of the sample was 32.8 (±9.8 SD) years. Only 24 (9.9%) of the patients in this study had history of previous TB infections. Twenty (83.3%) of the retreatment cases were reportedly due to relapse, 2 (8.3%)

due to default and another 2 (8.3%) due to treatment failure. Only 22 (9.1%) of the patients had all sputum AFB tests negative.

About 106 (43.8%) of the patients were HIV negative, 122 (50.4%) were HIV positive and 14 (5.8%) did not declare their HIV status. Ninety-three (38.4%) of the patients had no formal education, 52 (21.5%) had primary school certificates, 18 (7.4%) had junior secondary school certificates, 60 (24.8%) had secondary school certificates, 15 (6.2%) had undergraduate certificates, and 4 (1.7%) had graduate degrees and above. Seventy-six (29.8%) of the patients were unemployed, 18 (7.1%) were students, 55 (21.6%) were small scale business men and women, 42 (16.5%) are farmers, 26 (10.2%) were either drivers, laborers, security guards or menial workers and 10 (3.9%) were commercial sex workers.

Average number of people living in the patient's household was 6.43 (±5.37 SD). Average delay in diagnosis was estimated at 5.61 (±2.67 SD) weeks and the average number of facilities visited before diagnosis was 2.74 (**Table 4.1**).

Table 4.1. The characteristics of the study population

Description	***Number (%)***
History of hospitalization at least 6 months before diagnosis, during diagnosis and after diagnosis	
Hospitalized	104 (43.0%)
Not hospitalized	138 (57.0%)
Gender	
Female	110 (45.5%)
Male	132 (54.5%)

History of prior TB illness	
New TB cases	218 (90.1%)
Retreatment	24 (9.9%)
Reasons for retreatment	
- Relapse	20 (83.3% of the retreated)
- Default	2 (8.3% of the retreated)
- Treatment failure	2 (8.3% of the retreated)
HIV status	
HIV negative	106 (43.8%)
HIV positive	122 (50.4%)
Unknown HIV status	14 (5.8%)
Employment	
Un-employed	75 (31.0%)
Students	10 (4.1%)
Civil servants	28 (11.6%)
Small scale businesses	53 (21.9%)
Farmers	40 (16.5%)
Drivers, Labourers, Security guards or Menial workers	26 (10.7%)
Commercial sex workers.	10 (4.1%)
Mean annual income	
Female	$449.90/year
Male	$960.65/year
The mean age of the sample population	**32.8 years (15 – 59 years)**

4.3.1. Income lost

The income lost among the hospitalized group was estimated at $156/patient and about $114 in the non-hospitalized patients group (**Table 4.2**). The income lost varied by history of hospitalization, gender and HIV status of the patients (**Table 4.3 and 4.4, Figures 4.1 and 4.2**).

Table 4.2. Income lost by hospitalization status

Description	***Hospitalized***	***Not hospitalized***
Average income lost by patient throughout the TB illness	$75.09 (min. -$53.69; max. $1100.08; SD $164.97	$69.62 (min. -$77.18; max. $1107.38; SD $167.24)
Average income lost by other household members throughout the TB illness	$80.87 (min. -$161.07; max. $1436.24; SD $224.02)	$43.89 (min. -$268.46; max.$2805.37; SD $266.24)
Total	$155.96	$113.51

Table 4.3. Income lost by gender and hospitalization

Gender	***Hospitalized***			**Not hospitalized**		
	Income lost in US $	Value of time spent in US$	Total	Income lost in US $	Value of time spent in US$	Total
Female	$75.45	$125.2	$200.65	$38.2	$79.0	$117.2
Male	**$114.32**	**$112.4**	**$226.72**	**$82.8**	**$79.3**	**$162.1**

Table 4.4. Income lost by HIV status and hospitalization

HIV status	*Hospitalized*			*Not hospitalized*		
	Income lost in US $	Value of time spent in US$	Total	Income lost in US $	Value of time spent in US$	Total
HIV +	$110.32	$118.72	$229.04	$72.57	$84.0	$156.57
HIV-	**$79.52**	**$119.67**	**$199.19**	**$57.59**	**$75.55**	**$133.14**

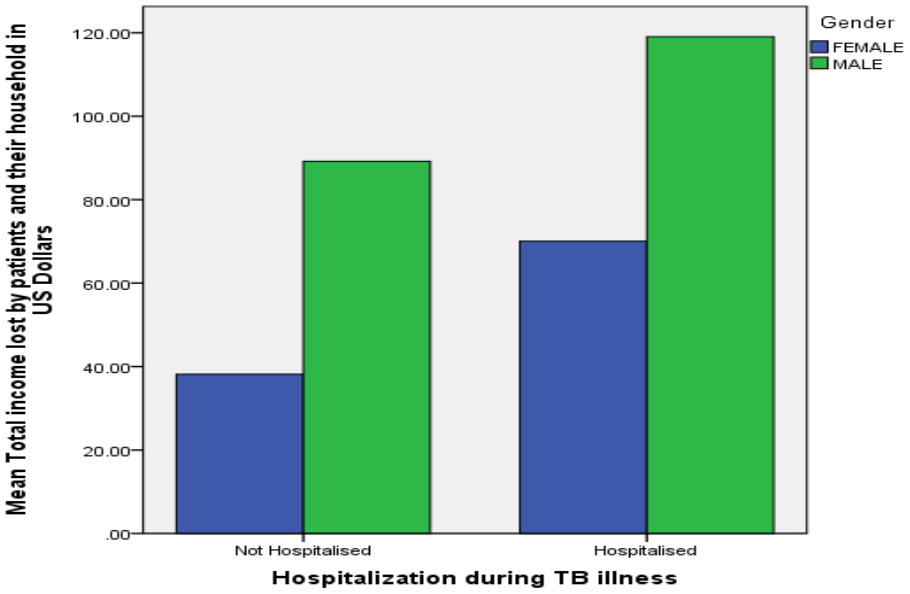


Figure 4.1. Average Income lost by patients and their households by gender and hospitalization history

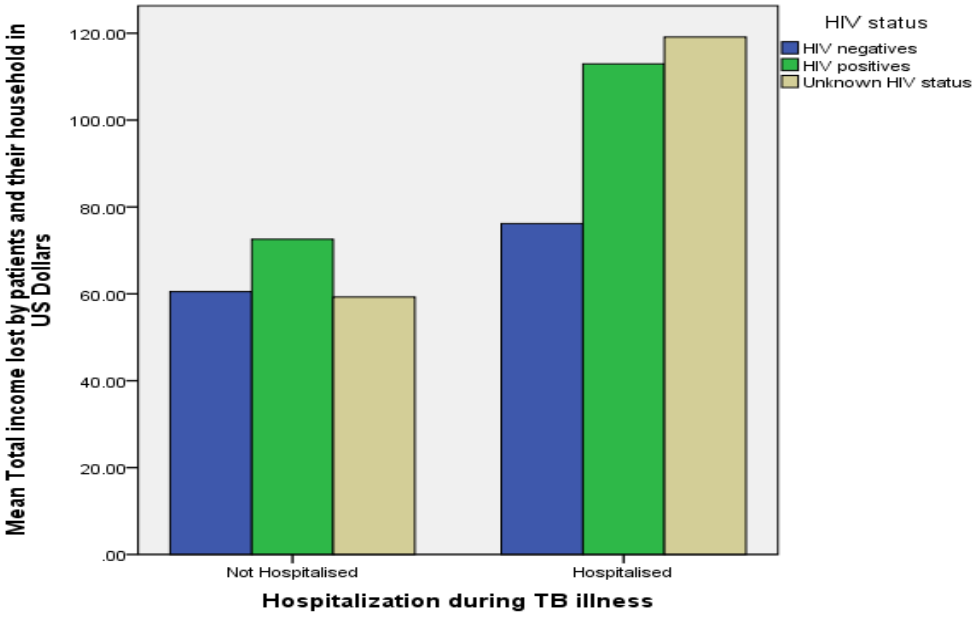


Figure 4.2. Average Income lost by patients and their households by HIV status and hospitalization history

4.3.2. Time spent by patients and household

Patients with history of hospitalization during the TB illness spent an average time of 924.98 hours for seeking diagnosis and treatment whereas the non-hospitalized group spent an average of 141.29 hours. The estimated US dollar valued for these hours based on the US0.56/hour GNI assumption was US517.98 and US $79.13 for hospitalized and non-hospitalized patient groups, respectively (Table 4.5).

Hospitalization and facility of diagnosis were statistically significant (p-value <0.05), and associated with the total time (patients and household) spent on TB (**Table 4.5, Figures 4.3, 4.4 and 4.5**).

Table 4.5. Time spent by patients and 'others' in hours and value in US dollars by hospitalization status

Description	*Hospitalized*		*Not hospitalized*	
	Time (Hrs)	Cost in US$	Time (hrs)	Cost in US$
Average time patients used for diagnosis and care throughout the TB illness	517.33 Hrs	$289.70	120.37 Hrs	$67.41
Average time spent by others on a TB patient throughout the TB illness	407.65 Hrs	$228.28	20.92 Hrs	$11.72
TOTAL	**924.98 Hrs**	**$517.98**	**141.29 Hrs**	**$79.13**

Expectedly, both the time spent on TB illness and income lost by patients themselves and relatives varied based on whether patient was hospitalized or not during the TB illness.

The income lost among the hospitalized group was estimated at $156/patient and about $114 in the non-hospitalized group. This difference is mainly from the higher income lost among the friends and relatives of patients that were hospitalized group, which was also found to be statistically significant (p-value < 0.001).

The US dollar valued average time spent throughout the TB illness for seeking diagnosis and treatment varied between $518 and $79 between the hospitalized and non-hospitalized groups and was also found to be statistically significant (p-value < 0.001).

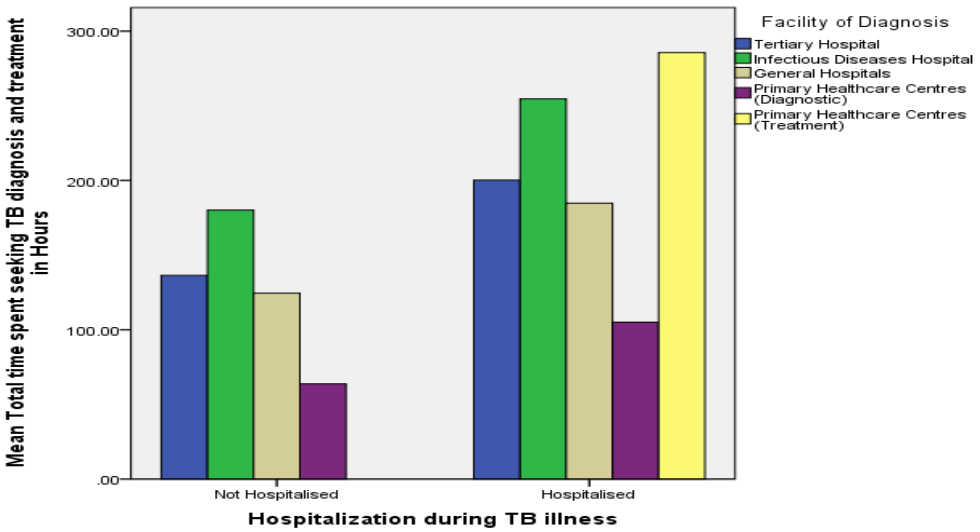


Figure 4.3. Average time spent by patients and 'others' on tuberculosis diagnosis and treatment by hospitalization history

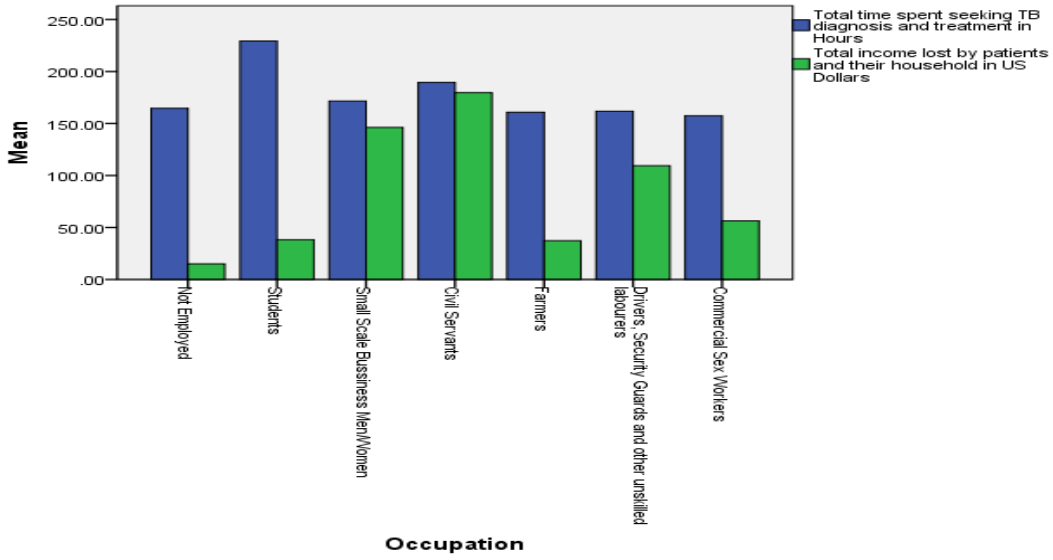


Figure 4.4. Average time spent by patients and 'others' on tuberculosis diagnosis and treatment by the occupation of the patient

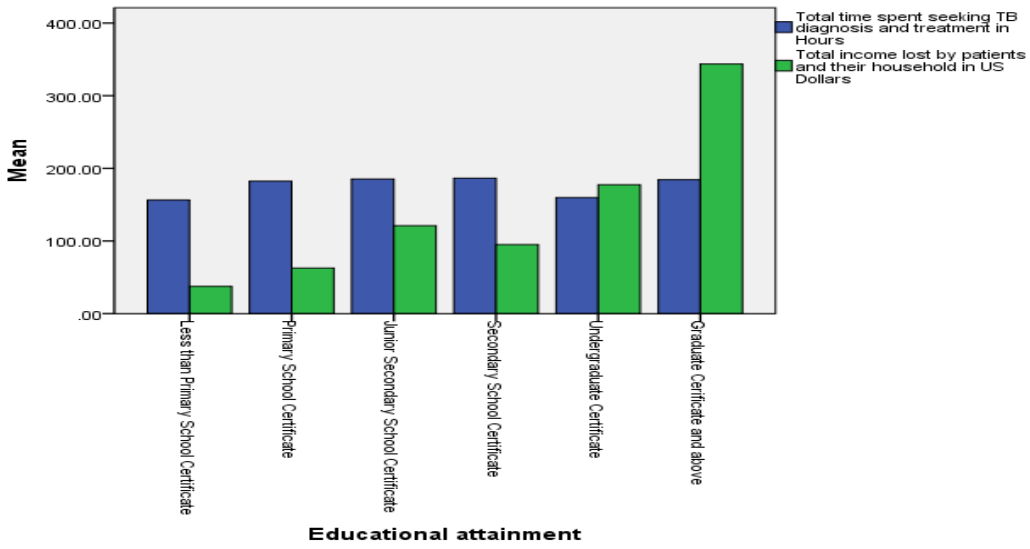


Figure 4.5. Average time spent by patients and 'others' on tuberculosis diagnosis and treatment by educational attainment of the patient

Univariate General Linear Model showed that age, gender, facility of diagnosis, level of education and occupation were statistically significant (p-values <0.05) predictors of the total (both patients and their households) income lost. However, AFB sputum-smear result and HIV status had no significant effects on the income lost (**Table 4.6**).

Table 4.6. Test of Between-Subject Effects (Univariate General Linear Model)

	Total time spent by patients and households in Hours			**Total Income lost by patients and households in US Dollars**		
	Df	F	p-value	Df	F	p-value
Age	36	1.268	0.158	36	1.673	0.015**
Gender	1	0.613	0.435	1	6.309	0.013**
Facility of Diagnosis	4	3.950	0.004**	4	2.873	0.024**
Sputum Smear test	1	1.687	0.195	1	2.793	0.096

Level of Education	5	0.510	0.769	5	4.459	<0.001**
HIV status	3	1.342	0.264	3	1.084	0.340
Occupation	6	0.681	0.665	6	6.268	<0.001**
History of Hospitalization	1	23.803	<0.001**	1	3.181	0.076

4.4. DISCUSSION

The study estimated the average total income lost by TB patients and their household for the hospitalized and non-hospitalized patients groups at US$156.96 and US$113.51 respectively. Income lost in individual patient incomes did not vary much based-on history of hospitalization (US$75.09 vs. US$69.62 for the hospitalized and non-hospitalized patient groups respectively). However, average income lost to household members was observed to be much higher in the hospitalized patients group (US$80.87 vs. US$43.89 for the hospitalized and non-hospitalized patient groups respectively).

Age, gender, type of facility, level of education and occupation were found to be significant predictors of the total income lost (by patients and household) due to TB. AFB sputum-smear test result and hospitalization were not significantly associated with the total income lost.

In this study, we also found that TB patients and their household spent an average of 924.98 hours in the hospitalized and 141.29 hours in the non-hospitalized patients' groups seeking TB diagnosis and treatment. These times were valued at US$517.98 and US$79.13 for hospitalized and non-hospitalized patients respectively.

According to the WHO, income lost as a result of illness and death from TB are generally much more than the direct costs of TB (9, 96). In rural Uganda, it was estimated that 70% of costs to

TB patient are due income lost from work time, which can be either traced to loss of work or reduced productivity due to the illness (96, 131).

Hospitalization during the TB illness and the facility of diagnosis were found to be significant predictors of the total time spent. Age, gender, AFB sputum-smear results, level of education, HIV status and occupation were not significant predictors of the total time spent on TB illness.

While there are no comparable estimates in Nigeria, some studies have reported income lost due to Tuberculosis in some African countries. A study in Zambia reported an average of 48 days' loss of income due to TB illness (132), while Aspler and colleagues reported US$ 15.27 as the median total indirect cost of TB treatment in Zambia in 2006 (98). Another study conducted in Dar es Salaam, Tanzania in 2002 reported a median estimate of about US$431 as the household productivity lost due to Tuberculosis (123). In other separate reviews in sub-Saharan Africa, a short assessment of patients revealed household income grossly reduced among TB patients over time, increasing proportion of people classified as poor from 54% to 79%, with patients borrowing money and selling assets to cope with the cost of care (105, 131). Foster and colleagues stated that the indirect costs of TB on households could drive a 'medical poverty trap', as they adopt devastating coping strategies in the face considerable payments and assets losses during the illness (10). Considering the average annual income of TB patients in the study ($449.90 and $960.65 for female and male patients respectively), the income lost due to TB as reported in this study could be described as catastrophic (more than 10% of the annual income (114)) to many patients and their households. As most indirect costs are due to lost income and time, it is important for experts working on TB control to factor these into potential research and interventions, with emphasis on the contextual needs of the poor who are actually the most affected in several settings.

4.5. STUDY LIMITATIONS

There were several limitations that affected this study. As with questionnaires and interviews, recall biases may have led to inaccurate cost estimates. Although several questions on costs, income and time lost and job losses were linked to memorable events in the history of the patient, this was still difficult to ascertain, this giving the results presented wide uncertainties. Some authors have recommended that to attain some degree of accuracy, there may be need to estimate direct costs first, and then link this using some sets of scores and guidelines to arrive at losses of time and potential income as a result of the illness (105). This is rather hypothetical, as there is yet a standard guideline that best integrates this simulation. The results in this study are therefore presented against these limitations. Other general limitations such as selection bias, observational bias discussed in the previous Chapter also applies.

4.6. CONCLUSION

This study suggests a high indirect cost attributable to TB in Nigeria. Tuberculosis poses tremendous burden in terms of time and productivity lost to both patients and their households that could be catastrophic to many patients and their families whom are mostly impoverished and economically very vulnerable. Indirect cost of household members was particularly high in hospitalized patients, suggestive of prolonged hospital stay, poor state at presentation, and challenges with the capacity of health facilities to promptly respond to patient needs. There is need for resources to be directed towards prevention, early diagnosis and treatment, and better health service delivery in Nigeria and indeed across several African settings. Incorporating patients' nutrition into national treatment plans may help reduce feeding costs on households, particularly among patients that are HIV positive who need more nutritional supplements. For those on treatment already, it may also be helpful that treatment support be given at community

levels as this reduces the impact on the household particularly during the intensive first two month of treatment. Largely, it is important that local, national and global TB policies and interventions be directed at early identification of TB patients and community-based support of patients in ways that reduces poverty and ensures quick recovery. Having highlighted the provider cost implications, and patients' direct and indirect attributable cost due to TB in Nigeria (as contained in *Chapters 2-4*), it is important to highlight the cost and impact of TB control programme and interventions in Nigeria, towards an informed policy driven and public health response to TB in the country.

5. THE COST AND IMPACT OF SCALING UP OF THE TB CONTROL PROGRAMME IN NIGERIA

This Chapter describes the cost and impact regarding the number of TB cases detected and treated in Nigeria, and cases potentially averted among migrants coming into the UK in the next 20 years.

5.1. BACKGROUND

Poor case detection, treatment and coverage on existing interventions for TB have been widely reported in Nigeria (108). In 2015 alone, the incidence of multidrug resistance TB in Nigeria was 16 per 100,000 population accounting for over 29000 new cases (2). With increasing cases of drug resistant TB and high prevalence of HIV infection amidst a rapidly-growing population, migrating Nigerians, and indeed migrants from other similar developing countries, remain the main importers of TB to UK and several developed countries (133).

In 2009, the World Health Organization (WHO) estimated the cost of improving health systems in 49 developing countries, as a measure to scale up health service delivery for top causes of morbidity and mortality in these settings (6). Based on country prices and using a normative approach, the total additional cost of scaling up health service provision in these countries was US$ 251 billion spanning 7 years (134). Interestingly, sub-Saharan Africa (sSA) account for over 60% of this estimate at US$ 151 billion. It is expected that if these funds are efficiently utilized, mortality would reduce significantly across the 49 countries, particularly in sSA, averting 23 million deaths over the period 2009-2015 (134). Indeed, due to fragile health systems in sSA, the need to invest in top causes of mortality remain one of the major strategies towards alleviating the disease burden on these settings.

Arguably, 'investment' by developed countries, to scale up TB control programme in Nigeria and other countries in sSA through provision of funds (towards bridging the gaps for full implementation of all the activities recommended by the WHO Stop TB Strategy (96)) could be seen as not only an investment to help humanity, but also a preemptive approach to avert influx of TB cases from these countries. However, despite the seemingly worthwhile initiative, there is yet a detailed assessment of the cost and impact of such scale-up investment in a Nigerian setting (5, 82). Generally, economic analysis of TB in Nigeria has been a challenge over the years, due to the paucity of data and lack of a standard mechanism for routine collation of data on health financing, and other related building blocks of the health system (135).

Even in settings with limited data, designing a simple decision analysis model remain difficult. For example, Dowdy and colleagues explained that cost-effectiveness analysis may be misleading if applied only to scale-up of TB diagnostics (136). In such instances, the costs of false positive or negative diagnoses are often poorly defined and underestimated, and the operational and clinical impact of the diagnostics are mostly not accounted for (136). Besides, as a result of the challenges in determining accuracy (sensitivity and specificity) of diagnoses, several investigations are ordered, which rather results in the diagnostic activities competing with available resources when specific TB treatments are needed (137). This often makes it difficult to specify standardized cost-effectiveness thresholds for specific aspects of TB management.

Hence, this chapter provides an opportunity to examine the projected cost of an '*investment*' in TB management (including scale-up of diagnosis, treatment, prevention and control) over a period of 20 years in Nigeria. It also describes how this can fit into the '*funding gap'*,

prospectively estimated from the difference between what is required for full implementation and the resources that are likely going to available over the next 20 years.

5.2. METHODS

A Microsoft Excel™ based model was developed to extrapolate disease and treatment burden of TB in Nigerian population over a period of 20 years, with the cost estimated element by element. For instance, per patient TB control programme, cost elements were estimated from the World Health Organization TB control planning and budgeting tools multiplied by unit patients accessing services calculated (8, 138). The products were finally summed up to give the total expected programme expenditure. All currency value reported in the study was based on the US $ PPP as at November 2008 value. Amounts quoted in UK Pound Sterling (£) is also based on November 2008 $/£ exchange rate.

The driver of the programme cost was regarded as the number of patients accessing services, including the coverage, case detection and treatment success rates.

5.2.1. General Assumptions

US Dollar was used as the currency for all TB diagnostics and treatment expenditures in Nigeria which was subsequently converted to Great Britain Pound sterling based November 2008 exchange rate £1.00=$1.55=NGR 148.00, as this was an investment expected from the UK to Nigeria (120). All future costs were discounted by 3.5%. It was assumed that by full scale up of TB control programme in Nigeria, the TB incidence in the country will be declining by about 6% annually. This assumption is based on a study conducted in Peru that showed a 6% annual decline in TB incidence following full scale up of DOTS (79). It is understandable that there are distinct contextual differences between Nigeria and Peru, as the latter has a much lesser incidence of Tuberculosis. However, as noted, there are no comparable comprehensive

study in sSA, with the study in Peru as identified from the literature search conducted (**Table 1.2**), being a developing economy providing a relatively comparable estimate. However, a sensitivity analysis and apparent limitation of this assumption have been included, and discussed extensively in *Chapter 6*.

Meanwhile, at the present level of TB service coverage in Nigeria, the incidence rate of TB has been declining over the past few year at a rate of 2.7% and 2.6% were reported between 2006-2007 and 2007-2008, respectively (8). Hence, in the first three years of implementing the scale up, the incidence rate was assumed to remain 2.7% annually and subsequently 6% annually for the remaining 17 modeled years. Achieving a full scale-up was considered a reasonable target based on the Peru experience within the first 3 years. All currency value reported in the study was based on the US $ PPP as at November 2008 value. Amounts quoted in UK Pound Sterlings (£) is also based on November 2008 $/£ exchange rate.

5.2.2. The cost elements and assumptions

- *National and State TB control programme logistics and overhead*- The cost per patient for national and state TB control programme logistics and overhead was estimated at US $43 per patient based on the WHO Budget estimate in 2006 (8).
- *Routine programme management, supervision activities*- The cost per patient treated for routine programme management, supervision activities, meetings, equipment and training was estimated at US $72 per patient, also based on the WHO Budget estimate in 2006.
- *Private-Public Mix (PPM*)- The cost for PPM activities was estimated. A sum of US $171,054 will be needed in 2012 for PPM activities, US $178,532 in 2013, US

$188,595 in 2014 and US $196,846 in 2015. In this study, the 2015 figure was assumed to be the annual requirement from 2015 to 2031.

- *Practical Approach to Lung Health (PAL)* - The estimated cost for PAL activities was US $207,941 annually from 2012 to 2031.
- *Communities TB care (CTBC)*- The estimated cost for CTBC activities was US $271,353 in 2012, US $285,288 in 2013, US $299,889 in 2014 and US $315,175 in 2015, and assumed (in this study) to remain so annually up to 2031.
- *Advocacy, Communication and Social Mobilization (ACSM)* – The cost of ACSM activities was estimated at US $20,143,067 in 2012, US $21,177,500 in 2013, US $22,261,413 in 2014 and US$ 23,396,071 in 2015, and assumed to remain same up to 2031.
- *Technical support*- The cost for technical assistance by staff and consultants in country based and International organizations was also estimated at US $320,000 annually from 2012 to 2031.
- *Monitoring, Evaluation, Surveillance and Operational Research (M&E, S, O.R)*- The cost of activities was estimated at US $1,012,000 in 2012, US $1,000,000 in 2013, US $1,058,400 in 2014, and US $1,101,000 annually from 2015 to 2031.
- *Multi-Drug Resistant TB (MDR TB) treatment cost*- The cost of treating a case of MDR TB in Nigeria was estimated at US $3,106 per MDR-TB patient and assumed not to be affected throughout the 20 years' model period. This cost includes the cost of MDR TB drugs, hospitalization for MDR TB patients, outpatient and DOT visits by MDR TB patients, sputum smear, culture, DST and X rays, MDR TB programme and

data management, provision of food parcels to MDR TB patients, services for adverse drug effects, and other costs relevant for MDR TB patients.

- The cost of TB/HIV collaboration activities was estimated at US $0.42 per HIV patient screened for TB, treatment for latent TB in HIV patient at US $33 per patient completing IPT, HIV counseling and testing at US $22 per patient tested and counseled, cost of HIV prevention activities at US $24 per TB patient treated, cost of care and support for HIV+ TB patients at US $66 per patient treated for 6 months, cost of ART for HIV+TB patients at US $1363 per patient for 6 months, and cost of CPT per HIV+ TB patient for 6 months at US $71.

5.2.3. Modeled impact in the United Kingdom

5.2.3.1. Characteristics of migrants/entrants population coming into the UK

The age and gender composition of Nigerian migrants into the UK, based on data from Labor Forces Survey (conducted by the Office of National Statistics in 2006), are reported below. Nigerian migrants in the UK were estimated to be 146,300 first generation population of Nigerian migrants (133, 139). The survey reported the gender and age composition of this population as:

Gender composition: 52% were male

48% were female

Age composition: 8% were aged 0-15 years

12% were aged 16-24 years

53% were aged 25-44 years

23% were aged 45-64 years

4% were aged 65+ years

Based on this age distribution, entrants' exposure to Tuberculosis and estimated burden was calculated. A projection was made for the 20-year model period for both intervention (CXR, IGRA and Investment to scale-up TB control in Nigeria, and the hypothetical no intervention '*doing nothing*' scenarios. Based on these projections, numbers and proportions of entrants coming into the UK in each TB state were estimated.

5.2.3.2. Economic and legal status of entrants

Most of the Nigerians who enter the UK are legal entrants, i.e. work permit holders, students, and refugees and asylum seekers (133, 139). Among the long-term migrants, about 76% were employed, 7% were unemployed and 17% were inactive, 50% either own a property outright or have bought a home with a mortgage (140). There was no information about the income of Nigerian migrants in the UK. There was also no published information on the income of visitors and other short term entrants from Nigeria in the UK. It was however assumed that no visitor works while in the UK. All children under the age of 15 years were assumed not to be working.

5.3. RESULTS

5.3.1. Drugs sensitive patients' hospitalizations, outpatient care, investigations and drugs

With a potential implementation of the proposed scale-up intervention, the annual cost of treatment for all expected drug sensitive TB cases in Nigeria raised from GBP 12,717,947 in 2012 to a peak level of GBP 43,848,666 in 2015, before declining to GBP 15,124,897 by 2031. However, in a scenario where the intervention is not implemented, the annual cost of treatment for all expected drug sensitive cases in Nigeria will slightly reduce from GBP 12,717,947 in 2012 to GBP 12,098,635 by 2031 (**Figure 5.1**).

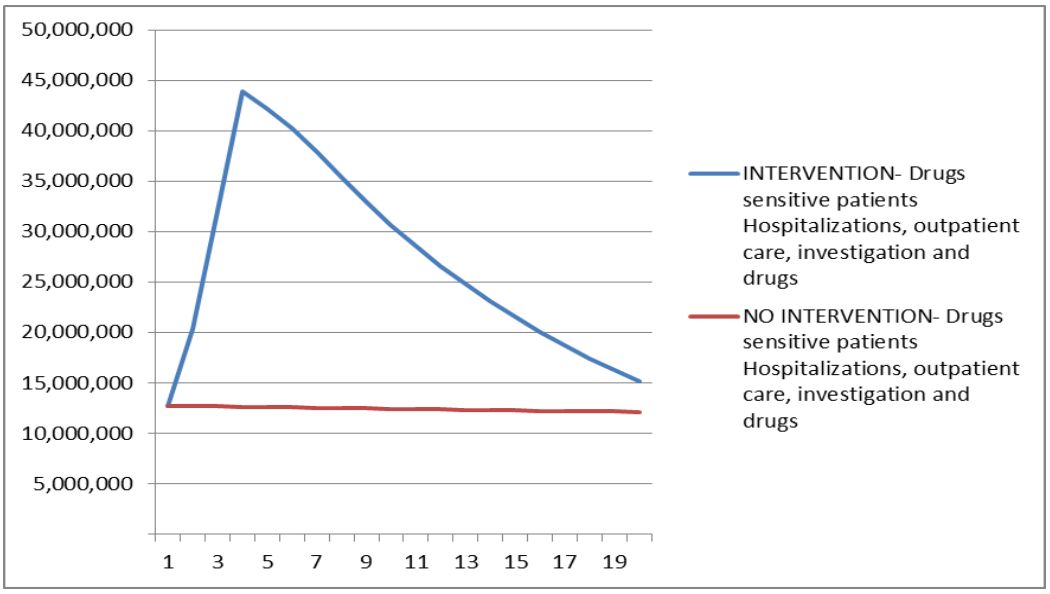


Figure 5.1. Line diagram showing total cost of drug sensitive patients' hospitalizations, outpatient care, investigation and drugs through the model years

5.3.2. Drugs resistant patients' hospitalizations, outpatient care, investigations and drugs

With the proposed intervention implemented, annual cost of treatment for all expected drug resistant TB cases in Nigeria will rise from GBP 3,542,755 in 2012 to a peak level of GBP 12, 214, 634 in 2015 before declining to GBP 4,213,243 by 2031. However, in a scenario where the intervention is not implemented, the annual cost of treatment for all expected drug resistant TB cases in Nigeria slightly reduces from GBP 3,542,755 in 2012 to GBP 3,370,237 by 2031 (**Figure 5.2**).

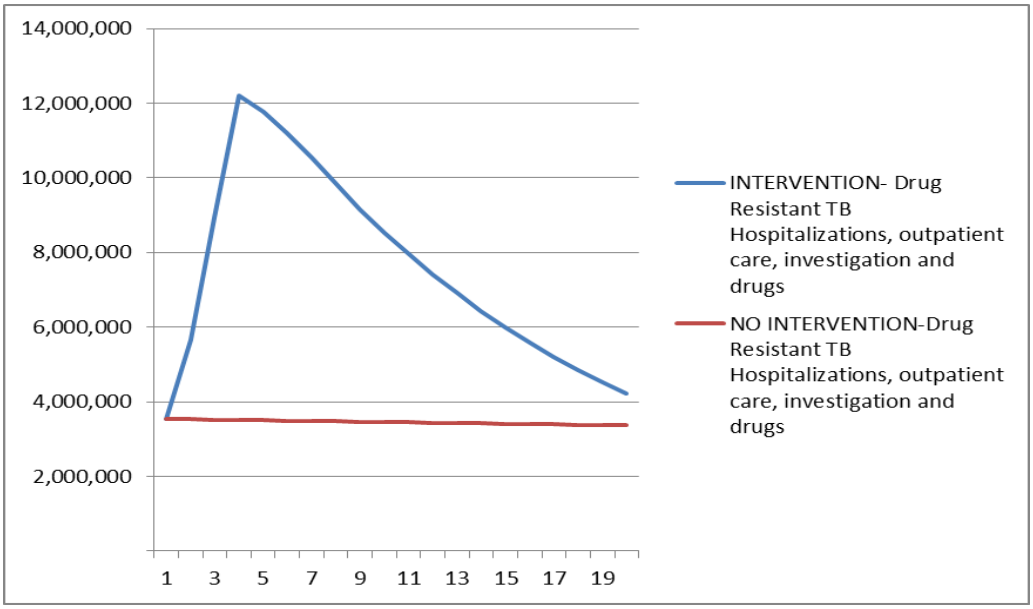


Figure 5.2. Line diagram showing total cost of drug resistant patients' hospitalizations, out-patients' care, investigation and drugs through the model years

5.3.3. National and State TB control programme

With the proposed intervention, annual cost of national and state general TB control programme in Nigeria is expected to rise from GBP 62,282,420 in 2012 to peak at GBP 151,429, 071 in 2015 and subsequently decline slightly annually to GBP 110,331,044 by 2031. However, in a scenario where the proposed intervention is not implemented, this cost element was assumed to remain at the 2012 estimate of 2012 throughout the 20 model years (**Figure 5.3**).

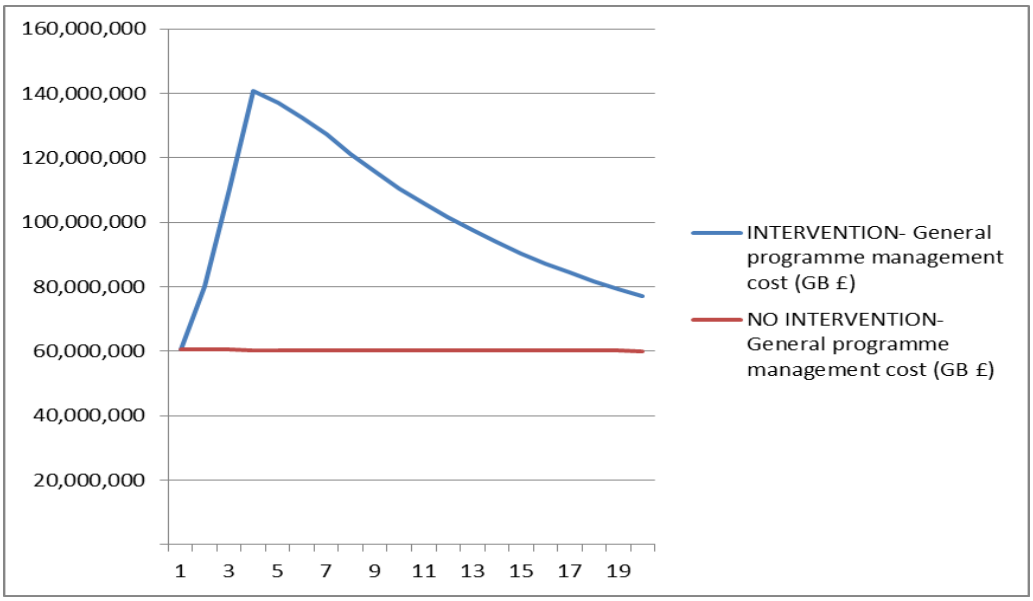


Figure 5.3. Line diagram showing general programme management cost through the model years

5.3.4. Total programme (scale-up) management

When the proposed intervention is implemented, the total programme scale up cost in Nigeria will to rise from GBP 76,822,658 in 2012 to a peak level of GBP 203,890,020 in 2015 before declining to GBP 144,685,342 by 2031. However, in a scenario where the intervention is not implemented, the total annual cost of TB control programme will rise from GBP 76,822,658 in 2012 to a peak of GBP 106,885,183 by 2019 decline to GBP 93,636,754 in 2031 (**Figure 5.4**).

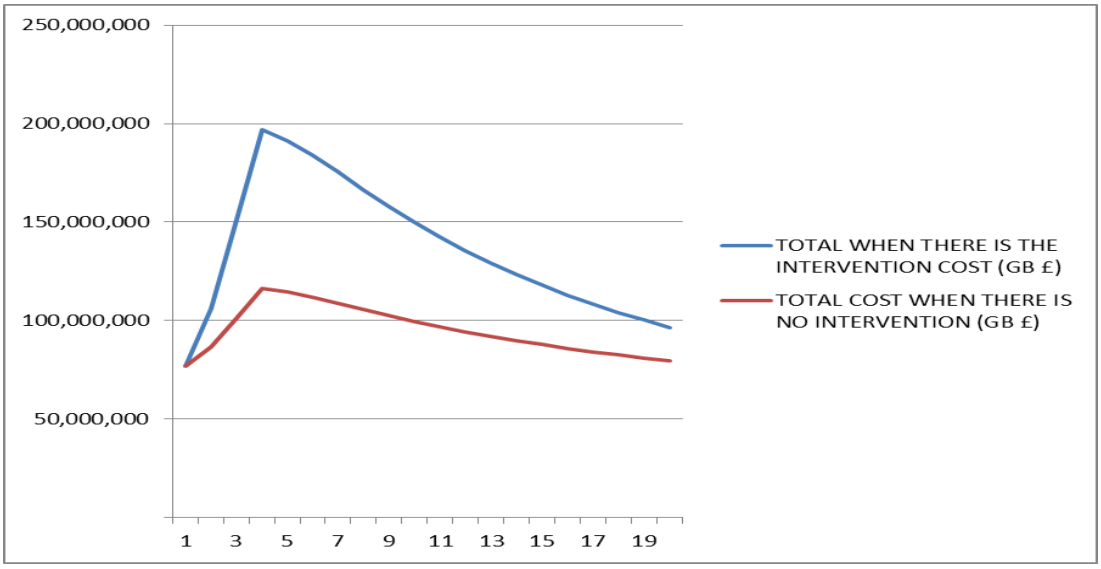


Figure 5.4. Line diagram showing total programme (scale-up) cost, with and without proposed intervention through the model years

5.3.5. Total cost of scaling up and the funding gap

The total annual funding gap for scaling up TB programme in Nigeria was estimated to raise from GBP 0 in 2012 to peak at GBP 97,380,987 (GBP 94,459,558 discounted) in 2015 and subsequently reduced to GBP 51,048,588 (GBP 49,517,130 discounted) in 2031 (**Figure 5.5**).

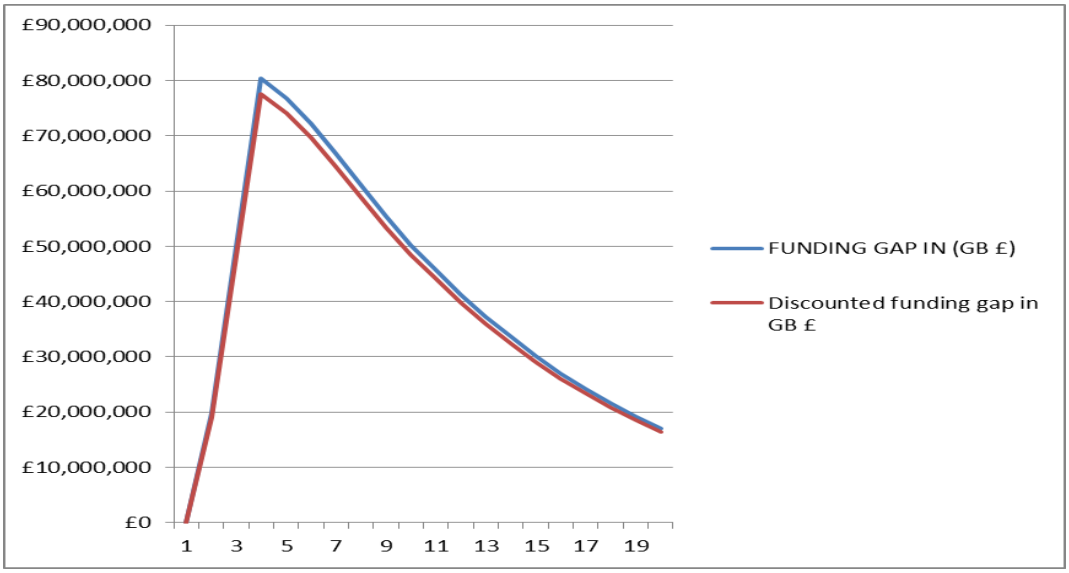


Figure 5.5. Line diagram showing total funding gap for scaling up TB control programme in Nigeria through the model years

5.3.6. Projected impact of intervention in Nigeria TB control

5.3.6.1. ***In Nigeria***

Incidence rate of TB cases in Nigeria decline over the 20 years study period, from 311/100,000 in 2012 to 189/100,000 (without proposed intervention) or 66/100,000 (with the proposed intervention) in 2031. In other words, the intervention will hasten the observed decline in TB incidence from the expected cumulative 122% reduction based on the present 2.6% annual decline rate to 245% reduction in 2031.

A similar trend will be observed in both sputum smear positive and negative TB patients. Over the 20-year period, sputum smear negative incidence rate declined from 180/100,000 to 109/100,000 without proposed intervention and 38/100,000 with the intervention in the country and sputum positive incidence rate declined from 131/100,000 to 79/100,000 without the intervention and to 28/100,000 with the intervention (**Figure 5.6**).

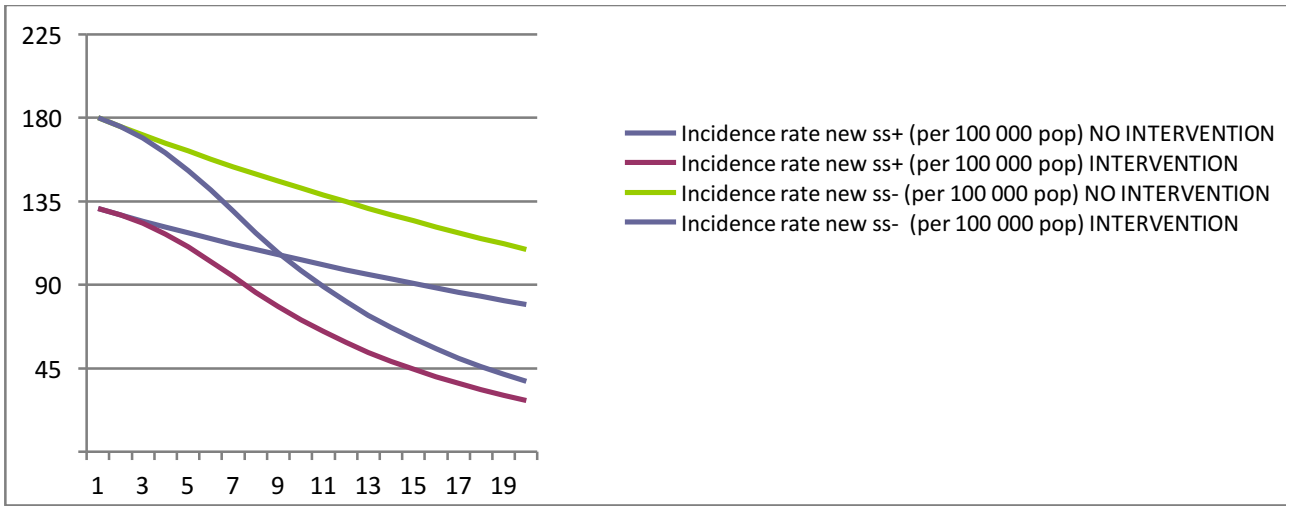


Figure 5.6. Line diagram showing decline of projected incidence rates of sputum smear negative and positive TB in Nigeria through the model years

Total number of new TB cases in Nigeria: Thus, the total number of new TB cases in the country is expected to decline, from 519,211 in 2012 to 493,928 without intervention and 172,252 with the intervention in 2031 as shown in the line diagram (**Figure 5.7**) below:

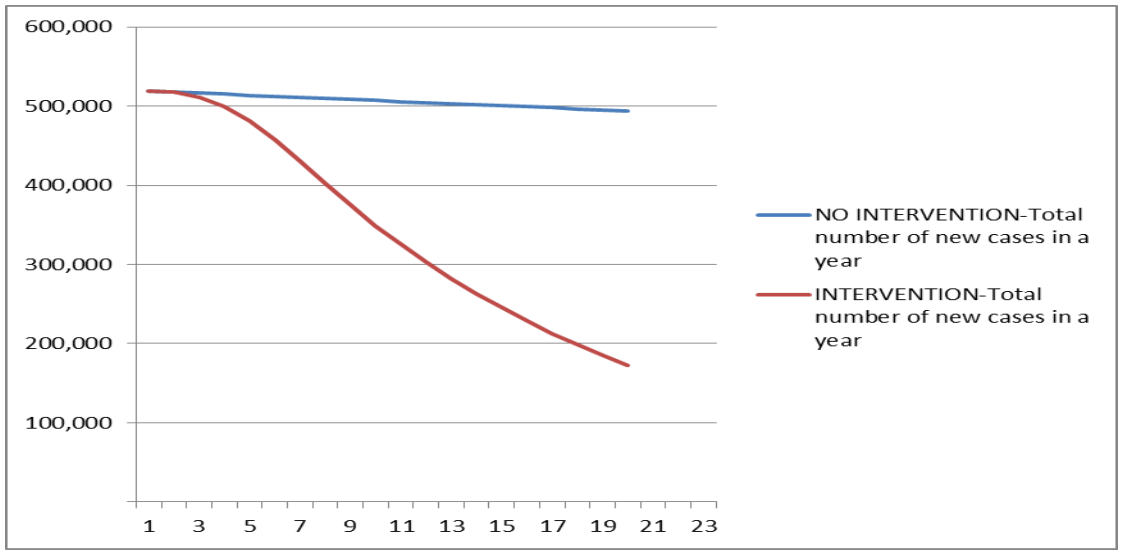


Figure 5.7. Line diagram showing decline of projected number of new cases of TB, with and without scale-up intervention, in Nigeria through the model years

Total number of TB patients to be treated in Nigeria: The number of TB patients to be treated is expected to increase sharply, from 101,388 in 2012 over the first few years to a peak at 349,564

in 2015 then declines to 120, 576 without and 96,451 with the proposed intervention by 2031 as the burden of the disease significantly decrease in the country (**Figure 5.8**).

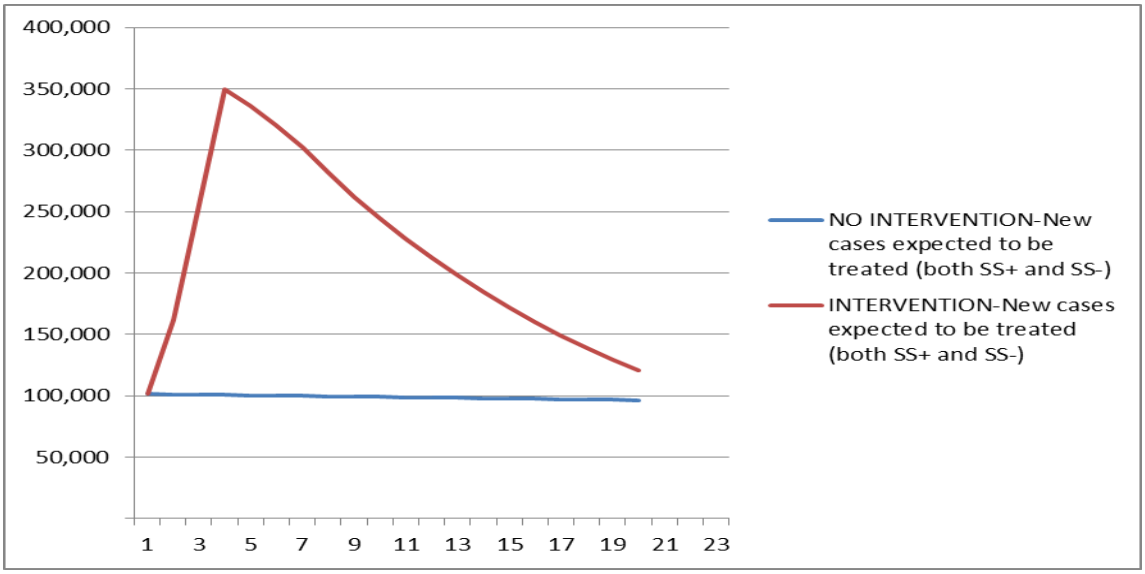


Figure 5.8. Line diagram showing decline of projected total number of TB to be treated annually in Nigeria through the model years

Total number of TB patients that would not get treated: The number of TB patients expected not to get treated decreased from 417,823 in 2012 to 397,477 without the proposed intervention, and sharply to 51,676 with the intervention by 2031, mirroring similar reduction in the total burden of the disease decrease in the country. The decline with intervention was steeper in the first 3 years but slows down after the case detection rate peaked at 70% and remained so through the remaining period in the model (**Figure 5.9**).

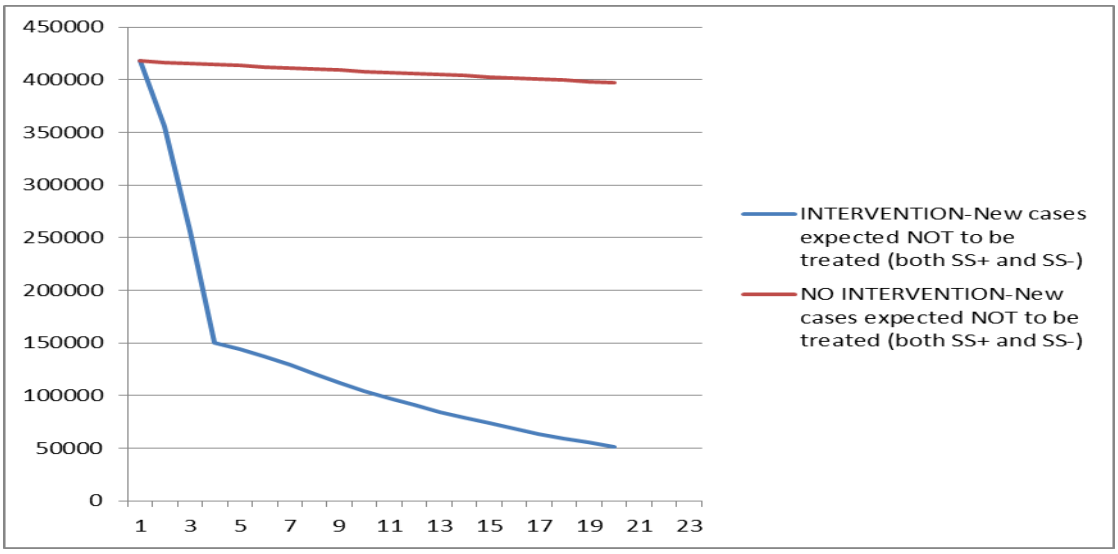


Figure 5.9. Line diagram showing decline in the total number of TB that will not be treated annually in Nigeria through the model years

Annual number of TB infections averted increased from 0 in 2012 to 321,676 per annum with the intervention and 170, 006 per annum without intervention in 2031. Cumulatively, about 3,171,261 lives and about 2,470,196 lives will be saved with and without the proposed intervention, respectively over the 20-year period (See **Figure 5.10**).

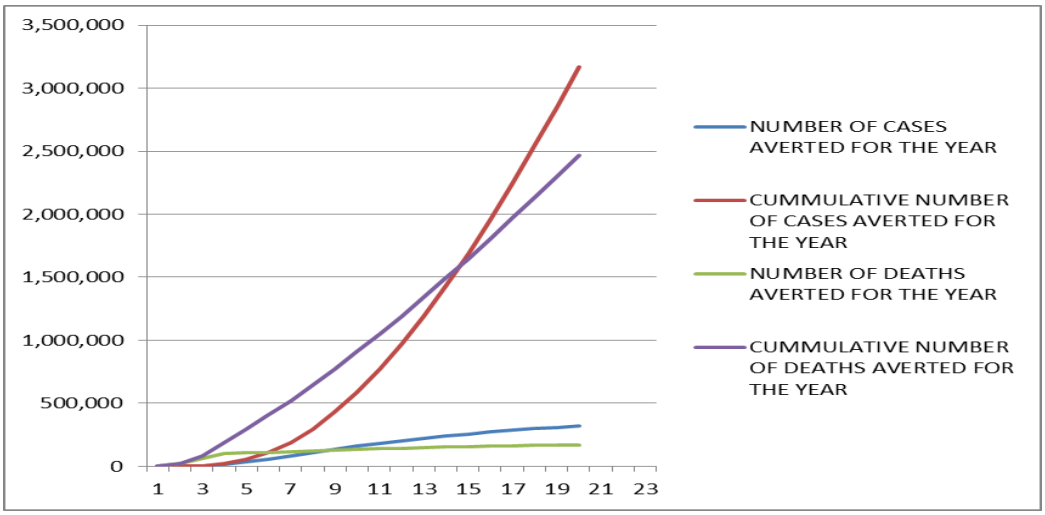


Figure 5.10. Line diagram showing total number of TB cases and deaths that will be averted with the intervention annually in Nigeria from 2012 to 2031

5.3.6.2. ***Amongst Nigerian migrants in the UK***

A major assumption in the study is that there will be corresponding decline in the burden of TB among Nigerian migrants with decline in the disease burden in Nigeria. The total annual burden of TB will decline from 21,608 in 2012 to 15,858 in 2031 if there is no intervention in Nigeria, and 5,246 with the proposed intervention. The cumulative number of all the TB infections coming into the UK from Nigeria over the 20 years was estimated at 370,135 without the intervention and 267,149 when there is intervention. Thus, the intervention will avert about 102,986 cases of all forms of TB among migrants/entrants from Nigeria in the UK (**Figure 5.11, Table 5.1**).

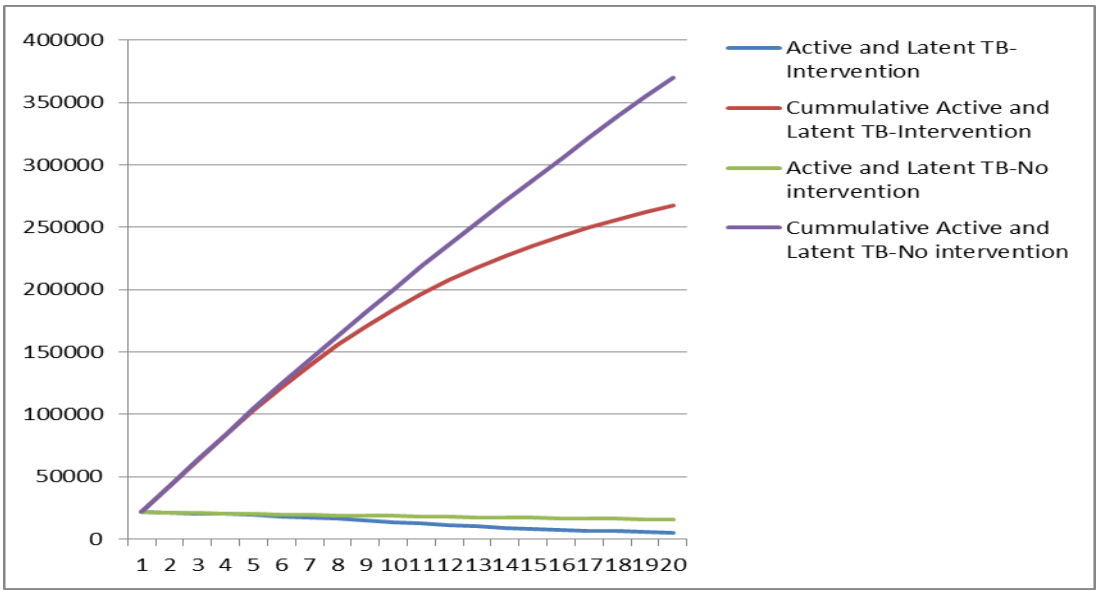


Figure 5.11. Line diagram showing the annual and cumulative TB cases among Nigerian migrants entering the UK with and without the intervention in Nigeria through the model years

Active TB cases entering UK from Nigeria: The annual number of active TB cases among migrants coming to the UK from Nigeria will decrease from 283 in 2012 to 172 without

intervention and 60 with proposed intervention by 2031 as the burden of the disease in Nigeria proportionately decreased over the 20-year period (**Figure 5.12, Table 5.1**).

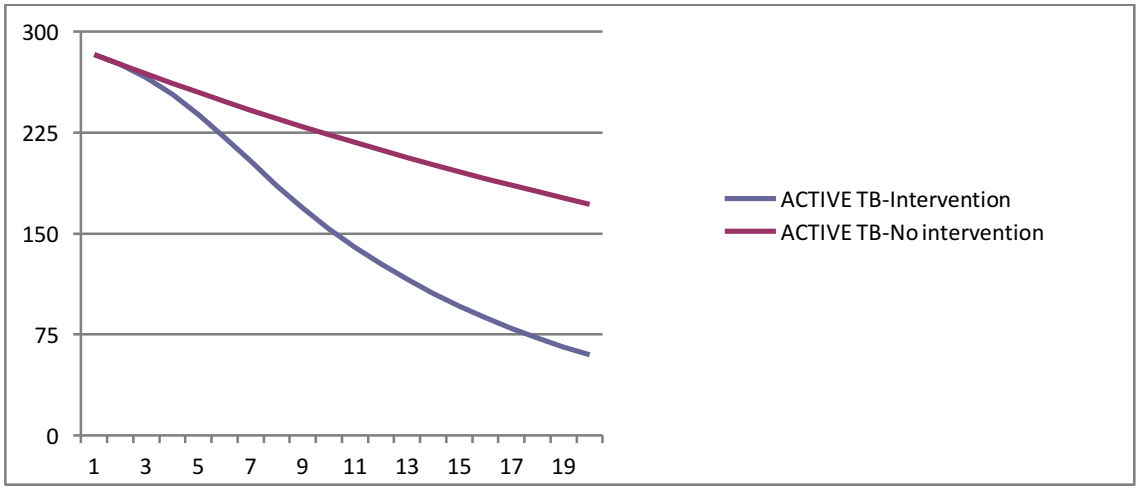


Figure 5.12. Line diagram showing decline in the number of active TB cases entering the UK from Nigeria, through the model years

Table 5.1. Projections annual influx of TB cases from Nigeria into the UK

Year	*No investment in Nigeria TB control*				*Investment in Nigerian TB control*			
	Active TB	Recent latent TB	Longstanding latent TB	Total	Active TB	Recent latent TB	Longstanding latent TB	Total
2012	283	1246	20079	21608	283	1246	20079	21608
2013	276	1220	19733	21228	276	1220	19733	21228
2014	269	1195	19395	20859	266	1185	19265	20716
2015	262	1170	19067	20498	254	1142	18690	20086
2016	255	1146	18746	20148	238	1089	17974	19301
2017	248	1123	18435	19806	222	1030	17188	18440
2018	242	1100	18131	19473	204	968	16354	17526
2019	235	1078	17835	19149	186	904	15490	16579
2020	229	1057	17547	18833	169	811	13807	14787
2021	223	1036	17266	18526	154	741	12655	13549
2022	218	1016	16993	18226	140	677	11606	12423
2023	212	996	16727	17935	127	611	10417	11155
2024	206	977	16467	17650	116	556	9479	10151
2025	201	958	16215	17374	105	506	8626	9238
2026	196	939	15969	17104	96	461	7850	8406
2027	191	922	15729	16842	87	419	7143	7650
2028	186	904	15496	16586	62	381	6500	6943
2028	181	887	15269	16337	72	347	5915	6335
2030	176	871	15047	16094	66	316	5383	5765
2031	172	855	14832	15858	60	287	4898	5246
	4461	**20696**	**344978**	**370135**	**3182**	**14897**	**249052**	**267132**

Recent' latent TB cases entering UK from Nigeria: The annual number of 'recent' latent TB cases among migrants and other entrants coming to the UK from Nigeria also decreased from 1246 in 2012 to 855 (with intervention) and 287 (without intervention) by year 2031 (**Table 5.1, Figure 5.13**).

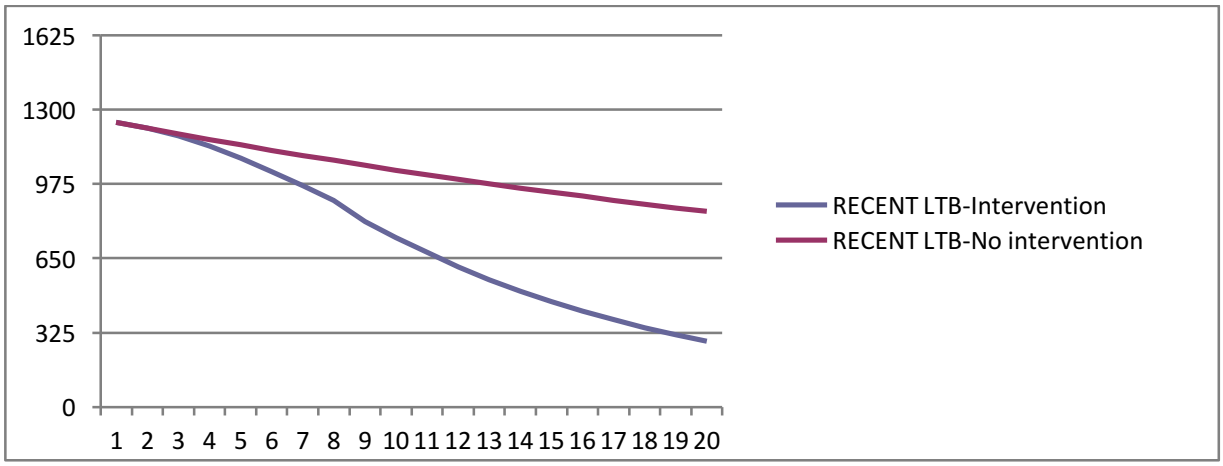


Figure 5.13. Line diagram showing decline in the number of 'recent' latent TB cases entering the UK from Nigeria, through model years

*Longstanding' latent TB cases entering UK from Nigeria***:** The annual number of 'longstanding' latent TB cases among migrants coming to the UK from Nigeria decreased from 20079 in 2012 to 14832 (without the proposed intervention) and 4898 (with the proposed intervention) by 2031 as shown in the line diagram below (**Table 5.1, Figure 5.14**).

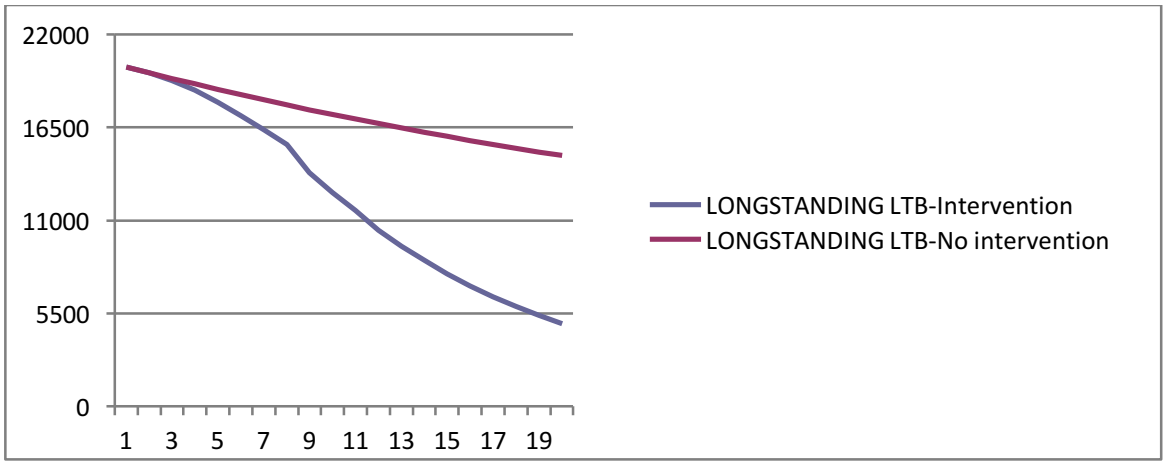


Figure 5.14. Line diagram showing decline in the number of 'longstanding' latent TB cases entering the UK from Nigeria, 2012 to 2031

5.4. DISCUSSION

The study found that although total of about GB £3.34 billion is required for implementation of full scale TB control program in Nigeria over the next 20 years, but based on the current spending by Nigerian government and other funders (8), its estimated that only about GB£ 1.99 billion is likely going to be available over the 20-year period.(8). This leaves a gap of about GB£ 1.35 billion (about 40%) over the next 20 years. An estimated funding gap of US$ 251 billion dollar will be needed over seven years to scale-up the health system of 49 low-income studies enlisted in the WHO costing exercise. This amounts to an average of US$ 5.1 billion per country included in the costing. This is relatively higher than the GB£ 1.35 (US$ 1.70) estimated in this study, possibly because this was not a disease-specific scale-up, but targets the entire sector. It may therefore still be assumed to be comparable with the estimate in this study. The cost-effectiveness of this investment is examined in detail in *Chapter Six*, with the model based on the assumption that the UK government may 'invest' as much as 25% of this gap over 20 years as a proactive strategy to reduce the influx of TB from Nigeria. The implications of this assumption and other related assumptions are also critically examined and discussed.

The WHO clearly stated that realizing desired outcomes in health indices strictly depends on the availability of more resources allocated for health in developing countries, and ensuring there is capacity to effectively utilize these funds to meet targeted health needs (141) Indeed, implementation of the WHO strategy has been proved to be effective in substantially reducing the incidence and prevalence of TB in countries with a high TB burden (96). However, due to inadequate funds and several contextual factors, the implementations of this strategy in many developing countries remain far from complete. These countries act as reservoirs for TB, adding burden to countries where the disease has been hither-to controlled, particularly owing to significant international travels and migrations from the high TB incidence countries to low TB incidence countries.

This study reported a decline in the incidence rate of TB in Nigeria over the 20-year study period, from 311/100,000 in 2012 to either 189/100,000 (without proposed intervention) or 66/100,000 (with the proposed intervention) in 2031. Thus, the total number of new TB cases in the country is expected to decline, from 519,211 in 2012 to 493,928 without the intervention and 172,252 with the intervention in 2031. In the 2009 WHO report, some specific health sector benefits were also potentially identified following health systems strengthening and scale-up of specific health interventions. It was estimated that country-specific total expenditure for health among the 49 low-income countries would increase to an average of US$54 per capital, with hospital beds increasing to about 21 per 10000 population, and nurses and midwives to 1.9 per 1000 population (134).

Meanwhile, the cumulative number of all the TB infections coming in to the UK from Nigeria was estimated at 370,135 without the intervention and 267,149 when there was the intervention, thus, the intervention may avert about 102,986 cases of all forms of TB among migrants/entrants

from Nigeria in the UK over the 20-year study period. However, despite an apparent reduction in TB burden following investment in TB control in Nigeria, the potential impact among the rural and hard-to-reach populations who are relatively poor and without the needed resources to access urban health facilities remain uncertain. It is unclear how these interventions would improve living conditions of an average rural dweller infected with TB. This challenge was also raised by the WHO, suggesting that most health system scale-up exercise and the estimated costs may not produce the "ideal" health system with evenly spread resources and service delivery across all settings, but may only offer a reasonable leverage for the local capacity to respond to pressing population health needs (134).

5.5. STUDY LIMITATIONS

One important limitation of this study is that the probability of TB cases among migrants was calculated based on the expected prevalence of TB in Nigeria after full scale up of TB. This probability was estimated at 0.0017, which was based on the assumption that with TB control strategies in Nigeria, there may be a decline of about 6% annually in the incidence of TB in the country, as observed in Peru, which provides a developing country comparison with Nigeria. Unfortunately, the plausibility of this argument is highly debatable, particularly because of the contextual differences between Nigeria and Peru. However, sensitivity analysis testing the robustness of this assumption was done and reported in the later section of this chapter. The probability active TB among migrant was doubled to about 0.0034 and was lowered by about half (to 0.0010) to find whether the cost effectiveness analysis result would be significantly changed but found that the order of effectiveness haven't changed.

Other major limitation of this study includes the assumption that there would be proportionate decline in the prevalence of TB among Nigerian coming to UK with decrease in the prevalence of TB in Nigeria. This possibility like likely makes our estimation of the Utility (QALY) gain among migrants an over estimation, however, the unity gain in Nigeria will be significant, although not estimated in this study.

Some cost estimated of some commodities and services in this study were drawn from other studies and validity of some of these estimates weren't ascertained. This also posed a limitation on the significance of this study. Efforts were made to critically appraise the validity of evidence before inclusion in this study.

The estimates provided in this study should therefore be interpreted against this limitation.

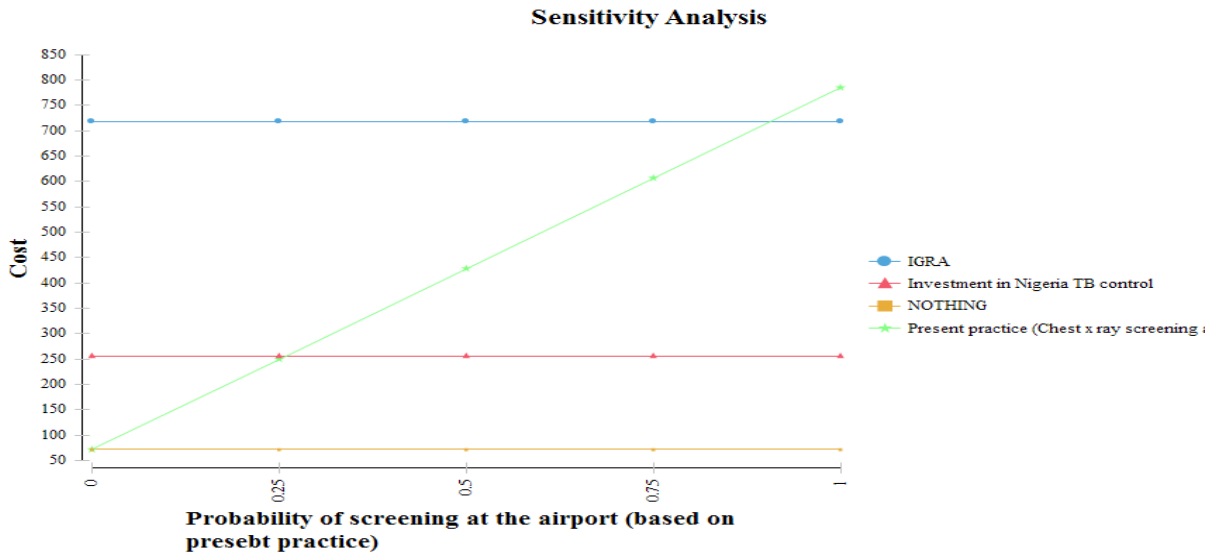
5.6. CONCLUSION

This study has suggested potential benefits in the scale-up of TB control in Nigeria, but with some uncertainties and limitations (already described). In the next chapter, cost-effectiveness analysis of selected TB control strategies among Nigerians migrants/entrants in the UK will be conducted. This builds essentially on the results already presented in this chapter. To test the robustness of the key assumptions from this chapter (and other assumptions in the next chapter), sensitivity analyses will be conducted to find if the results will significant vary.

Table 6.17. Sensitivity analysis for variable 'Proportion of entrants/migrants chest x ray screened at point of entry' (pScr)

pScr	STRATEGY	COST	EFF	C-E	I-C	I-E	ICE	Remark
0	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0	Present practice (Chest x ray screening at the airport)	72.15578	17.24856	4.18329	0.1262	-0.00118	-106.54554	Dominated
0	Investment in Nigeria TB control	255.84464	17.30379	14.78547	183.81506	0.05405	3401.06238	
0	IGRA	717.74166	17.30225	41.48257	461.89702	-0.00154	-299503.4286	Dominated
0.25	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.25	Present practice (Chest x ray screening at the airport)	250.38639	17.26573	14.50193	178.3568	0.01599	11157.54379	
0.25	Investment in Nigeria TB control	255.84464	17.30379	14.78547	5.45826	0.03806	143.40793	
0.25	IGRA	717.74166	17.30225	41.48257	461.89702	-0.00154	-299503.4286	Dominated
0.5	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.5	Investment in Nigeria TB control	255.84464	17.30379	14.78547	183.81506	0.05405	3401.06238	
0.5	Present practice (Chest x ray screening at the airport)	428.61699	17.2829	24.80006	172.77234	-0.02089	-8270.08465	Dominated
0.5	IGRA	717.74166	17.30225	41.48257	461.89702	-0.00154	-299503.4286	Dominated
0.75	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.75	Investment in Nigeria TB control	255.84464	17.30379	14.78547	183.81506	0.05405	3401.06238	
0.75	Present practice (Chest x ray screening at the airport)	606.84759	17.30007	35.07776	351.00294	-0.00372	-94319.3783	Dominated

0.75	IGRA	717.7416 6	17.30225	41.48257	461.89702	-0.00154	-299503.4286	Dominated
1	NOTHING	72.02958	17.24974	4.17569	0	0	0	
1	Investment in Nigeria TB control	255.8446 4	17.30379	14.78547	183.81506	0.05405	3401.06238	
1	IGRA	717.7416 6	17.30225	41.48257	461.89702	-0.00154	-299503.4286	Dominated
1	Present practice (Chest x ray screening at the airport)	785.0781 9	17.31724	45.33507	529.23354	0.01345	39352.95046	


Sensitivity Analysis
Cost
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800
750
700
650
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550
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400
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300
250
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0
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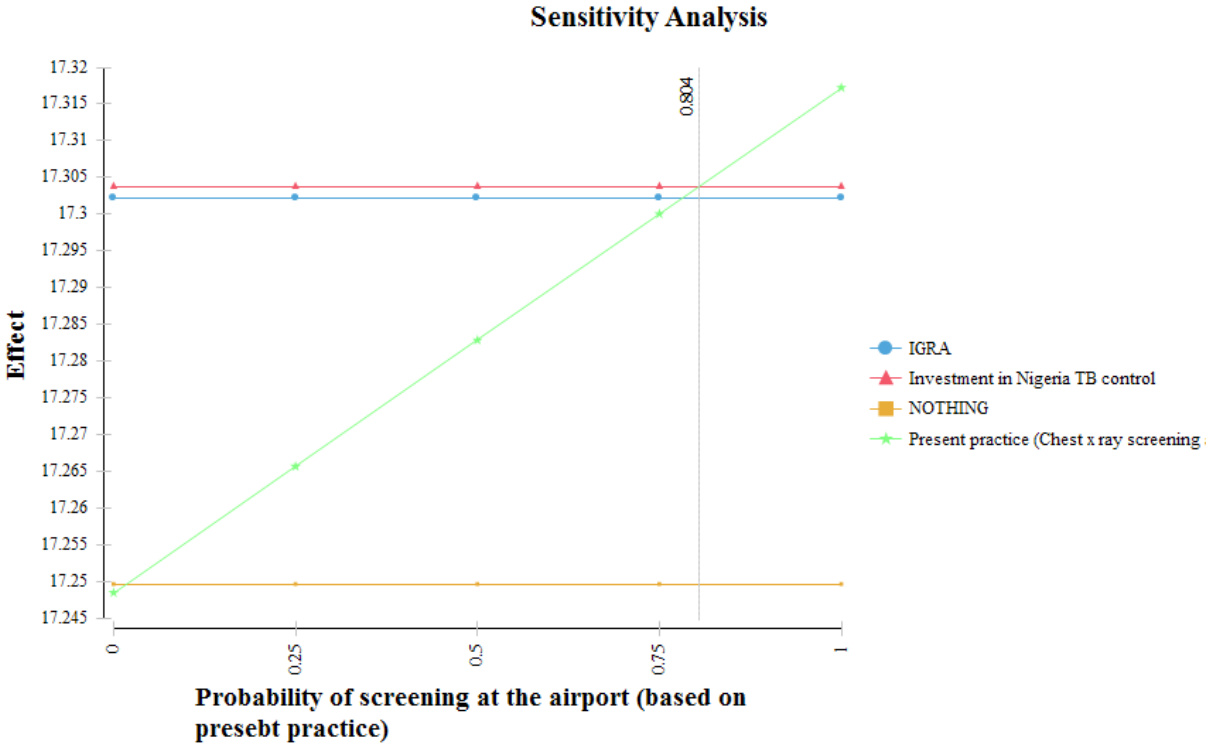
1
Probability of screening at the airport (based on presebt practice)
IGRA
Investment in Nigeria TB control
NOTHING
Present practice (Chest x ray screening


Sensitivity Analysis
Effect
17.32
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17.3
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Probability of screening at the airport (based on presebt practice)
IGRA
Investment in Nigeria TB control
NOTHING
Present practice (Chest x ray screening

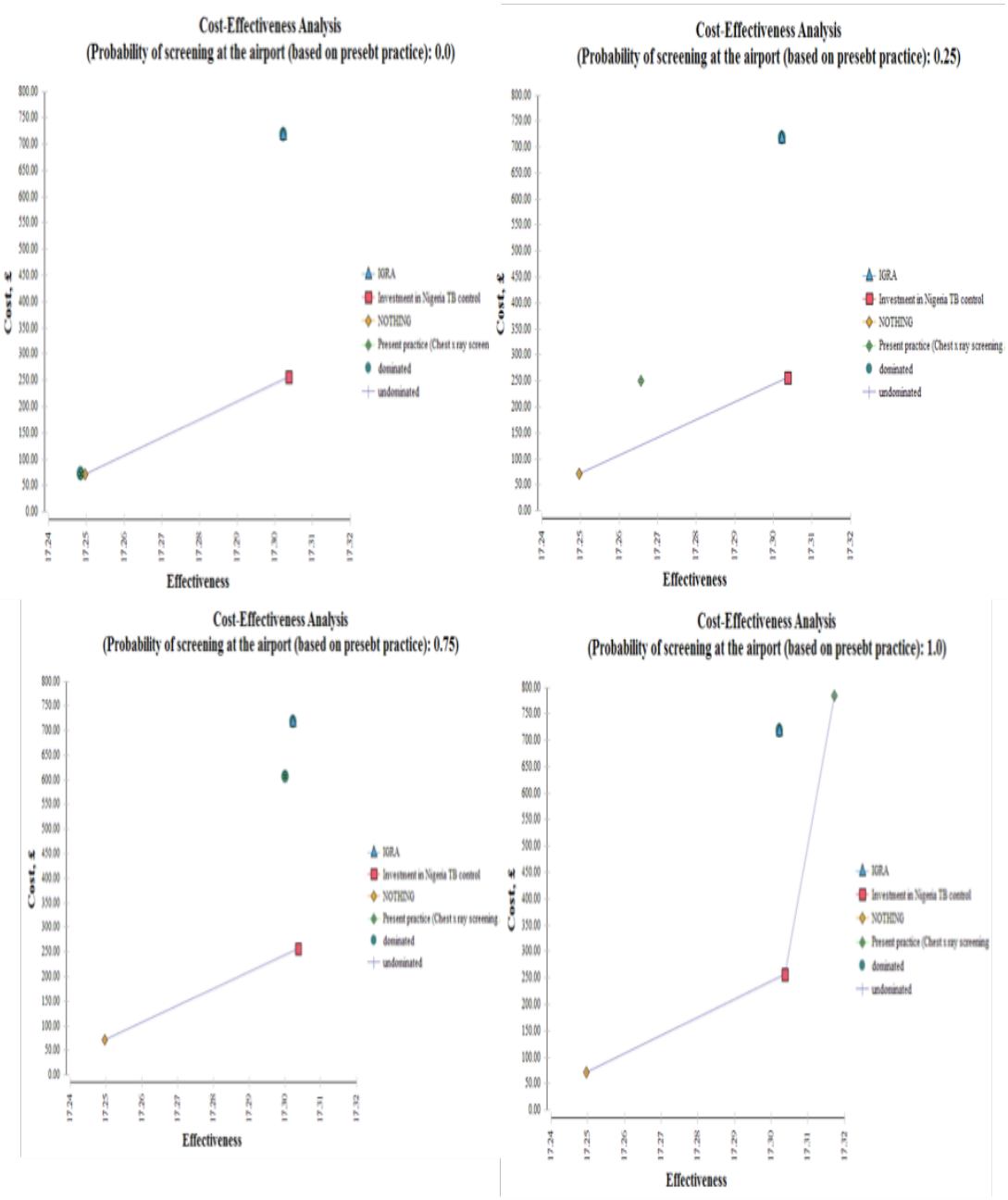


Figure 6.39. Sensitivity analysis for variable 'Proportion of entrants/migrants chest x ray screened at point of entry' (pScr) (in Figures)

5.6.1.5. Proportion of entrants/migrants screened using IGRA at point of entry (pScrIGRA)

The sensitivity of this cost-effectiveness model to changes in the proportion of Nigerian migrants/entrants screened at the airport using IGRA method was evaluated.

As shown in **Table 6.18** below, when 0% of entrants undergo IGRA screening, the most cost effective alternatives when none of the migrants is IGRA screened are strategies 1 (investment in Nigerian TB control) and strategy 2 (Chest x ray screening) and strategy 3 (IGRA) were dominated.

When 10% of migrants are IGRA screened, the most cost effective strategy is strategy 1 (Investment in Nigeria control); next strategy 2 (chest x ray screening) followed by strategy 3 (IGRA) in that order.

When 20% of migrants are screened, the most cost-effective strategy is strategy 1 (Investment in Nigeria control) followed by strategy 2 (chest X ray screening) then 3 (IGRA) in that order.

When 30% of migrants are screened, the most cost-effective strategy is strategy 1 (Investment in Nigeria control) followed by strategy 2 (chest X ray screening) in that order. Strategy 3 (IGRA) is dominated.

When 40% of migrants are screened, the most cost-effective strategy is strategy 1 (Investment in Nigeria control) followed by strategy 2 (chest X ray screening) in that order. Strategy 3 (IGRA) is dominated.

When 50% of migrants are screened, the most cost-effective strategy is strategy 1 (Investment in Nigeria control) followed by strategy 2 (chest X ray screening) in that order. Strategy 3 (IGRA) is dominated.

When 60% of migrants are screened, the most cost-effective strategy is strategy 1 (Investment in Nigeria control) followed by strategy 2 (chest X ray screening) in that order. Strategy 3 (IGRA) is dominated.

When 80% of migrants are screened, the most cost-effective strategy is strategy 1 (Investment in Nigeria control) followed by strategy 2 (chest X ray screening) in that order. Strategy 3 (IGRA) is dominated.

When all migrants are screened, the most cost-effective strategies is strategy 1 (Investment in Nigeria control) followed by strategy 2 (chest X ray screening) then strategy 3 (IGRA) (see **Table 6.18**, and group of figures below—**Figure 6.40**)

pScr IGRA	*STRATEGY*	*COST*	*EFF*	*C-E*	*I-C*	*I-E*	*ICE*	*Remark*
0	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0	IGRA	72.15578	17.24856	4.18329	0.1262	-0.00118	-106.546	(Dominated)
0	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
0	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.1	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.1	IGRA	143.8876	17.25452	8.33912	71.85797	0.00478	15030.2	
0.1	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	85.11116	0.00914	9307.841	
0.1	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.2	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.2	IGRA	215.6193	17.26049	12.49207	143.5897	0.01075	13361.77	

0.2	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	13.3794	0.00318	4209.182	
0.2	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.3	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.3	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
0.3	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.3	IGRA	287.3511	17.26645	16.64216	31.50643	-0.03733	-843.893	(Dominated)
0.4	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.4	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
0.4	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.4	IGRA	359.0828	17.27242	20.78938	103.2382	-0.03137	-3291.06	(Dominated)
0.5	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.5	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
0.5	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.5	IGRA	430.8146	17.27839	24.93373	174.97	-0.0254	-6887.54	(Dominated)
0.6	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.6	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
0.6	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.6	IGRA	502.5464	17.28435	29.07522	246.7017	-0.01944	-12691.4	(Dominated)
0.7	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.7	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	

0.7	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.7	IGRA	574.2781	17.29032	33.21386	318.4335	-0.01347	-23634.9	(Dominated)
0.8	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.8	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
0.8	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.8	IGRA	646.0099	17.29628	37.34964	390.1653	-0.00751	-51969.3	(Dominated)
0.9	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.9	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
0.9	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
0.9	IGRA	717.7417	17.30225	41.48257	461.897	-0.00154	-299503	(Dominated)
1	NOTHING	72.02958	17.24974	4.17569	0	0	0	
1	Present practice (Chest X ray screening at the airport)	228.9987	17.26367	13.26478	156.9691	0.01392	11272.52	
1	Investment in Nigeria TB control	255.8446	17.30379	14.78547	26.84593	0.04012	669.1169	
1	IGRA	789.4734	17.30821	45.61265	533.6288	0.00442	120643.2	

Table 6.18. Sensitivity analysis table for variable 'Proportion of entrants/migrants screened using IGRA at point of entry' (pScrIGRA)

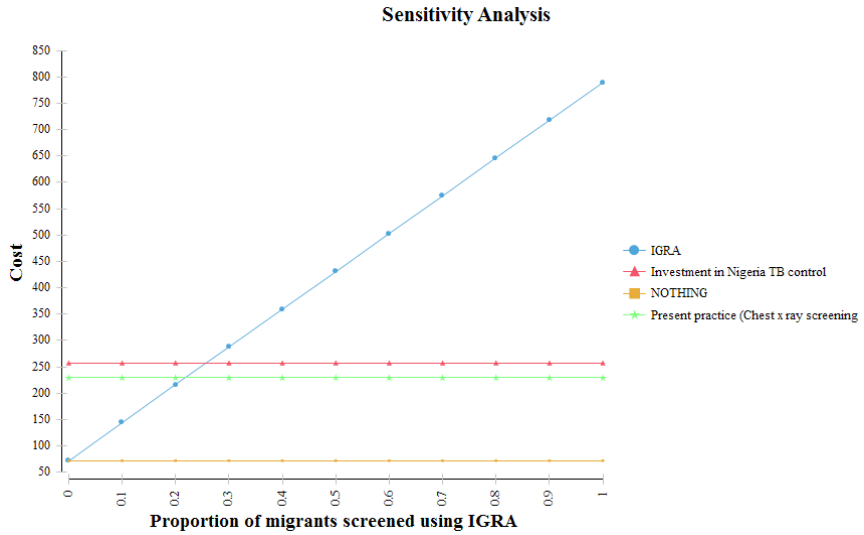


Figure 6.40. Sensitivity Analysis plot showing the total cost (,000) in US Dollars of the 4 alternative interventions by proportion of migrants screened using IGRA at the POE

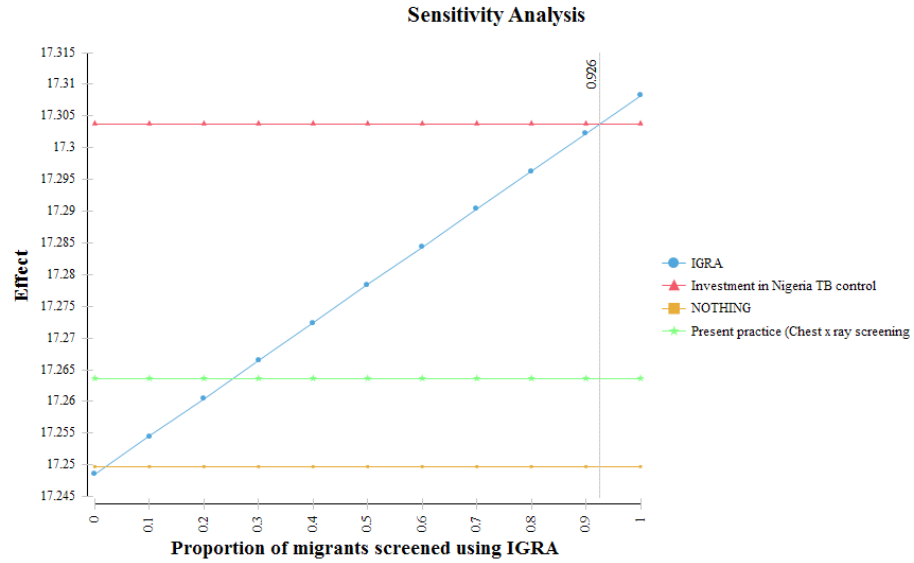


Figure 6.41. Sensitivity Analysis plot showing the Effect/migrant in QALYs of the 4 alternative interventions by proportion of migrants screened using IGRA at the POE

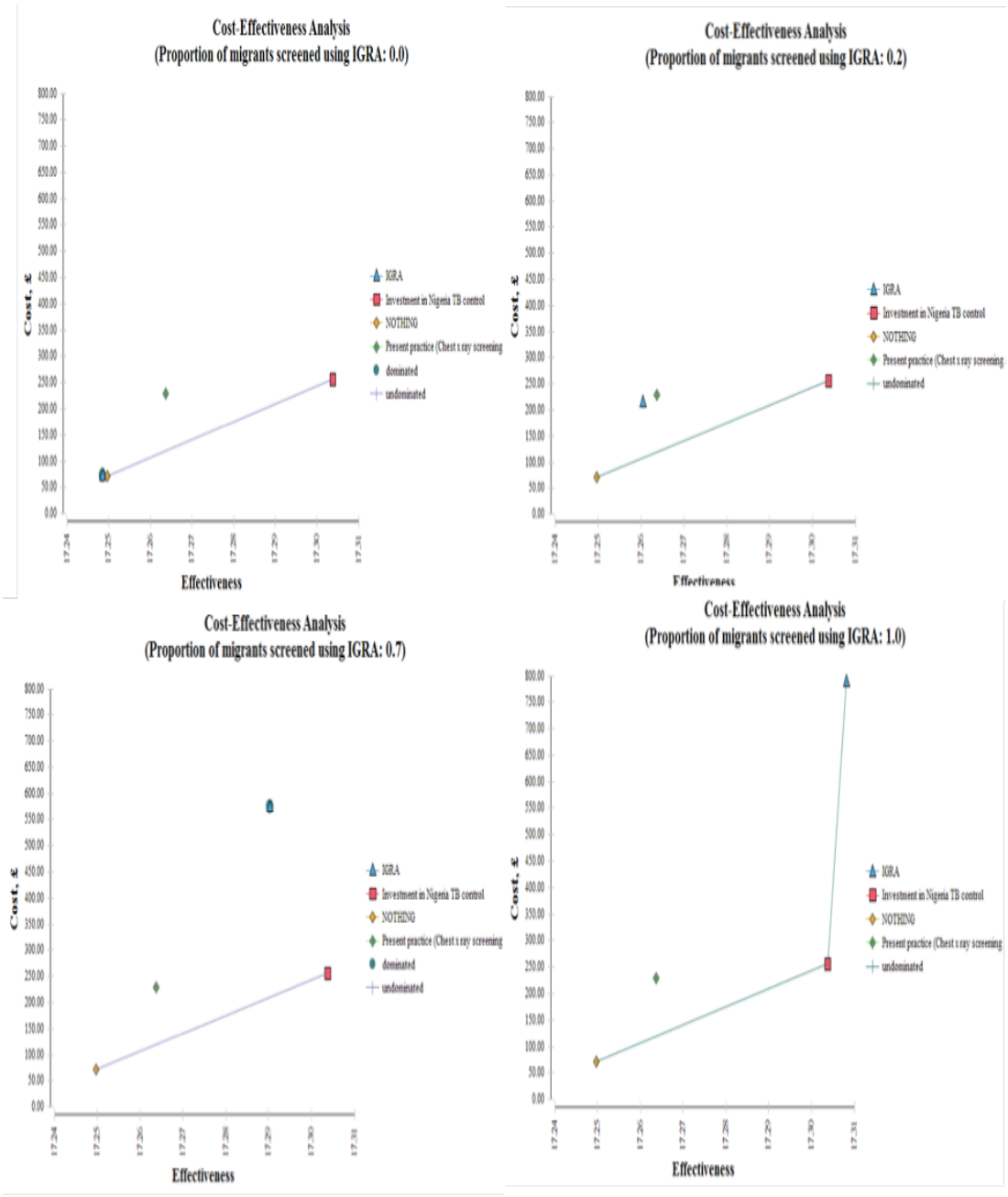


Figure 6.42. Sensitivity analysis for variable 'Proportion of entrants/migrants screened using IGRA at point of entry' (pScrIGRA) (in Figures)

5.6.1.6. Proportion of entrants/migrants that are HIV positives (ppHIV)

The sensitivity of this CE model to change in the proportion of Nigerian migrants/entrants that HIV positive was evaluated.

When 0% of entrants are HIV positive, the most cost effective alternatives is strategies 1 (investment in Nigerian TB control) with ICER of £3465.45/QALY followed by strategy 3 (IGRA) with ICER of £48847.19/QALY. Strategy 2 (Chest X ray screening) was dominated.

When 25% of entrants are HIV positive, the most cost effective alternatives is strategies 1 (investment in Nigerian TB control) with ICER of £3433.14/QALY followed by strategy 3 (IGRA) with ICER of £139785.74/QALY. Strategy 2 (Chest X ray screening) was dominated.

When 50% of entrants are HIV positive, the most cost effective alternatives is strategies 1 (investment in Nigerian TB control) with ICER of £3401.06/QALY. Strategy 2 (Chest X ray screening) and 4 (IGRA) were dominated.

When 75% of entrants are HIV positive, the most cost effective alternatives is strategies 1 (investment in Nigerian TB control) with ICER of £3,369.22/QALY. Strategy 2 (Chest X ray screening) and 4 (IGRA) were dominated.

When all entrants are HIV positive, the most cost effective alternatives is strategies 1 (investment in Nigerian TB control) with ICER of £3337.60/QALY. Strategy 2 (Chest X ray screening) and 4 (IGRA) were dominated (see group of figures below—**Figure 6.41**)

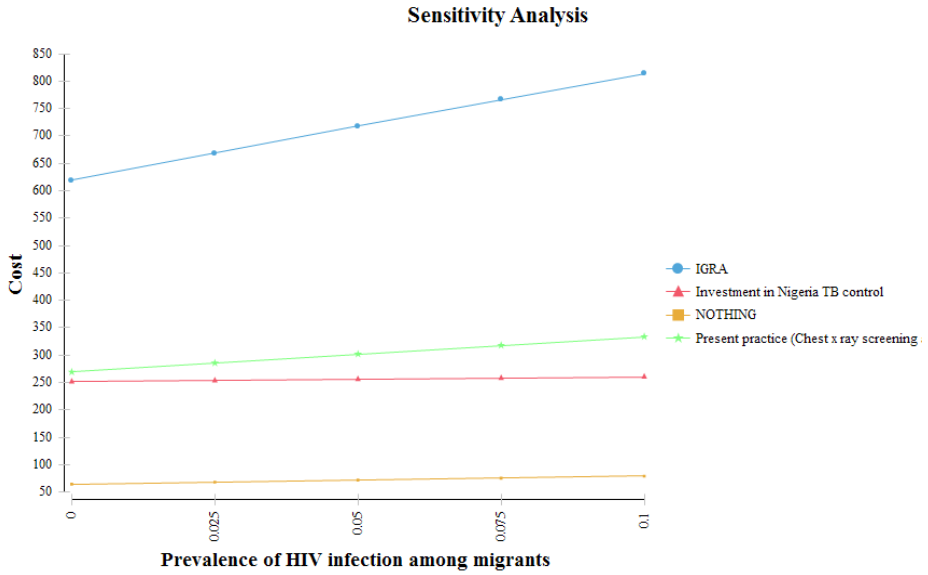


Figure 6.43. Sensitivity Analysis plot showing the total cost (,000) in US Dollars of the 4 alternative interventions by prevalence of HIV infection among migrants from Nigeria.

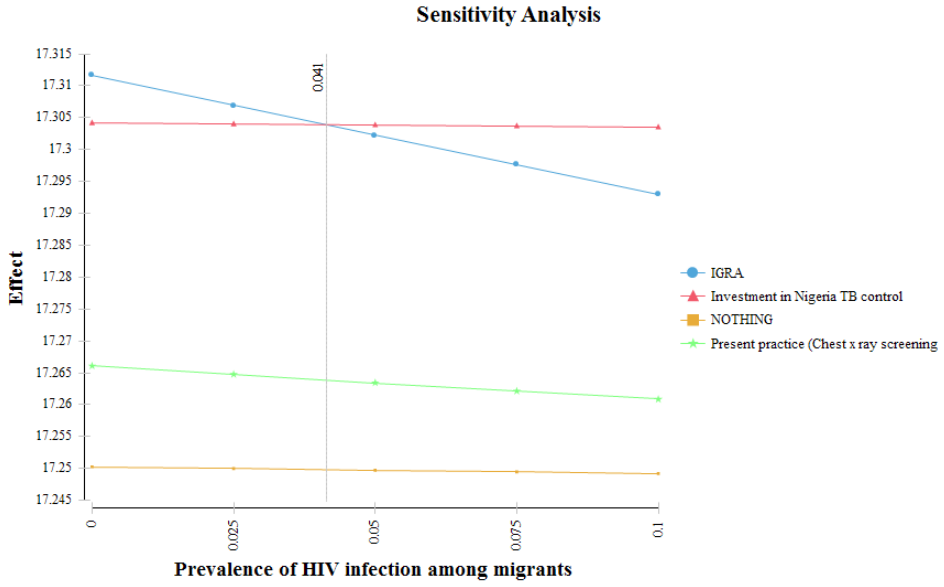


Figure 6.44. Sensitivity Analysis plot showing the Effect/migrant in US QALY for the 4 alternative interventions by prevalence of HIV among Nigeria migrants coming into the UK.

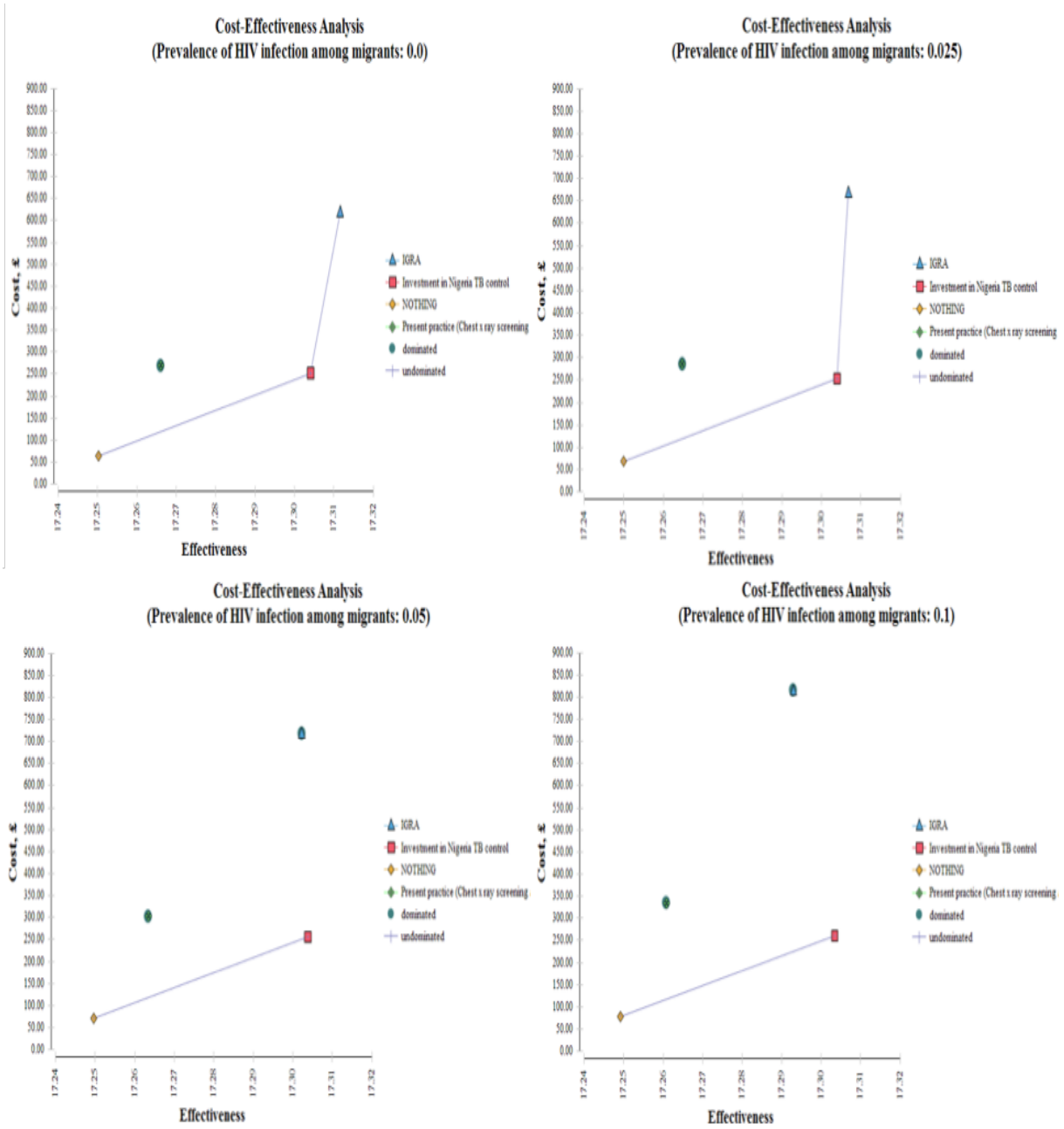


Figure 6.45. Senasitivity analyses for proportion of entrants/migrants that are HIV positives (ppHIV) (in Figures)

5.6.1.7. Proportion of entrants/migrants that have drug resistant TB (pDRA)

The sensitivity of this CE model to changes in the proportion of Nigerian migrants/entrants entering the UK with drug resistant TB was evaluated.

As shown in Table x below, when 0% of entrants have drug resistant TB, the most cost effective strategy is strategies 1 (investment in Nigerian TB control) ICER £671.05/QALY followed by strategy 2 (Chest X ray screening) ICER £11320.65/QALY. Strategy 3 (IGRA) is dominated.

When 2% of entrants have drug resistant TB, the most cost effective strategy is strategies 1 (investment in Nigerian TB control) ICER £668.90/QALY followed by strategy 2 (Chest X ray screening) ICER £11320.65/QALY. Strategy 3 (IGRA) is dominated.

When 4% of entrants have drug resistant TB, the most cost effective strategy is strategies 1 (investment in Nigerian TB control) ICER £666.76/QALY followed by strategy 2 (Chest X ray screening) ICER £11213.79/QALY. Strategy 3 (IGRA) is dominated.

When 8% of entrants have drug resistant TB, the most cost effective strategy is strategies 1 (investment in Nigerian TB control) ICER £662.45/QALY followed by strategy 2 (Chest X ray screening) ICER £11107.23/QALY. Strategy 3 (IGRA) is dominated.

When 12% of entrants have drug resistant TB, the most cost effective strategy is strategies 1 (investment in Nigerian TB control) ICER £658.19/QALY followed by strategy 2 (Chest X ray screening) ICER £11000.98/QALY. Strategy 3 (IGRA) is dominated.

When 16% of entrants have drug resistant TB, the most cost effective strategy is strategies 1 (investment in Nigerian TB control) ICER £653.92/QALY followed by strategy 2 (Chest X ray screening) ICER £10895.03/QALY. Strategy 3 (IGRA) is dominated.

When 18% of entrants have drug resistant TB, the most cost effective strategy is strategies 1 (investment in Nigerian TB control) ICER £651.78/QALY followed by strategy 2 (Chest X ray screening) ICER £10842.16/QALY. Strategy 3 (IGRA) is dominated (see group of figures below—**Figure 6.42**)

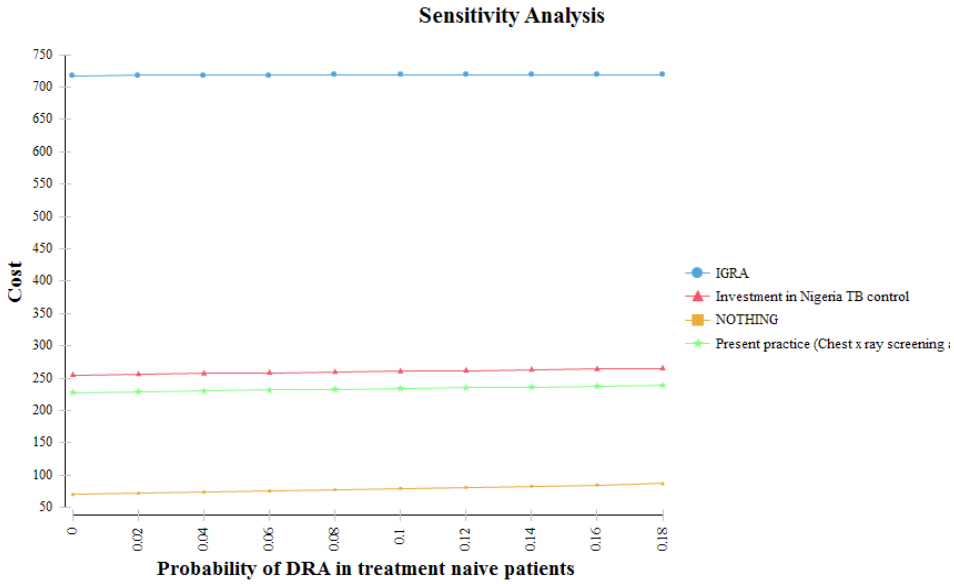


Figure 6.46. Sensitivity Analysis plot showing the total cost (,000) in US Dollars of the 4 alternative interventions by probability of DRA among Nigerian migrants.

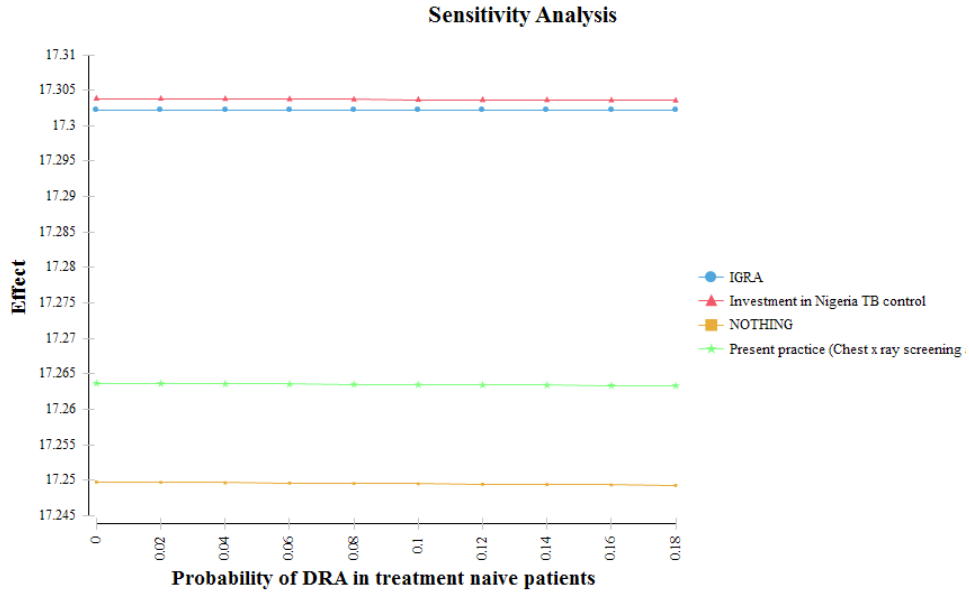


Figure 6.47. Sensitivity Analysis plot showing the Effect/migrant in QALYs for the 4 alternative interventions by probability of DRA among Nigerian migrants.

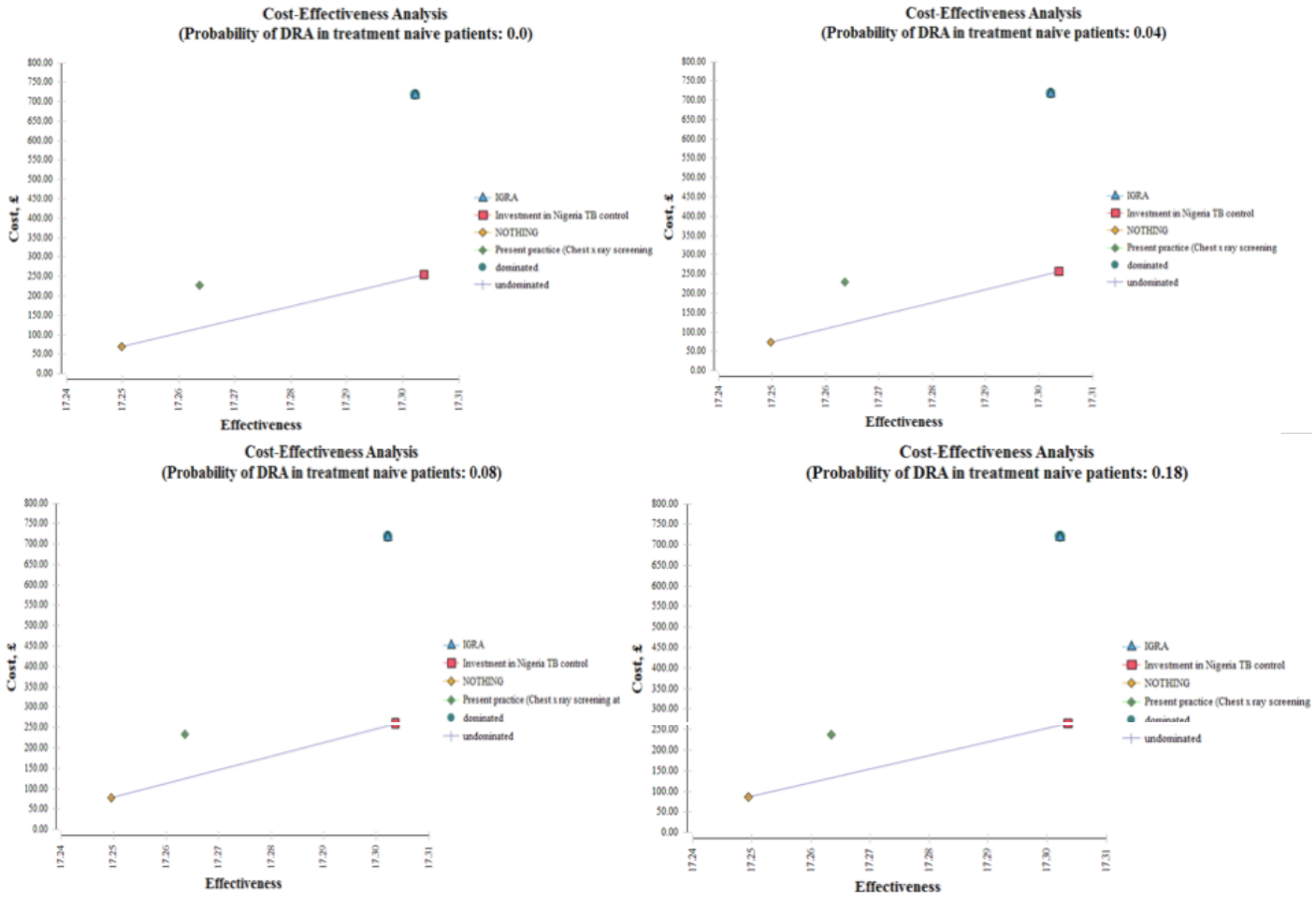


Figure 6.48. Sensitivity analyses for probability of DRA among entrants/migrants (in Figures)

The above (*subsections 6.3.6.1-6.3.6.7*) are the main sensitivity analyses conducted in the study. However, there are other sensitivity analyses that were conducted along with these main ones. For details of other sensitivity analyses, please refer to *Appendix 19*.

5.4. DISCUSSION

This study has compared the costs and utilities (effectiveness) of three main alternatives for Tuberculosis control among Nigerian migrants and their contacts in the United Kingdom. The study shows that the proposed alternative that UK government invests in Nigerian DOTS scale-up is the most cost-effective strategy for mitigating the impact of influx of TB from Nigeria to the UK. The prevalence of active and latent TB among migrants coming to the UK from Nigeria was estimated as 0.24% and 20% respectively. This study also shows that among those screened, 0.24% and only about 0.22% true positive active and latent TB respectively will be detected with CXR screening and 0.20% (active TB), 19% (latent TB) will be true positives when IGRA screening used.

Although about 99.76% and 80% of migrants do not have active and latent TB respectively, CXR screening estimates 66.84% and 0% as true negative active and latent TB respectively while IGRA estimates about 98.76% and 79.12% true negative active and latent TB respectively. The study also found that with CXR screening, about 32.92% and 79.92% are likely going to be false positive for active and latent TB respectively, but with IGRA screening only about 1% and 0.8% of active and latent TB respectively will be false positive. However, false negative results were reported in 0% and 17.78% for active and latent TB, respectively, using CXR. While it was 0.4% and 1% active and latent TB respectively when IGRA was used. This suggests a relatively better specificity and sensitivity of IGRA compared to CXR. This finding has been reported by several authors, with IGRA highly recommended and approved for immigrant screening in many countries over the years (77, 155). However, some studies have been conducted recently with apparently contradictory findings reported (77). In

a 2011 systematic review, Nienhaus and colleagues reported that there is no substantial difference in the effectiveness of some selected strategies, including CXR and IGRA, to screening LTBI (155). They specifically noted that the contradictions in results across studies could have been due to methodological issues, which has already been identified in the cost-effectiveness analyses of IGRA screening (155). While guidelines have been published to standardize analyses, a host of factors, often related to population and relevance, have prevented researchers from following these guidelines. Researchers have recommended the development of standard input parameters and assumptions in economic modeling studies.

e. Moreover, in the reported estimates in this study, about three hundred and five thousand (305,000) Nigerians were estimated to come to the UK for varying reasons and durations annually and are estimated to spend a total of 91,052 person years every year through the 20 years modeled. Only about 21.62% annually are estimated to be screened by CXR at present and is assumed to remain same in the next 20 years if there is no intervention. All currency value reported in the study was based on the US $ PPP as at November 2008 value. Amounts quoted in UK Pound Sterlings (£) is also based on November 2008 $/£ exchange rate.

The mean cost, to the UK government, for investment (paying the whole funding gap) in scaling up TB control in Nigeria (strategy 1) was estimated as £253.78 (SD £25.84) per Nigerian migrants coming into the UK, the cost of CXR screening was estimated at £293.41 (£102.95), IGRA screening at £690.93 (£113.45) and not doing anything 'do nothing' will still cost the UK government £70.29 (£31.52). The mean effectiveness, to the UK government, for

investment (paying the whole funding gap) in scaling up TB control in Nigeria (strategy 1) was estimated at 17.327 QALY (SD 0.172 QALY) per Nigerian migrants coming into the UK, CXR screening was 17.279 QALY (0.189 QALY), IGRA screening 17.319 QALY (0.188QALY) and not doing anything was estimated at 17.265 QALY (0.177 QALY).

The study found investment in scaling up Nigerian TB control as the most cost effective strategy with ICER of £2,964/QALY followed by IGRA screening strategy with an ICER of £11,430/QALY and CXR screening with ICER of £15,713/QALY. Investment in scaling up Nigerian TB control as an alternative was found to remain most cost effective. It was independent of proportion of migrants screening by both IGRA and CXR at the airports, the proportion of migrants with HIV infection, and proportion with drug resistant TB infection.

Some findings have been reported which are in keeping with the results presented in this study. For instance, Dasgupta and colleagues stated specifically that the ideal long term TB control strategy lies in a global investment in strategies to improving TB control in high incidence countries, as this has the most likely probability of reducing transmission of TB across international borders by human migrants from high TB incidence countries (29). This, according to the authors, would be more humanitarian and cost-effective than other approaches (29). In Norway, Haukaas, reported that the combining TST and IGRA may not be a cost-effective strategy at any willingness-to-pay threshold, but rather the focus should be on targeting immigrants before arrival, which requires some level of investment in TB control in their respective countries (156, 157). Nienhaus et al. elaborated further on the need to have standard criteria on willingness-to-pay threshold with this clearly stated before a strategy is

labelled cost-effective (155). In sub-Saharan Africa, most cost-effectiveness studies have been silent on this.

Meanwhile, Schwartzman et al. explained that the cost-effectiveness of any strategy can be greatly improved if it is dependent on strict-adherence to medications, stating that rather than only screening immigrants, some level of investment should be directed at identifying and treating them in their home country (68). However, Zammarchi and colleagues, opined that LTBI control strategies may only be effective if they focus on young persons in high incidence countries, as most people affected in these settings are in the young and productive age groups (158).

Meanwhile, in two separate systematic reviews, the authors reported that CXR and TST screening programmes for LTBI have little impact and are in fact not cost-effective, stating that embarking on LTBI treatments based on these two may require coercion to ensure maximum impacts in population covered (29, 44). These finding were due to some operational problems and acceptance of the strategies and the treatment plans. The authors further stated that screening with sputum cultures improved cost-effectiveness marginally, especially when this was followed by contact-tracing within the communities (29). Pareek et al. stated in their report that screening for LTBI should be able to identify most migrants with LTBI and prevent future cases of active TB for it to be cost-effective (31).

Finally, very few studies employed QALY as their measure of effectiveness, hence this could not allow direct comparisons with the estimates reported in this study. This was identified as major challenges in a 2015 systematic review by Campbell et al, further emphasizing that

varying parameters, study designs and assumptions have limited the comparability of different studies' findings (37).

5.6. STUDY LIMITATIONS

The main limitation of the study is the uncertainty resulting from some of the major assumptions in the analysis. The assumption of 6% decline in both incidence and prevalence of TB in Nigeria after full scale-up TB program is largely debatable. This was based on studies conducted in South America, a setting with distinct contextual differences from Nigeria and indeed sub-Saharan Africa. This is even further challenged by the current decline in TB in Nigeria, estimated at 2.7%. As there are no country-based projections suggesting an increase to 6% in the coming years, the assumption thus raises further questions. However, as noted in *Chapter 5*, studies assessing the decline in TB incidence following documented population-wide interventions in sub-Saharan Africa are largely unavailable, meaning that the study in Peru and Chile, a developing setting, may provide some relative comparisons to Nigeria.

Another example is the assumption that the patterns of migration from Nigeria would remain same throughout the 20 years. This is yet a definitive assumption, which has not taken into consideration several confounders, including demographic and epidemiological transitions in these settings. Africa, and indeed, Nigeria is experiencing the fastest rate of population growth worldwide. With seemingly poor socio-economic status and standards of living, internal migration from rural to urban, and international migration to developed countries, may not be unexpected. Besides, there may also be strict immigrations laws and controls from both the UK and Nigeria that may increase or reduce the number of migrants entering the UK. This

may be due to diplomatic reasons or some emerging political interests. This obviously limits the assumption of a constant pattern of migration in the country. In fact, the implication here is that if the number of migrants decrease in future years, then the scaling up of TB control in Nigeria would become least cost saving. But, if the number increases, the cost spent per migrant becomes much higher, then the investment in Nigeria's TB control produces greater savings.

Another sensitive assumption is the proportion of unscreened migrants which is difficult to ascertain due to operational challenges. The guidelines for screening migrants may change depending on several factors, including epidemiological or clinical variations, or possibly due to competing political interests. In such instances, the number of screened and unscreened migrants maybe affected. However, this may not significantly affect both the cost and effectiveness of the alternative 'Investment in Nigeria' strategy.

A meta-analysis would have also added to the evidence provided in this study. However, as meta-analysis is dependent on data available with emphasis on the degree of heterogeneity from study designs and sample population, this becomes relatively difficult to conduct in a sub-Saharan African setting.

Largely, the representativeness of the estimates provided remain uncertain, as it is clearly based on several assumptions, especially due to paucity of data on some cost elements. As explained in the introduction to this chapter, Braithwaite and colleagues noted that it may be difficult to "trust" decision analytic models as it is often based on wide range study designs, opinions, and not clearly defined population parameters, which rather makes the evidence presented weak (142). Given the evidence available in this study, it has been noted that cost-

effectiveness analyses vary considerably across studies. The usefulness of these analyses therefore become subject of debate if they continue to provide unclear and contradictory results on how to invest the rather "limited" funds. This calls for more research, and agreed standards and guidelines in the conduct of such, particularly in sub-Saharan Africa and developing countries.

However, having conducted a wide range of sensitivity analyses around the assumptions included in this study, a better understanding of the cost-effectiveness of the four strategies in the Nigerian migrant population to the UK may have been presented, and possibly could prompt further vital research.

5.7. CONCLUSION

The Stop TB strategy is a cost-effective approach of TB control globally, particularly in the high TB burden countries that are relatively poor. Despite the reported benefits, the full implementation of this strategy has not been achieved in most of these countries primarily due to poor funding, and several other health system challenges, particularly in low-income settings. Notwithstanding the limitations stated above, this study suggests a potential benefit to the United Kingdom when the WHO Stop TB Strategy program is fully scaled up in Nigeria and other counties where most TB cases come from. There may be need for more comprehensive and comparative studies in other 'migrants originating' and 'migrants-receiving' countries for more evidence-based findings, and particularly towards a potential application of the current findings between high-income countries that receive large numbers of migrants, and poor but higher TB incidence countries like Nigeria.

7. SUMMARY OF FINDINGS AND CONCLUSION

7.1. OVERVIEW

A series of distinct but interrelated research activities were carried out and reported in this thesis, with the principal aim of evaluating the cost-effectiveness of '*doing nothing*' as an alternative TB control strategy by the UK government to other alternative interventions vis-à-vis 'Investment to scale up TB control programme in Nigeria as a means of reducing the passive follow of cases to the UK'; 'Interferon Gamma Release Assay (IGRA) screening at the point of entry'; or 'CXR screenings for migrants at points of entry' (*Chapter 6*).

The measure of outcome (QALY) was estimated from the literature and similarly the estimates for the cost of CXR screening at the POA, IGRA screening, and treatment of TB in the UK estimated from the review of literature (*Chapter 1*). However, due to paucity of literature about cost of TB treatment in Nigeria, data had to be collected and analyzed from Nigeria to estimate the provider cost for the treatment of TB (*Chapter 2*), as well as the direct cost, and the valued time and productivity lost to TB patients because of their illness and treatment in Nigeria (*Chapter 3* and *Chapter 4*).

Data on the programme management component of the TB control programme was deduced from WHO estimates and was used together with provider cost of treatment and consumables to estimate the total cost of TB control programme, the cost of scaling up the TB programme (towards a coverage rate of 100%, case detection rate of 80% and treatment success rate of 80%), and funding gap estimate (*Chapter 5*). The impact of scaling up TB control programme in terms of number of latent and active TB cases averted in Nigeria and amongst migrants coming to the UK was also estimated (*Chapter 5*).

7.2. THESIS SYNTHESIS

In this concluding chapter, I review the overall research undertakings reported in the thesis to ascertain if the research problems and hypothesis guiding the study have been addressed adequately. As described earlier [in *Chapter 1*], the research has been largely motivated by the relative knowledge gap on the potential returns in donor countries (anticipated accrued savings from cases and deaths averted in donor countries) from investments in disease control programmes in low-income countries. This is particularly important in this study because most of the TB cases in the UK are either migrants or contacts of migrants from high TB incidence country.

Accordingly, this thesis contributes towards improved understanding of the cost effectiveness of other TB control strategies in addressing the problem of influx of TB cases from high-incidence countries to UK and other developed countries. It may also serve as a resource material for enlightening policy- and decision-makers, and the public on the benefits that could directly or indirectly accrue in the donating countries, rather than just being a diplomatic or humanitarian gesture.

In *Chapter 1***,** the research problems, study background, main motivations, fundamental principles and significance of the research work were presented. This Chapter also introduced some of the fundamental assumptions in this study and the basis for the use of some estimates as parameters in the study models. *Chapter 2* outlined the methodology, assumptions, analysis and results for estimation of the provider cost of Tb-treatment in Nigeria. This addressed the first objective of the thesis. In *Chapters 3 and 4*, the methodology, assumptions, analysis and results for estimation of the direct and indirect cost of TB treatment in Nigeria (from the

patients' perspectives) were presented. This addressed the second objective of the thesis.

Chapter 5 described the methodology, assumptions, descriptions and evaluation of the total cost of Tb-control programme in Nigeria (addressed objective 3), the cost of scaling up the programme (addressed objective 4), the impact of the scale up in terms of cases averted in Nigeria and among migrants coming to the UK (addressed objective 5), and the required funding gap for the scale up (addressed objective 6).

Chapter 6 described the method, assumptions, descriptions and evaluation results of the cost effectiveness analysis model (objective 7)

7.3. SUMMARY OF KEY FINDINGS

It is noteworthy that the cost analysis reported in this thesis, to the best of my knowledge, is the first ever conducted in Nigeria focusing on TB control and Nigerian migrants to the UK. Based on the key findings of the study [as discussed in *Chapters 2, 3, 4 and 5*], the following findings were reported:

1) The average proportion of TB patients in facilities was 3.4% in overall, 3.3% among inpatients and 3.1% in the outpatient population. The average cost spent to treat a patient with TB was estimated at US $227.14. The cost of inpatient care averaged $16.95/patient; DOT and outpatient services was $133.34/patient, while the overhead cost per patient was $30.89. The overall cost and all computed cost elements, except for DOT services, were highest in the tertiary center, and least expensive in the 'infectious diseases' hospital. This, partly, could be due to the higher administrative and other overhead recurrent spending in the tertiary health facility, while the lower overhead cost in 'infectious diseases' hospital could be due to the economy of scale

because of the relative higher number of TB cases seen in the facility operating with relatively same level of resources as other facilities in the state.

2) The median out-of-pocket cost for hospitalized patients was estimated at US$166.11, while ambulatory patients paid an estimated median cost of US$94.16, equivalent to about 9-38% of their average annual income. Female patients spent a higher proportion of their income on diagnosis and treatment than males ($p < 0.0001$). The median out-of-pocket costs borne by patients before, during and after diagnosis were estimated at US$35.23, US$27.12 and US$23.43 respectively for ambulatory patients, and additional average out-of-pocket spending of US$66.44 for patients hospitalized during their illness. Pre-diagnosis, diagnosis and post-diagnosis out-of-pocket spending did not vary significantly by human immunodeficiency virus status ($p > 0.05$) and sex ($p > 0.05$).

3) The income lost among the hospitalized group was estimated at $156/patient, and about $114 in the non-hospitalized patients group. Age, gender, facility of diagnosis, level of education and occupation were significantly (p-values <0.05) associated with total (both patients and their households) income lost. However, AFB sputum-smear result and HIV status had no significant effects on the income lost. Hospitalized patients spent an average time of 924.98 hours for diagnosis and treatment whereas the non-hospitalized spent an average of 141.29 hours. The estimated US-dollar value of these hours was US517.98 and US$79.13 for hospitalized and non-hospitalized patient groups, respectively. Hospitalization and the facility of diagnosis were statistically significant ($p <0.05$) predictors of the time the patients and household spent on TB.

4) The ICER for strategies 'Investment in Nigeria TB control', 'CXR screening', and 'IGRA screening' compared to strategy 'nothing' was estimated as £2,964/QALY, £15,712/QALY and £11,429/QALY respectively., suggesting the 'Investment in Nigeria TB control' was a more cost-effective strategy.

7.4. POLICY IMPLICATIONS

One major purpose of a cost-effectiveness analysis is to contribute to decision making process. Hanrahan and Shah described economic evaluations of health interventions as guide to assist policy-makers in allocating available resources amidst other competing needs (159). Most decision analytic tools in health have been able to describe the scope of disease burden and how best to intervene. Unfortunately, in Africa and several developing countries, such analyses have only had minimal impacts on the population, owing to poor implementation or inaccuracies in the predictions of the economic models. This is a major concern for researchers and policy makers, hence the need for an in-depth painstaking review (and re-review if need be) of results of cost-effectiveness analyses towards ensuring the population gains maximally and an efficient utilization of the limited resources available.

In this study, late detection of TB was identified as an underlying factor for the high costs of TB care to providers, patients and households. The implication for policymakers therefore is towards ensuring TB cases are detected early. It is now clear that no matter how cost-effective the intervention is, it probably amounts to nothing when cases are diagnosed late. In most developing countries, estimates reveal only two-thirds of new cases are detected each year (43). There is a potentially large market for TB diagnostics, given the large number of undetected cases who continue to be the main sources of ongoing and new TB transmissions. To ensure

resources are well-directed from the increasing number of diagnostic strategies before clinicians and implementers, there is need for considerable thorough investment and collaboration spreading across the developers, researchers, policymakers, national government and international regulatory bodies.

In the action of policymakers, it is not just only to direct resources at detecting active TB cases, as reactivation of latent TB infection (LTBI) was also major source of transmission of TB among migrants. It is therefore important that the investment and collaboration should be targeted at identification and treatment of LTBI in high-incidence countries, while ongoing interventions may continue for early diagnosis and treatment of active cases (45).

Still on investment and collaboration among all parties, Sinanovic and colleagues highlighted the possibility of strong economic gains in achieving this through public private partnerships (PPPs) in TB treatment (160). In such cases, they recommended that PPPs can be tailored to target groups (e.g organizations, churches, mosques, trade unions) affected with TB in the community and supported by the public sector (160); the sharing of resources and a relative sense of ownership it brings may allow the scaling-up of interventions to be achieved at much lower costs. Besides, some other findings also reveal that TB treatments conveyed through PPPs were more accessible and convenient for patients, and that the various target groups took responsibility of the needs of their members (or employees), with this also reducing the impact of the indirect costs attributable to TB (161, 162).

One other important policy consideration is to direct investments toward improved research on TB and cost-effectiveness analyses in Nigeria, and across several low-and middle-income

countries (LMICs). From the literature search conducted in this study, using broad search terms, there were 399 hits on MEDLINE, and 536 hits on EMBASE, however, narrowing the search to only migrant's population the number of hits reduced to only 17 and 22 from MEDLINE and EMBASE respectively. This shows the low level of research on this topic in LMICs, and further highlights the major concerns and limitations of this thesis regarding the paucity of data on economic analyses of TB interventions in Nigeria. To really address the problems and guide policy-makers in making the right decisions, there is need for robust evidence-based research. Several authors have stated the lack of routine health data on the African continent (163). This can be the starting point of actions for the decision-maker—ensuring regular up-to-date data on TB and other priority health issues in Nigeria, spreading across the various levels of health care and administration in the country. Policies on this will need to be developed in line with national health needs, while considering the impact it may have on neighboring countries, frequently visited countries by the citizens (as in the case of TB), and the larger international society. In fact, to get policy recommendations and endorsements of relevant international organizations (e.g. the WHO), proposed interventions and implementation plans must have been examined by multiple studies focusing on the test performance and utility stretch of such interventions in various settings and among key population groups in the country (32). This therefore underscore the importance of robust research findings in the implementation of any health intervention.

7.5. SUMMARY OF KEY CONCLUSIONS

1) Because the Nigerian GDP per capita is only about US$ 1160, of which only about $8.4 per capita is spent on health, the $227 cost attributable to TB services found in the

study suggests that TB disproportionately use resources in the health sector at the expense of other competing health needs. This further points the deplorable health indices in the country.

2) Although anti-tuberculosis treatment is supposed to be free in Nigeria, patients must pay significant out-of-pocket costs to access diagnosis and treatment services. The costs of anti-tuberculosis treatment found in this study are expensive and potentially catastrophic for many patients and their families.

3) Tuberculosis poses causes tremendous burden in terms of time and productivity lost to both patients and their households that could also be catastrophic to many patients and their families, whom are mostly impoverished and economically highly vulnerable.

4) The study suggests, albeit with important limitations, a potential benefit to the United Kingdom when the WHO Stop TB Strategy program is fully scaled up in Nigeria. There may be need for more comprehensive and comparative North-South studies for more evidence-based findings, particularly towards a potential application of the findings of this study in high-income countries that receive large numbers of migrants, and the low-income, but higher TB incidence, countries like Nigeria.

6. COST-EFFECTIVENESS ANALYSIS OF TB CONTROL STRATEGIES AMONG NIGERIAN MIGRANTS IN UK

6.1. OVERVIEW

This chapter describes the cost effectiveness analysis model, the assumptions underlying this model, and the results evaluating the cost and outcome of three main interventions—CXR screening for migrants at point of entry into the UK, IGRA screening at point of entry into the UK, and 'investment' towards scale-up of Nigerian TB control programme. These three were each compared with a hypothetical strategy— "*doing nothing*"—where Nigeria sustains the present level of coverage, migrants enter UK without screening, and the UK government bears cost of diagnosis and treatment when TB is imported into the UK by Nigerian migrants. This approach is an adaptation of the WHO CHOICE approach in which a "null" was used as a common comparator, which implies that in the cost-effectiveness analysis prospective interventions for different diseases had "*doing nothing*" as the main comparator (40).

As noted in *Chapter Five*, several cost-effectiveness analyses may give misleading results when not properly conducted and if the assumptions are implausibly achievable. Dowdy and colleagues did note that cost-effectiveness analyses need be designed taking into consideration a variety of implementation bottlenecks to ensure policy makers make choices that are likely to patient and population health across world regions (136). Braithwaite et al. also shared this opinion, emphasizing that the quality of evidence and realistic approach to decision analytic models largely determine positive outcomes of an intervention when implemented (142). There are widespread concerns that several cost-effectiveness analyses have not really been impactful as these incorporate data from all sources regardless of the quality of the evidence. Thus, the precision or otherwise of several decision analytic models have been subject of

debates over the years (142).

In sub-Saharan Africa however, it is understandable the data sources are limited and of varying quality. This implies that over the years, experts have only been able to develop sophisticated analytical models, often with questionable assumptions, and a very unlikely representation of current economic trends (143). However, given the increasing burden of TB in Nigeria and the possible threat this poses to countries that receive large number of Nigerian immigrants, it is important to make use of the available data to conduct a cost-effectiveness analysis of a range of TB interventions that are applicable to the settings. This chapter therefore seeks to conduct a cost-effectiveness analysis of three main TB interventions (CXR, IGRA and Investment in Nigerian TB control by the UK) and a hypothetical "*doing nothing*", and subsequently provide a critical discussion of the findings, especially with regard to the major assumptions the analysis was based on.

Although the cost effectiveness analysis in this study particularly evaluates cost and effectiveness of TB control strategies among Nigerian migrants, the perspective of the study is for the United Kingdom which bears the burden ion imported TB from Nigeria. In other words, this study attempts to evaluate evidence that could support for decision makers in the United Kingdom on what could be the most cost-effective alternative (either proactive intervention in Nigeria, screening using chest x-ray or IGRA) to control TB inflow from Nigeria compared to not doing anything at all.

6.2. METHODS

6.2.1. Background about the model

This is a decision-analysis model developed on TreeAge software, and incorporating multiple

Markov processes to estimate the cumulative probabilities of active and latent TB mortality and morbidity. It also estimates the associated costs among Nigerian migrants to the United Kingdom through a hypothetical period of 20 years in which the number, age characteristics, and types of migrants entering the United Kingdom annually is assumed to remain unchanged during the period. This model provides a platform for assessment of cost-effectiveness of four alternatives strategies for control of TB among immigrants from Nigeria into the United Kingdom. A Quality Adjusted Life Year (QALY) calculation was used to measure outcome. The model evaluated costs and outcomes from the UK government perspective. Future costs discounted at 3% (90).

Health states and transition dynamics in the model were assumed to be determined by the prevalence of TB in Nigeria at the time of entry and the health state transition probabilities, respectively. A separate Excel™ based model was also developed to extrapolate number of migrants coming into the UK over a period of 20 years.

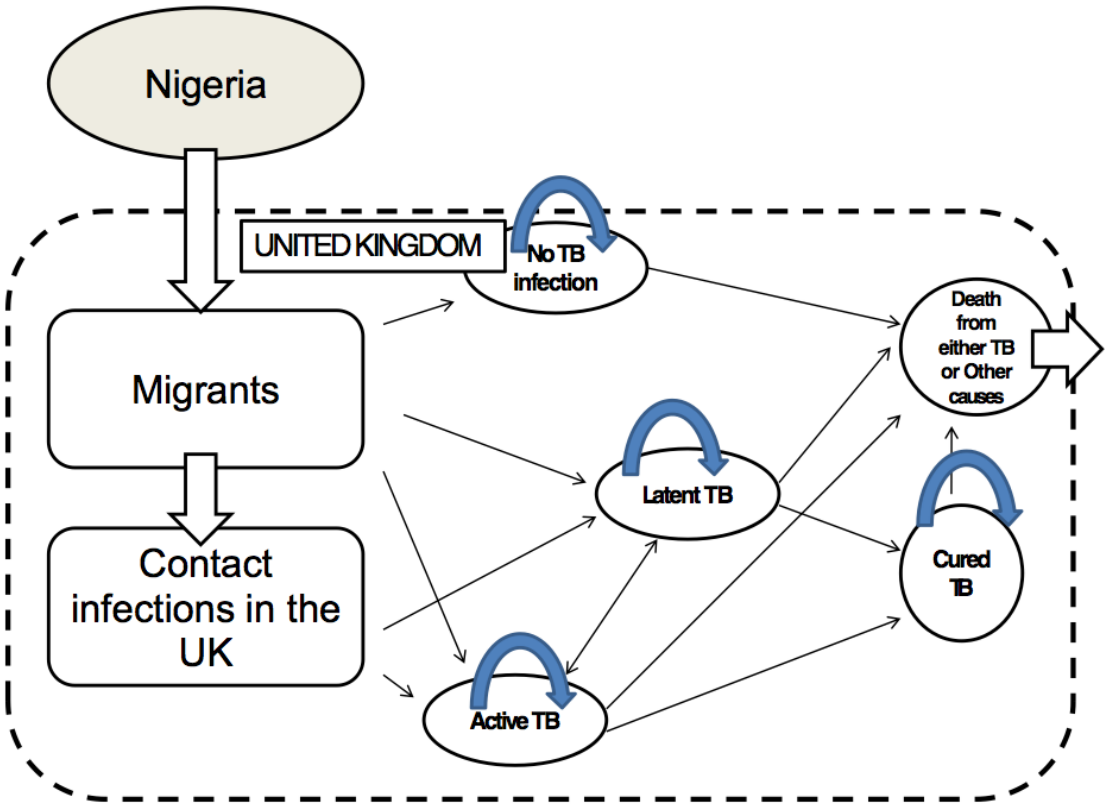


Figure 6.1. Simplified diagram of the state transitions in the model

6.2.1.1. Model framework and decision tree

The approach employed is the use of ***Main decision branches***. A decision-analysis model incorporating multiple Markov processes using TreeAge™ Software. A decision node compares the four competing alternative strategies (**Figures 6.24**).

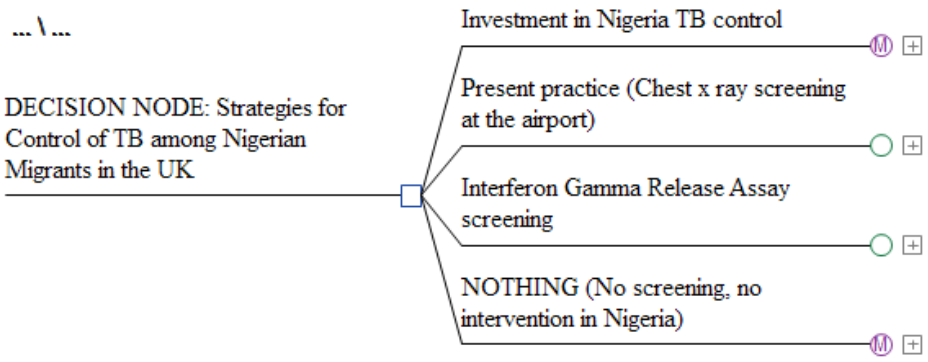


Figure 6.24. A decision-analysis model incorporating multiple Markov processes

Box 6.1. Decision analysis tree
A decision tree describes graphically how all possible interventions relate stochastically to the relatively ideal or possible outcome. Standard methods are applied on different parameters, which are labelled as probability distributions (refers to a range of probabilities in which some inputted parameters may be more likely that others) (Braithwaite). In cost-effectiveness analysis, it also helps the analysts to easily identify the cost elements and data needed for the analysis, with this offering a flexible and transparent frame to conduct the analyses. The limitations lie in the fact that different data from varying sources (to test probability) are likely to be incorporated in the analyses. However, the robustness of the findings can be assessed by allowing changes in the key parameters using sensitivity analysis (66).

Refer to *Appendix 19* for more details on this.

6.2.2. Assumptions underlying the Interventions and model

6.2.2.1. **Alternative 1**: ***'Investment' by the UK government to scale up Nigerian TB Control Programme.***

Evidence shows that implementation of the World Health Organization (WHO) strategy of directly observed treatment, short course (DOTS), can substantially reduce the incidence and prevalence of tuberculosis in countries with high incidence of the disease (80). However,

because of inadequate funding, global implementation of the DOTS program remains far from complete. One strategy to reduce the incidence of TB in high-income countries is to strengthen tuberculosis control through the expansion of the DOTS program in high incidence countries with key migrant population in the developed countries (144). Thus, a hypothetical preemptive TB control in the UK will be by reducing the influx of TB cases from Nigeria to the UK through a scale-up of TB control in Nigeria from the present 23% detection rate, 91% coverage rate and 76% treatment success rate, to the WHO benchmark of 70% case detection, 100% coverage and 85% treatment success rates over three years (8, 96). This target is considered reasonable based on the Peru and Chilean experience where full scale up was achieved within 3 years (79). After the full scale-up of TB services, the incidence and prevalence of both active and latent TB is assumed to decline by 6 percent annually in the general Nigerian population as well as among the departing migrants, based on the experience in these two countries. As noted in the previous chapter, in the absence of a similar detailed study in sub Saharan Africa (sSA), these two countries, albeit with distinct contextual differences from Nigeria, provide relatively comparative indices that the assumptions can be based on. The limitations of this are explained further in the discussion.

It was also assumed that treatment success and failure rates, case fatality, and prevalence of drug resistant TB will remain the same in both Nigeria and United Kingdom throughout the 20-year period.

Nigerian government and partners were also assumed to maintain the current annual spending on TB control through the next 20 years (as already described in Chapter 5), and will provide the facilities and personnel for the scale-up the TB services.

If all the proposed activities are implemented accordingly, it is assumed that the following targets will be achieved in 3 years, i.e. from 2012 to 2015:

- Case detection rate of at least 75%
- Treatment success rate of at least 85%.

In Nigeria, the incidence rate of TB has been observed to be declining over the last few years. Over the last couple of years the decline rates of 2.7% and 2.6% were reported between 2006-2007 and 2007-2008 respectively (5). Based on this, it was assumed that the incidence, prevalence and death rate will go down by at least 2.7% annually in the first 3 years of implementing the proposed programme and subsequently by at least 6% annually for at least the remaining 17 modelled years (based on the Peru and Chilean experience).

Although only about 10% of Nigeria emigrants go to the UK (133, 139), in this study, it was proposed that the UK Government, based on an '*enlighten self-interest*', invests in the TB control in Nigeria by providing an estimated 25% of the total funding gap for the full scale-up implementation of Stop TB strategy in Nigeria. This is relatively '*fair*' because the other countries hosting Nigerian migrants are mostly poor African countries, except the United States which receives only about 14% of this emigrant populations.

6.2.2.2. **Alternative 2**: ***CXR at the point of entry (POE).***

This practice is what was obtainable some year ago all the international airports in the UK (64). So, in this study a hypothetical scenario is assumed, that there will be CXR screening for migrants coming to the country the first time and declared their intention of staying for more than 3 months in the country. When the CXR is indicative of active pulmonary TB, entrants are referred to appropriate facility for further investigation and treatment.

6.2.2.3. **Alternative 3:** ***Interferon Gamma Release Assay (IGRA) screening at point of entry***

This has been recommended by several authors due to the reported advantages of this new screening method in detecting the latent form of TB (56, 77, 130). In this study, it was assumed that proportion of entrants coming to the country the first time would have to be screened at the point of entry.

The cost of CXR or IGRA screening at the airport, and the cost of diagnostics and treatment services for both migrants and their contacts are assumed to be shouldered by the UK government. These costs were estimated from available literature after critical appraisals of the reporting research methodology (77).

6.2.3. Other major assumptions

6.2.3.1. Number of Nigerian migrants and visitors (and length of stay) in the UK

There are about 146,300 Nigerian migrants residing in the UK (120) and it is assumed in this model that about half of this population travel and spend 30 days in Nigeria annually. It was also assumed that there will be about 11,900 students in the UK that will spend 11 months in the country annually. About 165,000 visitors were assumed to be visiting the UK from Nigeria annually staying for an average of 21 days. Other entrants with work permit, all dependents of work permit holders, all migrants admitted based on other point based system, all those admitted as husband, wife, fiancé or fiancée, all refugees/exceptional leave cases and their dependents, and all others given leave to enter and any migrant granted settlement on arrivals were all assumed to stay in the country longer than 6 month. It was also assumed that there are no illegal entrants into the UK from Nigeria within the reference period.

To test the robustness of these important assumptions, sensitivity analyses were conducted evaluating the outcomes in different scenarios (this is discussed further under *Study Limitations*).

Person years of visitors' and other migrants' time (**Table 6.1**) in the UK was calculated from the expected total number of entrants each year and the expected average length of stay for different sub-groups. Inherent in the person-year method is the assumption that the daily risk of a person developing tuberculosis in visitors (for instance staying in the UK for 3 weeks) is the same daily risk with a person who stays a full year.

Table 6.1. Person's years spent by Nigerian migrants and visitors in the UK from September, 2008 to August, 2009

Purpose for entry to the UK	**Number**	**Average length of stay**	**Person days spent**	**Person years spent**
Ordinary visitors	165,000*	21 days *	3,465,000	9493
Business visitors	25,600*	12*	307,200	842
Students	11,900*	335 days **	3,986,500	10,922
Work permit- Employed for 12 months or more	275*	335 days **	92,125	252
Work permit- Employed for less than 12 months	155*	170 days**	26350	72
Dependents of work permit holders	560*	335 days**	187,600	514
Point Bases System	240*	170 days**	40800	112
Admitted as a husband or fiancé	635*	335 days**	212725	583

Admitted as wife or fiancée	705*	335 days**	236175	647
Passengers in transit	21,400*	0	0	0
Passengers returning after a temporary absence abroad	71,700*	335 days**	24,019,500	65807
Refugees, exceptional leave cases and their dependents	5	365 days**	1825	5
Others given leave to enter	7,040	90 days**	633,600	1736
Granted settlement on arrival	140	180 days**	25200	69
TOTAL	**305,000**		**33,234,125 (Person days)**	**91052 (Person years)**

*Sourced from: Travel Trend 2008, Publication of Office of National statistics (145). http://www.statistics.gov.uk/downloads/theme_transport/Travel_Trends_2008.pdf . Accessed on 6th February, 2009. ** Assumption

6.2.3.2. TB states of migrants/entrants population coming into the UK

Approximately 91,052 Nigerians are expected to enter the UK from Nigeria annually through-out the 20-year cycle of the model (refer to *Chapter Five*, **Table 5.1** and **Appendixes 4-12**). Based on the entrants' age distribution, exposure to TB was computed, and TB burden among this migrant population was estimated (**Table 6.2**).

Table 6.2. Numbers of proportion of Nigerian migrants coming to UK by TB state

	Number (Proportion)	***Number (Proportion)***
Recent drug sensitive latent TB (DSLTBr)	24464 (0.013434120402)	14629 (0.008033388985)
Recent drug resistant latent TB (DRLTBr)*	448 (0.000246246606)	268 (0.000147251529)

Longstanding drug sensitive latent TB (DSLTBL)	394356 (0.216555209238)	244569 (0.134301824798)
Longstanding drug resistant latent TB (DRLTBL)**	7229 (0.003969443754)	4483 (0.002461744243)
Drug sensitive active TB (DSATB)	5561 (0.003054020000)	3125 (0.001716078076)
Drug resistant active TB (DRATB)***	102 (0.000055980000)	57 (0.000031455606)
No TB infection (NO TB)	1388880 (0.762684980000)	1553908 (0.853308256763)
TOTAL	1821040 (1)	1821040 (1)

*1.8% of all recent latent TB infections based on drug resistance prevalence rate.
**1.8% of all longstanding latent TB infections based on drug resistance prevalence rate.*
****1.8% of all active TB infections based on drug resistance prevalence rate.*

6.2.3.3. Screening for TB at the Point of Entry (POE)

Migrants that declared their intention to stay for more than 3 months in the country are assumed to be most likely going to be CXR screened based on the current practice (**Table 6.3**).

Table 6.3. Classification and number of Nigerians migrant and visitors to U.K from September 2008 to August 2009 and likelihood of screening for TB based on the present practice

Purpose for entry to the UK	**Number**	**Number probably staying longer than 3 month**	**% likely screened for TB before arrival or at point of entry**
Ordinary visitors	165,000	16,500 (10%)	0 % (0)
Business visitors	25,600	2560 (10%)	0 % (0)
Students*	11,900	11,900 (100)	100 % (11,900)
Work permit- Employed for 12 months or more	275	275 (100%)	100 % (275)

Work permit- Employed for less than 12 months	155	155 (100%)	100 % (155)
Dependents of work permit holders	560	560 (100%)	100 % (560)
Point Bases System	240	240 (100%)	100 % (240)
Admitted as a husband or fiancé	635	635 (100%)	100 % (635)
Admitted as wife or fiancée	705	705 (100%)	100 % (705)
Passengers in transit	21,400	0 (0%)	0 % (0)
Passengers returning after a temporary absence abroad	71,700	71,700 (100%)	10 % (Assumption) (7,170)
Refugees, exceptional leave cases and their dependents**	5	5 (100%)	100 % (5)
Others given leave to enter***	7,040	3,520 (50%)	50 % (Assumption) (1,760)
Granted settlement on arrival****	140	140 (100%)	100% (140)
TOTAL	305,000	108895	21.62% (23,545)

** Includes Student visitors, but excludes dependents which are included under 'Others given leave to enter'.*
*** Excludes such persons given temporary admission.*
**** Includes 46,700 journeys made in 2008 for which the category of admission is unknown*
***** Excludes asylum-related cases given indefinite leave to enter; these are included in 'Refugees, exceptional leave cases and their dependents'.*

Migrants are either:

i) Screened Immigrants – this group include entrants who were screened at the point of entry into the UK. It was estimated that about only about 21.62% of entrants will be

screened (which agrees with the Home Office 10-40% estimated range (33)), or

ii) Unscreened immigrants - this group include entrants who were not screened at the point of entry into the UK, estimated at about 78.38% of entrants.

6.2.3.4. Tuberculosis prevalence among the model migrant population

We assumed the TB and HIV burden among all entrants' categories in the UK to be the same as in the general populations of Nigerians in Nigeria, as estimated in 2009 WHO report (52) (see **Table 6.4**).

Table 6.4. Tuberculosis epidemiological detail of Nigerian population (64)

Description	**Estimates in 2007**
Number of all forms of TB (New cases)	460,000/year
Incidence of all forms of TB (New cases)	311/100,000 pop/year
Number of new ss+ cases	195,000/year
Incidence of new ss+ cases	131/100,000 pop/year
HIV+ incident TB cases (%)	27% of all TB cases
Number of all forms of TB (New and old)	772,000/year
Prevalence of all forms of TB	521/100,000 pop/year
Multidrug-resistant TB (MD R-TB) MDR-TB among all new TB cases (%)	1.8%
MDR-TB among previously treated TB cases (%)	9.4%
Percentage of extra pulmonary cases	5%

In this model, it was assumed that every migrant fall in one of a finite number of discrete health states.

The following are the states used:

- Uninfected: Neither active, no latent nor previous active TB.
- Recent latent TB infection: TB infection less than 2 years.
- Longstanding latent TB infection: TB infection more than 2 years.
- Active TB disease.
- Previous active disease (recovered).
- Dead from either from TB infection or other cause

Based on estimates of disease burden in Nigeria, proportional burden among entrants/migrants was assumed to be:

1) Active tuberculosis:

   Based on the prevalence rate of TB in Nigerian population estimated at 521/100,000 population, the number migrants with active TB among the Nigerian entrants (91,052 persons' years) is estimated as

   = 521*(91,052/100,000) person years

   = 474 cases of Active TB in the first year

2) Latent tuberculosis infection (LTBI), was estimated based on the Styblo's rule (125) that says for every 50 cases of incidence of smear positive active TB per 100,000 population, the Annual Risk of Infection (ARI) in that population is 1%.

   Thus, the ARI in Nigeria, where the incidence of smear positive TB is estimated at 131/100,000 is estimated as:

= (131/50) %

= **2.62 %**

It was also assumed that 30% of those exposed to TB get the infection, out of which about 5% develop active disease while the remaining 95% remain with the infection as a latent TB (5,6, 18).

Based on these estimates, the number of migrants/entrants with latent TB was estimated as shown in **Table 6.5** below:

Table 6.5. Estimate of the number of latent TB cases among Nigerian migrants in the UK grouped by age

Age (yrs)	*Midpoint (yrs)*	*% of migrants*	*Number*	*ARI (%)*	*Exposed to TB <2 yrs*	*Exposed to TB >2 yrs*	*Latent TB <2years*	*Latent TB >2years*
0-15	8	8%	7284	2.62%/yr	379	1148	108	327
16-24	20	12%	10926	2.62%/yr	573	5152	163	1468
25-44	34	53%	48258	2.62%/yr	1264	41724	360	11891
45-64	54	23%	20942	2.62%/yr	1097	19845	313	5656
65+	65	4%	3642	2.62%/yr	191	3451	54	984
TOTAL			**91052**		**3504**	**71320**	**998**	**20326**

Thus,

3) Number of entrants/migrants with recent latent TB (acquired < 2 years) = **998 persons /year**

4) Number of entrants/migrants with longstanding latent TB (acquired > 2 years) = **20326 persons/year**

5) No tuberculosis;

= Total person years-Active cases-Latent cases-Healed cases

= 91052 – 474 – 998 – 20326

= **69254 persons/ year**

6.2.3.5. <u>HIV prevalence</u>

HIV prevalence in adult (15-49 years) population in Nigeria is .3.1% (126)

Proportion that of HIV positive patients that have AIDS among the people living with HIV in the population is estimated at about 39% (126).

The number of HIV positive persons entering the UK from Nigeria within the first year

= 3.1%*91052

= **2823 persons/year**

Out of which;

i) Late infection - clinical AIDS:

= 39%*2823

= **1101 persons**

ii) Early (asymptomatic) HIV infection:

= 61%*2823

= **1722 persons**

iii) No HIV infection:

= 91052 – 1101 – 1722 = **88229 persons.**

6.2.3.6. Treatment outcome for Active TB cases

Based on the annual report on TB surveillance in the UK (17), 84.5% of TB cases completed treatment successfully within 12 months, about 2.7% died while on treatment, 4.4% were lost to follow-up, 0.9% treatment was stopped mainly because TB was a wrong diagnosis, 4.9% were reported as still on treatment, 1.2% transferred out, 0.4% treatment not completed for unknown reasons, and the outcome was reported as unknown in 1.2%.

However, to account for the outcome of those still on treatment (4.9%), treatment not completed for unknown reasons (0.4%), treatment stopped for wrong diagnosis (0.9 %), those that transferred out (1.2%), and those reported as unknown outcome (1.2%), an adjustment was made to make the proportion all-inclusive (61) (**Table 6.6**).

Table 6.6. Tuberculosis treatment outcomes at 12 months for Black Africans, UK, 2007

Treatment outcome	*Proportion (%) N=1711*	*Adjusted proportion (%)*
Treatment completed	84.5% (1446)	92% (1446)
Died	2.7% (46)	3% (46)
Still on treatment	4.9% (84)*	-
Lost to follow up	4.4% (75)	5% (75)
Treatment stopped	0.9% (15)*	-
Transferred out	1.2% (21)*	-
Treatment not completed (Unknown reason)	0.4% (7)*	-

Outcome reported Unknown	1.2% (21)*	-
TOTAL	100 % (1711)	100% (1567)

Sourced from Table 3.5 in the article titled: Tuberculosis in the UK: Annual report on tuberculosis surveillance in the UK, 2007. London, Health Protection Agency, July 2007 (17)

6.2.3.7. Treatment outcome for latent TB cases

The proportion of entrants completing at least 6 months of 'Latent TB' Isoniazid treatment was estimated from studies that reported proportions of foreign-born migrants completing at least 4 months of treatment with Isoniazid for treatment of latent TB (44, 146-149) and based on the estimates from these studies, proportion completing treatment of latent TB with 4 months Isoniazid was assumed to be 62% of patients with latent TB (both 'recent' and 'longstanding') that started the Isoniazid regimen.

6.2.3.8. Reactivation of latent TB and other clinical outcomes

The probability of having any clinical outcome largely depends on TB and HIV status of the migrants/entrants. Incidence of tuberculosis among migrants is highest in the first two years after entry or re-entry (69, 150). There is evidence that this is primarily due to recent infection, or re-infection (69, 150). In HIV negatives, the risk of reactivation of latent infection was assumed at 5% throughout the first 2 years (69, 150-153). It was also assumed that this risk reduces to annual rate of 0.1% (69).

Estimates for clinical outcome following treatment assumes that, once diagnosed, all categories of migrants would receive UK standard of care for their tuberculosis and therefore achieve UK national average cure rates (61).

For patients who defaulted after two months or less of therapy, cure rate is assumed to be 25% which is the same as in untreated patients. For those who defaulted therapy, risk of relapse and failure is higher, but cure rates were assumed to be 62% (69).

Patients who completed five months or more of therapy were considered to have the same cure rate as those who completed a full course and the risk of acquiring TB infection while in the UK was assumed to be negligible (154).

Treatment outcomes were also determined by underlying drug sensitivity (the probability of which was taken from published studies of prevalence of drug resistant TB in the countries of origin), and HIV infection. Co-infection with HIV did not alter probability of diagnosis, nor the treatment outcomes of cure, or relapse. However, mortality among HIV infected persons with active TB was 2.25 times higher during treatment, and was 100% if TB was undiagnosed (69). Latent and active TB were modeled as drug-sensitive and drug resistant (**Table 6.7**).

	Base	**Range**
Reactivation from LTBI		
'Longstanding' LTBI		
- HIV- Uninfected	0.1%/ year	0.1% -0.2%/yr
- HIV infected – Asymptomatic	3.4%/year	3.4% - 8.7%/yr
- HIV infected – AIDS	33%/year	33% - 67%/yr
'Recent' LTBI		
- HIV uninfected	5%	2% - 15%
- HIV infected – asymptomatic	33%	33% - 100%
- HIV infected – AIDS	100%	50% - 100%

Re-infection within 2 years		
- HIV uninfected – Protective effect 80%	1%	
- HIV infected – No protective effect	33% - 100%	
TB cases, HIV Negative		
(Untreated smear positive):		
- Mortality - 1 year, & 2 years	33%, & 50%	
- Spontaneous remission	25%	
- Relapse after spontaneous remission	2.5%/year	1.3% - 2.5%/yr
(Treated smear positive):		
- Relapse after cure (total over next 2 years)	3.0%	1.5% - 5%
- Cure rate if default (SDR or drug sensitive)	62.4%	
- Effect of drug sensitivity or treatment outcomes		
- RR of failure (SDR)		
- RR of failure (MDR)	2.0	
- RR of death (SDR)	10.5	
- RR of death (MDR)	1.0	
- In MDR – Probability of cure with treatment	4.5	
– Probability of death with treatment	48%	48%-73%
	12%	12%-26%

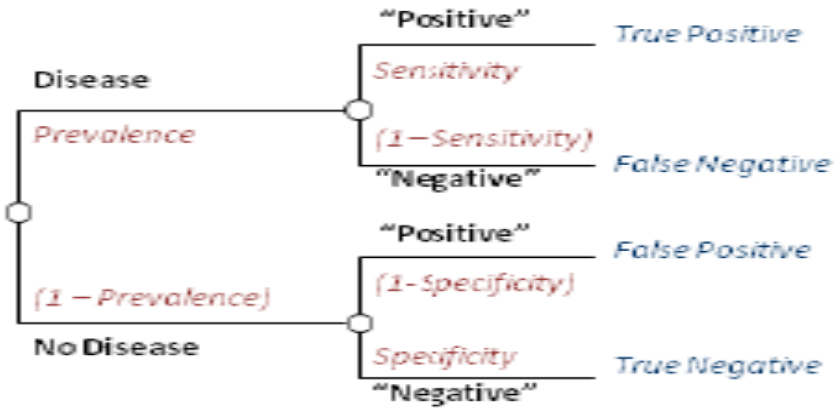
TB, HIV Positive		
- Av. Duration of HIV infection	9.8 years	7.3-9.8 yrs
- Av. Duration as HIV (AS)	9.0 years	
- AR of progress: HIV (AS) to AIDS	7%	7%-9%
- AR of death from HIV (AS)	4.6%	
- AR of death from AIDS	22%	
- Effect of prior active TB on RR of death from HIV	2.2	(2.2 – 4.0)
- Effect of HIV infection on RR of death during TB treatment (DS or SDR)	2.25	
- Relapse after successful TB treatment (cured)	3.1%	3.1% - 6.4%

Table 6.7. Some of the transition probabilities and parameters used in the model

Sourced from the Supplementary appendix of the article 'Kevin Schwartzman, et al. Domestic returns from investment in the control of tuberculosis in other countries. N Engl J Med 353;10, 09/2005 (68)

6.2.3.9. Predictive values of the screening tests

Probabilities of positive and negative results for detection of active and latent TB were estimated from the sensitivity and specificity of the screening test (**Figure 6.3**).



i) True Positives:

(*True Positive$_{a,l}$ = Prevalence$_{a,l}$*Sensitivity$_{a,l}$*)

a) CXR:

- True positive$_{\text{active TB}}$= 0.002449456477 (i.e. proportion with active TB)*1 (i.e. 100% sensitivity)= 0.002449456477
- True Positive$_{\text{latent}}$ TB=0.200805089(i.e. proportion with latent TB)*0.11(i.e. 11% sensitivity)= 0.022088559806

b) IGRA:

- True positive$_{\text{active TB}}$= 0.0024494565 (i.e. proportion with active TB)*0.82 (i.e. 82% sensitivity)=0.002008554311
- True Positive$_{\text{latent}}$ TB=0.200805089(i.e. proportion with latent TB)*0.95 (i.e. 95%

sensitivity)= 0.190764834687

ii) True Negatives:

(*True Negative$_{a,l}$ = (1-Prevalence$_{a,l}$)*Specificity$_{a,l}$)*

a) CXR:

- True negative$_{\text{active TB}}$= 0.997550543523 (i.e. proportion WITHOUT active TB)*0.67(i.e. 67% specificity)= 0.668358864161
- True negative$_{\text{latent TB}}$= 0.799194910855(i.e. proportion WITHOUT latent TB)*0.0 (i.e. 0% specificity)= 0

b) IGRA:

- True negative$_{\text{active TB}}$= 0.997550543523 (i.e. proportion WITHOUT active TB)*0.99(i.e. 99% specificity)= 0.987575038088
- True negative$_{\text{latent TB}}$= 0.799194910855(i.e. proportion WITHOUT latent TB)*0.99 (i.e. 99% specificity)= 0.791202961747

iii) *False Positives*:

(False Positive$_{a,l}$ = (1-Prevalence$_{a,l}$)*(1-Specificity$_{a,l}$))

a) CXR:

- False positive$_{\text{active TB}}$= 0.997550543523 (i.e. proportion WITHOUT active TB)*0.33(i.e.100- 67% specificity)=0.329191679363
- False positive$_{\text{latent TB}}$= 0.799194910855(i.e. proportion WITHOUT latent TB)*1 (i.e. 100-0% specificity)= 0.799194910855

Note: In this model, it was assumed that only about a quarter (25%) of the false positives will be followed up as often clinical judgment improves the accuracy of diagnosis.

b) IGRA:

- False $Positive_{active\ TB}$= 0.997550543523 (i.e. proportion WITHOUT active TB)* 0.01(i.e.100- 99% specificity)= 0.009975505435
- False $Positive_{latent\ TB}$= 0.799194910855(i.e. proportion WITHOUT latent TB)* 0.01 (i.e. 100-99% specificity)= 0.007991949109

iv. ***False Negatives:***

(*$False\ Negative_{a,l} = Prevalence_{a,l}*(1-Sensitivity_{a,l})$*)

a) CXR:

- False $Negative_{active\ TB}$= 0.002449456477 (i.e. proportion with active TB) *0.0(i.e.100-100% sensitivity)=0.0
- False $negative_{latent\ TB}$= 0.200805089 (i.e. proportion with latent TB) *0.89 (i.e. 100-11% sensitivity)= 0.178716529339

a) IGRA:

- False $negative_{active\ TB}$= 0.0024494565 (i.e. proportion with active TB)*0.18 (i.e. 100-82% specificity)= 0.000440902166
- False $negative_{latent\ TB}$=0.200805089(i.e. proportion with latent TB)*0.05 (i.e. 100-95% specificity)= 0.010040254457

However, for each test result, the probability of being active or latent TB depends on the proportional prevalence of active and latent TB in the population.

6.2.3.10. Hypothetical separate populations

Separate populations, N1 and N2, were assumed for active and latent TB. These hypothetical populations were assumed to be mutually exclusive, i.e. N3 is a hypothetical population

N1+N2. (**Tables 6.8 and 6.9**)

Table 6.8. Hypothetical separate populations TBa, TBl and combined TBa+l (CXR)

	TB_{N1}	TB_{N2}	TB_{N3}	pTB_a	pTB_l	pTB_{a+l}
TP	4461	40224	44685	0.0998229216	0.9001770784	0.0122690081
FP	599471	1455366	2054837	0.2917366107	0.7082633893	0.5641932951
TN	1217108	0	1217108	1.0000000000	0.0000000000	0.3341794321
FN	0	325450	325450	0.0000000000	1.0000000000	0.0893582647
	1821040 (N1)	1821040(N2)	3642080(N3)			1

Table 6.9. Hypothetical separate populations TBa, TBl and combined TBa+l (IGRA)

	TB_{N1}	TB_{N2}	TB_{N3}	pTB_a	pTB_l	pTB_{TB}
TP	3658	347390	351048	0.0104192509	0.9895807491	0.0963866945
FP	18166	14554	32719	0.5551985904	0.4448014096	0.0089837273
TN	1798414	1440812	3239226	0.5551985904	0.4448014096	0.8893889999
FN	803	18284	19087	0.0420661747	0.9579338253	0.0052405783
	1821040	1821040	3642080			1

6.2.3.11. Model Time-frame

Cohort simulation of TB-related events and outcomes for migrants/entrants from Nigeria to the UK was done, through a period 20 years, beginning from 2012 to 2031.

Migrants' health status at the beginning of each cycle depend on the events in the previous cycle, vis-a vis: treatment or not treated, treatment completed or defaulted, survived or died, etc. Since the risk of new TB infection was much lower after entry into the UK, the likelihood of development of active TB fell considerably after the first two years in the UK. A mortality rate from all other causes among entrants in the UK was assumed to be the same as for the UK general population.

6.3. *RESULTS*

6.3.1. Cost Analysis

Following Monte Carlo simulation, 1000 trials, the average cost for the 'investment in Nigerian TB control' per Nigerian migrant in the UK was estimated at £253.78, and average cost per migrant for chest x ray, IGRA screening or when 'Nothing' is done is £293.41 or £690.93 or £72.29 respectively (**Table 6.10, Figures 6.4-6.7**).

Table 6.10. The Mean, Median and dispersion of the costs of the 4 strategies in a Monte Carlos simulation

Cost in 2008 GB £	***Investment in Nigeria TB control in GBP***	***Present practice (Chest x ray screening at the airport) in GBP***	***IGRA in GBP***	***NOTHING in GBP***
Mean $\pm$ SD	253.78 $\pm$ 25.84	293.41 $\pm$ 102.95	690.93 $\pm$ 113.45	70.29 $\pm$ 31.52
Median	247.90	263.99	680.22	65.91
Minimum	225.04	153.47	501.48	26.96
Maximum	388.83	572.18	1019.47	211.79
2.5%	228.41	166.46	511.65	27.698
10%	233.11	188.46	565.553	39.392
90%	276.41	469.97	850.792	110.991
97.5%	313.01	520.60	997.388	147.153
Size (n)	100	100	100	100
Variance	667.84	10598.02	12870.52	993.55
Variance/Size	6.68	105.98	128.71	9.94
SQRT[Variance/Size]	2.58	10.29	11.34	3.15

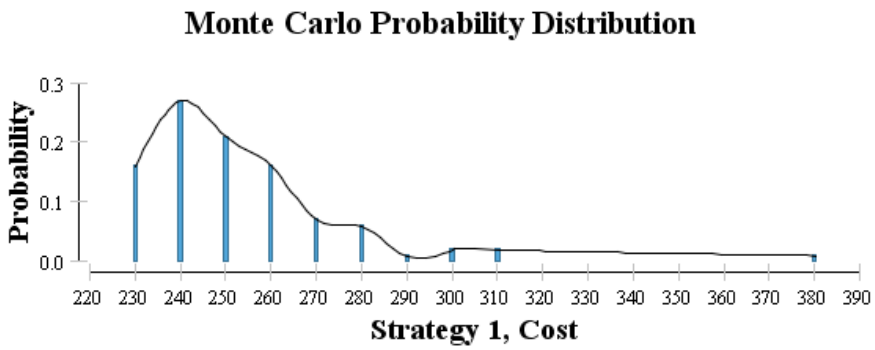


Figure 6.4. Probability distribution of the cost of investment in Nigerian TB control per migrant entering the UK

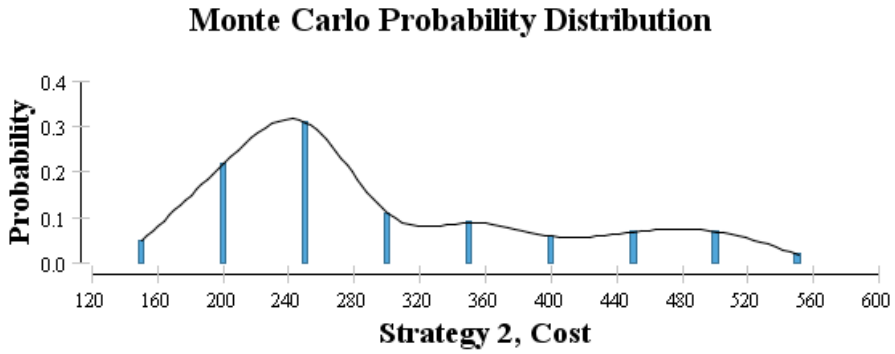


Figure 6.5. Probability distribution of the cost of present practice of x ray screening per migrant entering the UK

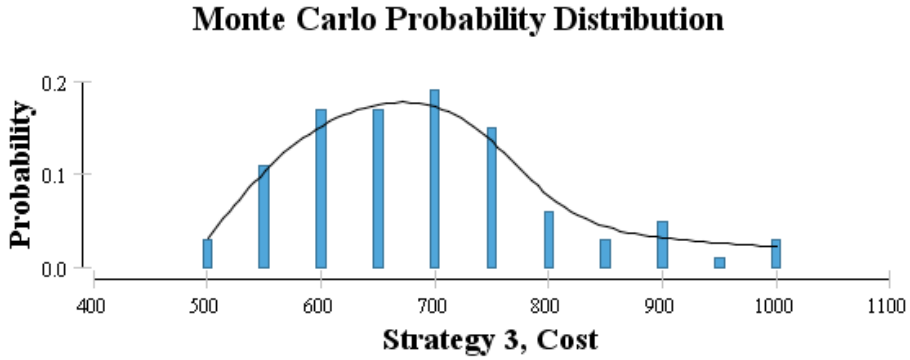


Figure 6.6. Probability distribution of the cost of IGRA screening per migrant entering the UK

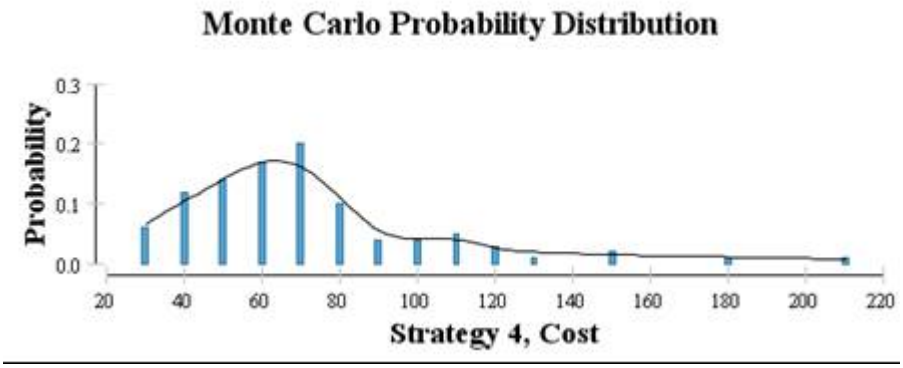


Figure 6.7. Probability distribution of the cost of 'nothing' per migrant entering the UK

6.3.2. Effectiveness Analysis

Following Monte Carlo simulation, 1000 trials, average QALY per Nigerian migrant in the UK when UK government invested in scaling up Nigerian TB control was estimated at 17.33 QALY, and for chest x ray, or IGRA screening or when 'Nothing' is done the QALYs are 17.23 or 17.32 or 17.26 respectively (**Table 6.11, Figures 6.8-6.11**).

Table 6.11. The Mean, Median and dispersion of the QALYs of the 4 strategies in a Monte Carlos simulation

Effectiveness in QALY	***Investment in Nigeria TB control***	***Present practice (Chest x ray screening at the airport)***	***IGRA***	***NOTHING***
Mean ± SD	17.3266 ± 0.1721	17.2789 ± 0.1885	17.3190±0.1881	17.2647 ± 0.1770
Median	17.3526	17.2736	17.3332	17.2756
Minimum	16.8766	16.7390	16.8488	16.7735
Maximum	17.7814	17.6986	17.7436	17.6907
2.5%	16.9724	16.9065	16.9426	16.9009
10%	17.0982	17.0791	17.0728	17.0152
90%	17.5391	17.5045	17.5579	17.4650
97.5%	17.6717	17.6675	17.6614	17.5815
Size (n)	100	100	100	100
Variance	0.029608107	0.035536022	0.035364236	0.031327102
Variance/Size	0.000296081	0.000355360	0.000353642	0.000313271
SQRT[Variance/Size]	0.017207007	0.018851000	0.018805381	0.017699464

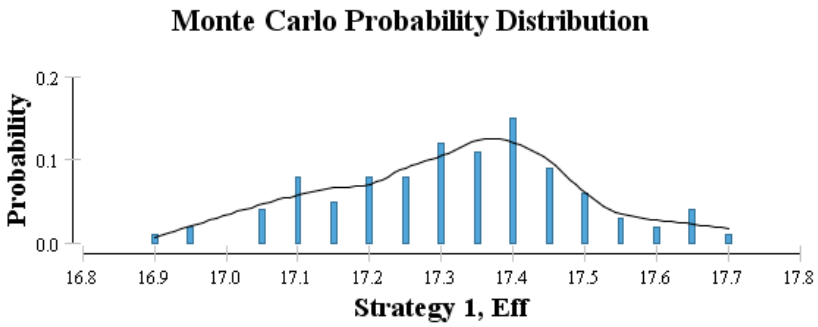


Figure 6.8. Probability distribution of the QALYs of investment in Nigerian TB control per migrant entering the UK

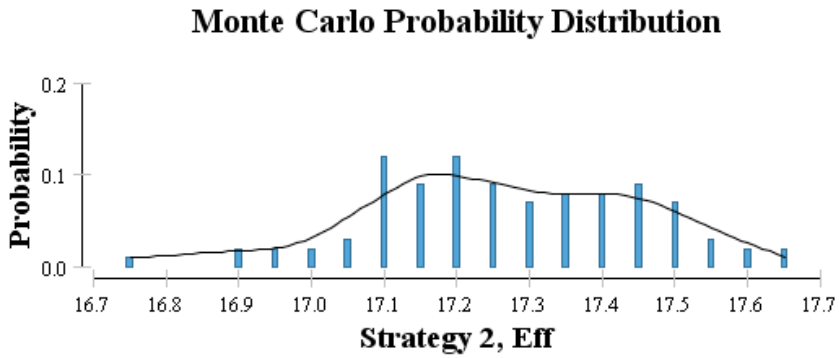


Figure 6.9. Probability distribution of the QALYs of present practice of x ray screening per migrant entering the UK

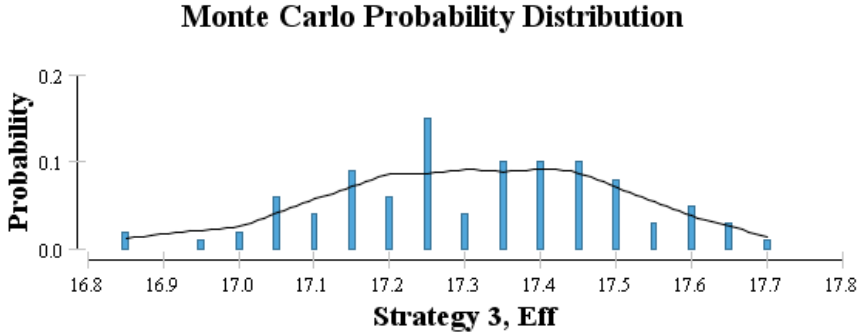


Figure 6.10. Probability distribution of the QALYs of IGRA screening per migrant entering the UK

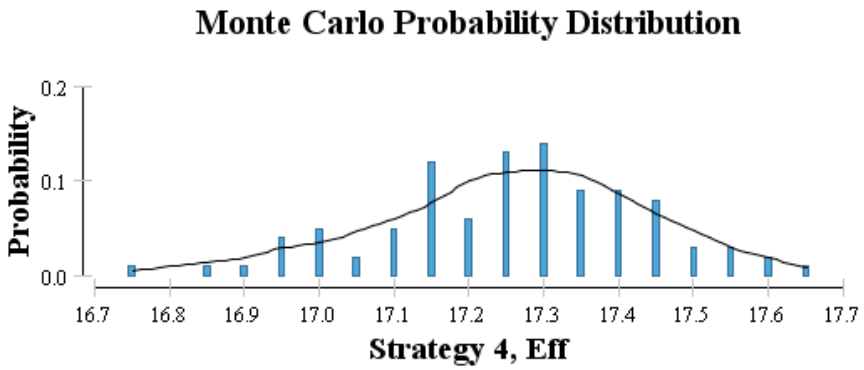


Figure 6.11. Probability distribution of the QALYs of 'nothing' per migrant entering the UK

6.3.3. Cost-Effectiveness Analysis

Following Monte Carlo simulation, 1000 trials, average cost and utility for strategy 'investment in Nigerian TB control' per Nigerian migrant in the UK was estimated at GB £253.78 and 17.33 QALYs respectively. Cost and utility for the CXR screening strategy was estimated at 2008 GB £293.41 and 17.28 respectively. Cost and utility for IGRA screening estimated at GB £690.93 and 17.32 QALYs while strategy 'Nothing' cost on average of GB

Table 6.12. The Mean Cost and QALYs of the 4 strategies in a Monte Carlos simulation

Strategy Name	***Cost (UK £)***	***Effectiveness (QALY)***
NOTHING	70.29	17.2647
Investment in Nigeria TB control	253.78	17.3266
Present practice (Chest x ray screening at the airport)	293.41	17.2789
IGRA	690.93	17.3190

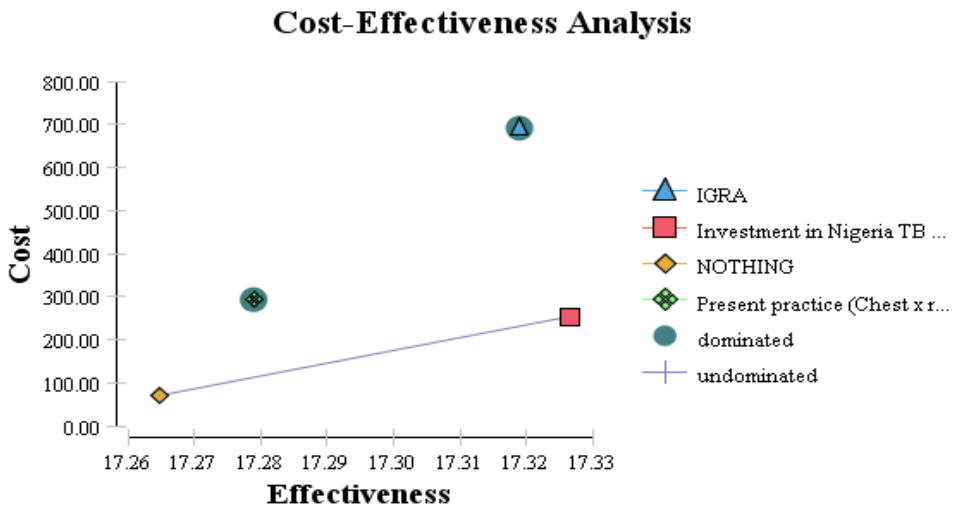


Figure 6.12. Cost-Effectiveness Analysis plot

6.3.4. Incremental Cost Effectiveness Ratio (ICER)

The incremental costs for strategy 1 (investment in Nigeria), strategy 2 (CXR), and strategy 3 (IGRA) when all are compared to strategy 4 ('nothing') are £183.49, £223.12, and £620.64 respectively and incremental effectiveness compared to strategy 'nothing' are 0.0619 QALY, 0.0142 QALY and 0.0543 QALY respectively. Hence ICER (compared to strategy 'nothing') was estimated as £2,964/QALY, £15,712/QALY and £11,429/QALY for strategies Investment in Nigeria TB control, Present practice (CXR screening at the airport) and IGRA respectively (**Table 6.13**).

Table 6.13. Cost, Effectiveness and ICER for strategies 1, 2, 3 compared to strategy 4

Strategy Name	*Cost (£)*	*Eff. (QALY)*	*Incr. Cost*	*Incr. Eff*	*ICER*
NOTHING	70.29	17.2647	0.00	0.0000	0.00
Investment in Nigeria TB control	253.78	17.3266	183.49	0.0619	2964.19

Present practice (Chest x ray screening at the airport)	293.41	17.2789	223.12	0.0142	15712.68
IGRA	690.93	17.3190	620.64	0.0543	11429.83

However, the incremental cost and incremental effectiveness for strategy 2 (investment in Nigeria) when compared to strategy 1 ('nothing') was estimated at GB £183.47 and 0.0619 QALYs. Strategy 3 (X ray screening), and strategy 4 (IGRA) when compared to strategy 2 (investment in Nigeria) are £39.63/-0.0477, and £437.15/-0.0077 respectively. The ICER for strategy 2 (Investment in Nigeria TB control) compared to strategy 1('nothing') was estimated as £2,964.19/QALY gained but ICER for strategy 3 (X ray screening) and strategy 4 (IGRA) compared to strategy 2 (Investment in Nigeria TB control) showed dominance of strategy 2 (investment in Nigeria) over both two strategies (**Table 6.14).**

Table 6.14. Cost, Effectiveness and ICER for strategy 1 compared to strategy 4 and strategies 2, 3 compared to strategy 1

Strategy Name	***Cost (£)***	***Eff. (QALY)***	***Incr. Cost***	***Incr. Eff***	***ICER***	***Remark***
NOTHING	70.29	17.2647	0.00	0.0000	0.00	
Investment in Nigeria TB control	253.78	17.3266	183.49	0.0619	2964.19	
Present practice (Chest x ray screening at the airport)	293.41	17.2789	39.63	-0.0477	-830.06	(Dominated)

IGRA	690.93	17.3190	437.15	-0.0077	-57062.40	(Dominated)

The next nine diagrams (**Figures 6.13-6.21**) displays the incremental cost and effectiveness, and the probability distribution for the incremental costs, with each diagram comparing the four strategies (CXR, IGRA, Investment and Nothing) in turn.

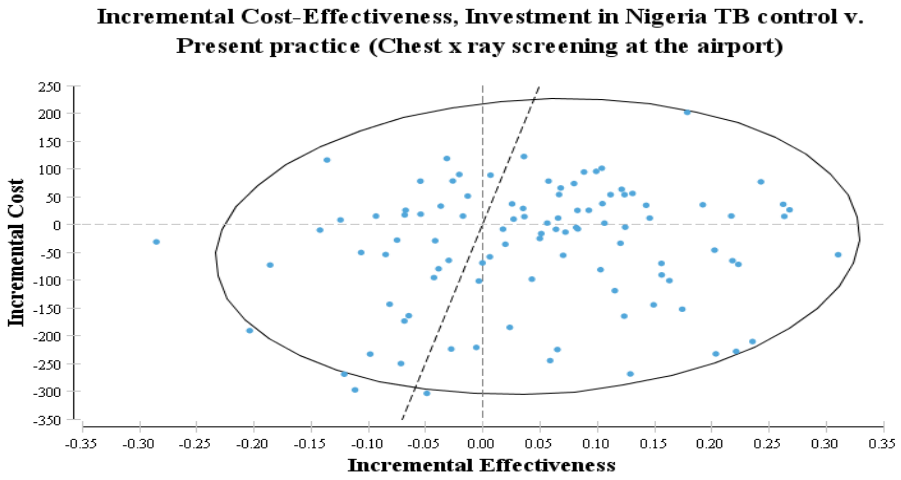


Figure 6.13. Incremental cost and effectiveness scatter plots comparing Investment in Nigeria (Strategy 1) verses Chest X ray screening (Strategy 2)

Figure 6.13 shows increasing incremental effectiveness as incremental cost also increases.

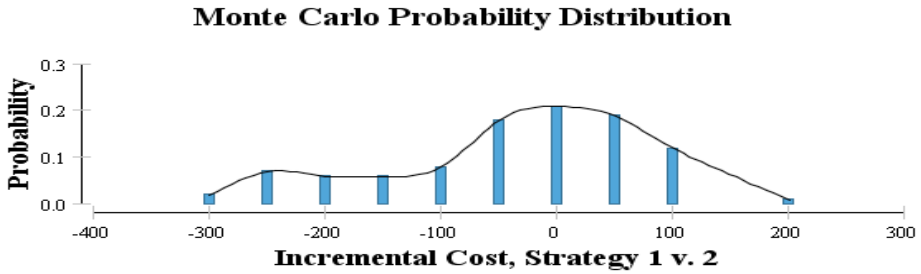


Figure 6.14. Probability distribution for the incremental cost comparing Investment in Nigeria (Strategy 1) verses Chest X ray screening (Strategy 2)

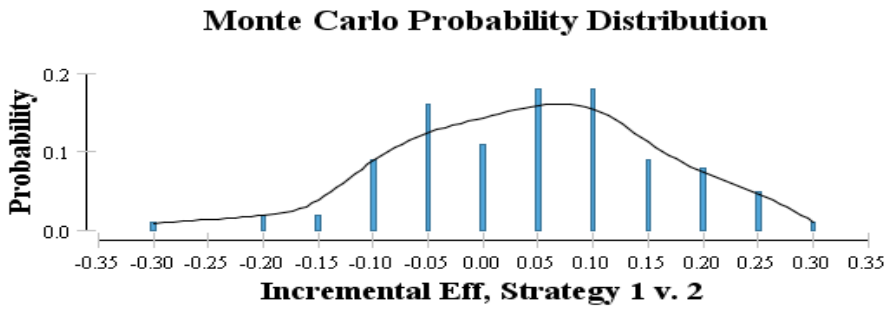


Figure 6.15. Probability distribution for the incremental effectiveness comparing Investment in Nigeria (Strategy 1) verses Chest X ray screening (Strategy 2)

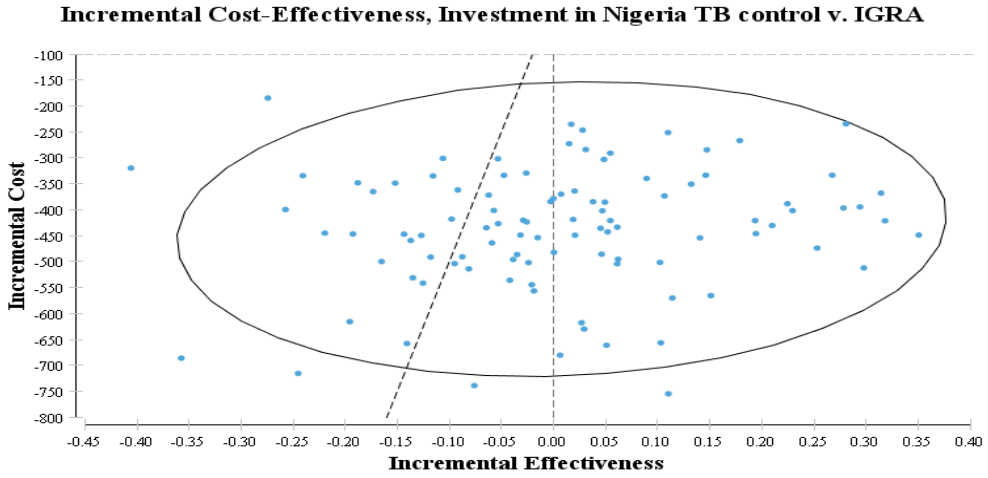


Figure 6.16. Incremental cost and effectiveness scatter plots comparing Investment in Nigeria (Strategy 1) verses IGRA (Strategy 3).

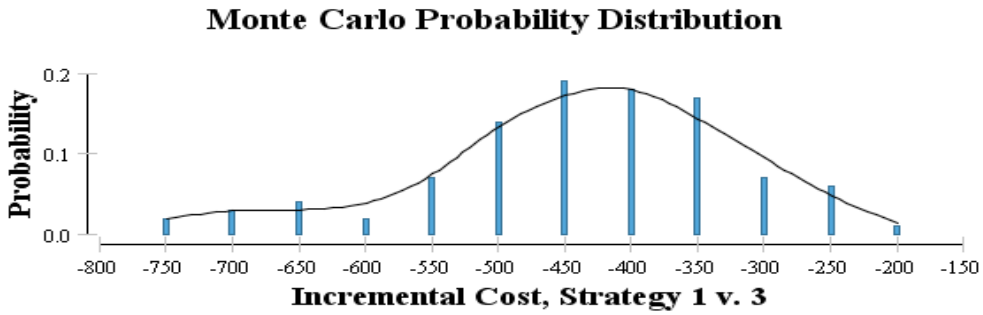


Figure 6.17. Probability distribution for the incremental cost comparing Investment in Nigeria (Strategy 1) verses IGRA (Strategy 3)

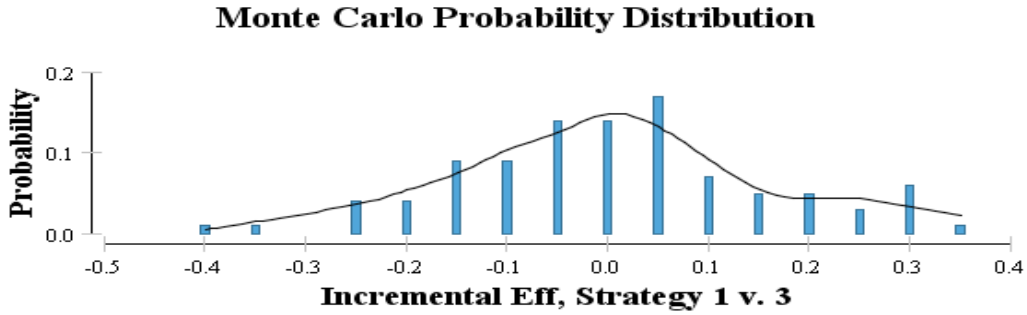


Figure 6.18. Probability distribution for the incremental effectiveness comparing Investment in Nigeria (Strategy 1) verses IGRA (Strategy 3)

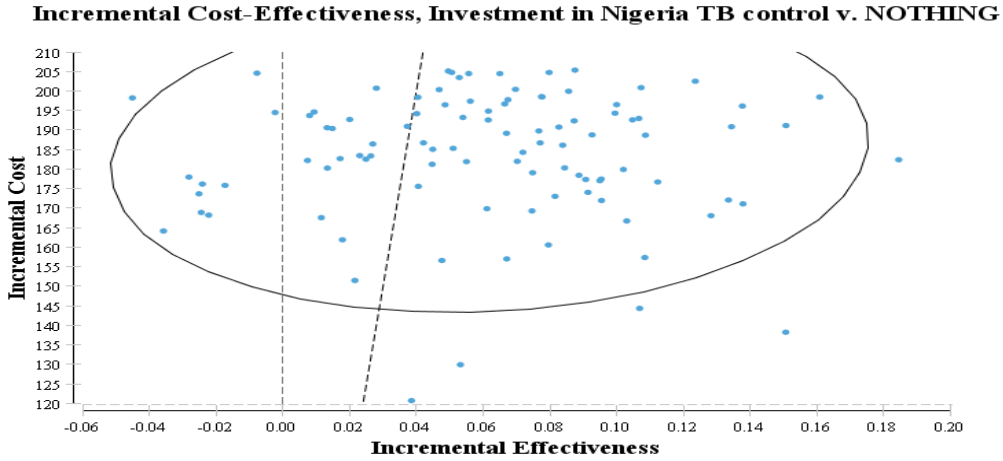


Figure 6.19. Incremental cost and effectiveness scatter plots comparing Investment in Nigeria (Strategy 1) verses 'nothing' (Strategy 4)

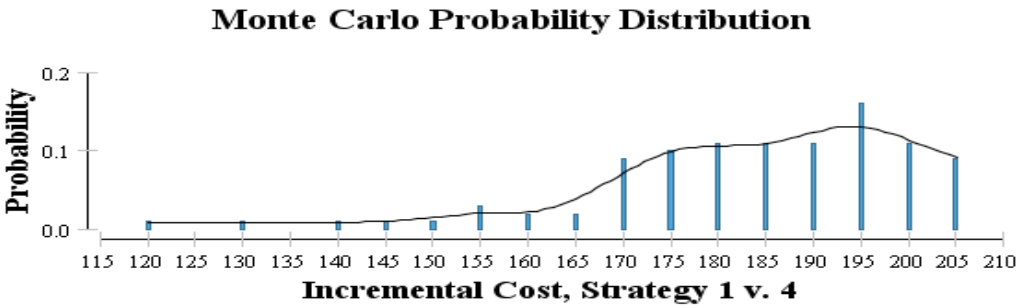


Figure 6.20. Probability distribution for the incremental cost comparing Investment in Nigeria (Strategy 1) verses 'nothing' (Strategy 4)

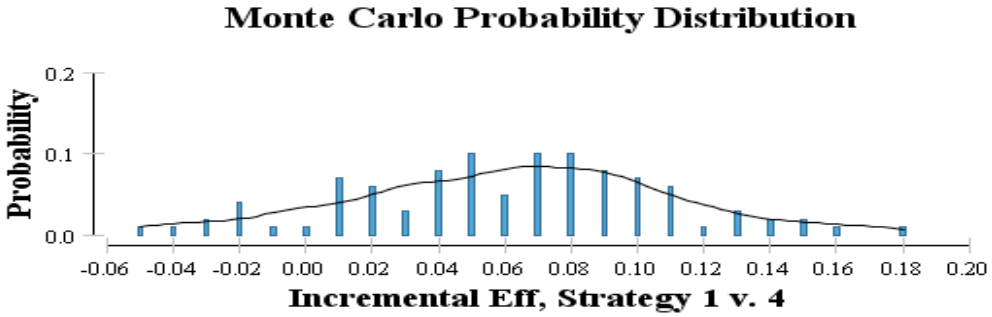


Figure 6.21. Probability distribution for the incremental effectiveness comparing Investment in Nigeria (Strategy 1) verses 'nothing' (Strategy 4)

6.3.5. Acceptability Curve

At £1000 threshold 'willingness to pay', the strategy 'nothing' has the highest iteration percentage of almost 90%, which falls to about 60% when the WTP threshold increased to £2,000. At about £3,000 WTP threshold, the strategy 'investment in Nigeria TB control' has the highest percentage iteration of about 45% then strategy 'IGRA' with iteration percentage of about 35% (**Figures 6.22-6.23**).

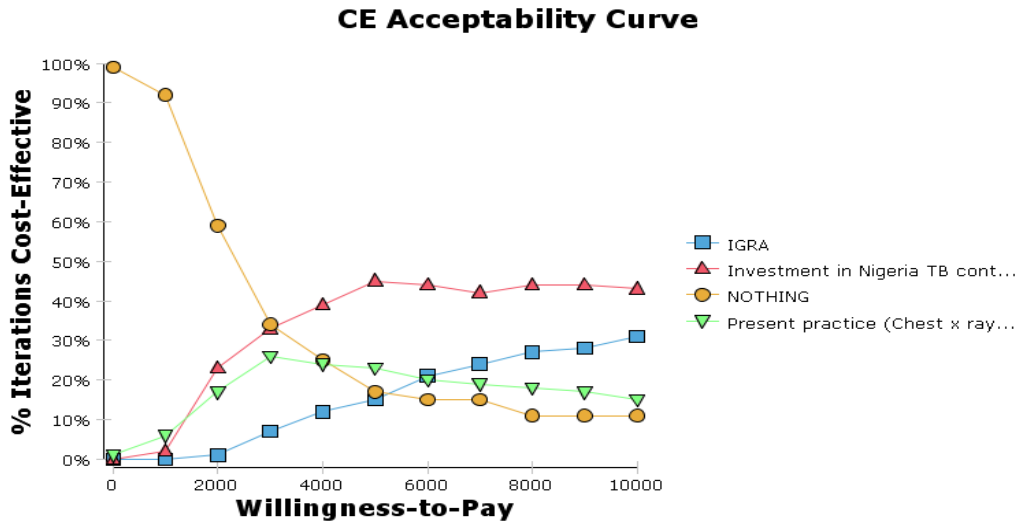


Figure 6.22. Acceptability curves for all the alternative strategies on scale of 'willingness to pay £0-10,000

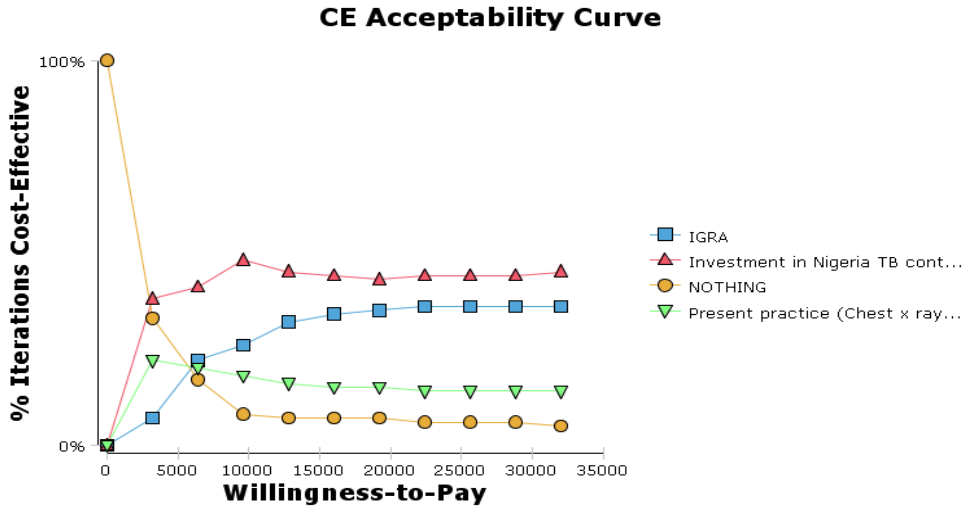


Figure 6.23. Acceptability curves for all the alternative strategies on scale of 'willingness to pay £0-35,000

6.3.6. Sensitivity Analysis

Sensitivity analysis assesses the robustness of the findings from the decision analysis model by varying key parameters and assumptions to assess the effect in the model outputs.

Favorable and unfavorable scenarios with respect to the PPV and NPV of CXR, IGRA screenings and the baseline prevalence of LTBI and HIV infection, and the probability of INH resistance and MDR-TB as well as the proportion of migrants screened at the point of entry evaluated. This section explores the sensitivity of the cost effectiveness to assumptions about four key parameters.

6.3.6.1. The total number of migrants coming into the UK from Nigeria over the model 20 years

The economic model assumes that about 1.8 million people will come to the UK over the 20 years included in the model. This was calculated based on the estimates of the number of different categories of migrants entering the UK from Nigeria and their length of stay in the UK, as obtained from the immigration data (see **Tables 6.1 and 6.2**). This implies about 90,000 immigrants from Nigeria will enter the UK annually and stay for at least 30 days. This estimate is one of the core parameters used in this model. Hence, to establish the validity of the results, the sensitivity analysis aimed to test the robustness of this model to varying scenarios (figures) of this key assumption.

Therefore, the outcome was evaluated based on varied assumptions on the number of Nigerians coming into the UK annually from only 25,245 immigrants, including about 11,900 students (that is 504,905 Nigerian immigrants in 20 years) to 38,407 annually (768,132 in 20 years), 51,568 annually (1,031,358 in 20 years), 64,729 annually (1,294,586 in 20 years), 77,891 annually (1,557,813), 91,051 annually (1,821,040 in 20 years). These were all based on inclusion of 10%, 20%, 30%, 40% and 50%, respectively, of Nigerian population living in the UK that travel to Nigeria annually to spend significant time (at least 30 days) in Nigeria.

'*Investment in Nigeria TB Control*' strategy remains the most cost-effective alternative in the model either when only about 504,905 or over 1.8 million Nigerians come into the country. In fact, it was observed that the more the migrants coming into the UK, the more cost-effective the '*Investment in Nigerian TB control*' compared to the other alternatives. Hence, this implies that even if the estimate used in the model is an overestimation of the number of Nigerian Migrants coming into the country, the result of the model could still be valid because the range of possible variability of this parameter couldn't significantly affect the result (**Table 6.15, Figures 6.25-6.32**).

Nigeria Migrants coming into the UK	STRATEGY	COST	EFF	CE	INCRCOST	INCREFF	INCRCE	DOMINATED	
504905	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
504905	Present practice (Chest x ray screening at the airport)	294.283	17.263	17.047	222.254	0.014	16213.135		-294.283
504905	Investment in Nigeria TB control	708.947	17.304	40.971	414.664	0.040	10279.704		-708.947
504905	IGRA	717.742	17.302	41.483	8.794	-0.002	-5702.466	(Dominated)	-717.742
768132	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
768132	Present practice (Chest x ray screening at the airport)	294.283	17.263	17.047	222.254	0.014	16213.135		-294.283
768132	Investment in Nigeria TB control	480.727	17.304	27.782	186.444	0.040	4622.028		-480.727

768132	IGRA	717.742	17.302	41.483	237.014	-0.002	-153684.920	(Dominated)	-717.742
1031359	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
1031359	Present practice (Chest x ray screening at the airport)	294.283	17.263	17.047	222.254	0.014	16213.135		-294.283
1031359	Investment in Nigeria TB control	369.002	17.304	21.325	74.718	0.040	1852.295		-369.002
1031359	IGRA	717.742	17.302	41.483	348.740	-0.002	-226130.190	(Dominated)	-717.742
1294586	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
1294586	Present practice (Chest x ray screening at the airport)	294.283	17.263	17.047	222.254	0.014	16213.135		-294.283
1294586	Investment in Nigeria TB control	302.710	17.304	17.494	8.426	0.040	208.896		-302.710
1294586	IGRA	717.742	17.302	41.483	415.032	-0.002	-269114.997	(Dominated)	-717.742
1557813	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
1557813	Investment in Nigeria TB control	258.821	17.304	14.957	186.792	0.054	3456.137		-258.821
1557813	Present practice (Chest x ray screening at the airport)	294.283	17.263	17.047	35.462	-0.040	-879.125	(Dominated)	-294.283
1557813	IGRA	717.742	17.302	41.483	458.920	-0.002	-297573.334	(Dominated)	-717.742
1821040	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
1821040	Investment in Nigeria TB control	227.621	17.304	13.154	155.591	0.054	2878.842		-227.621

1821040	Present practice (Chest x ray screening at the airport)	294.283	17.263	17.047	66.663	-0.040	-1652.605	(Dominated)	-294.283
1821040	IGRA	717.742	17.302	41.483	490.121	-0.002	-317804.50	(Dominated)	-717.742

Table 6.15. Sensitivity analysis: Effect of assumed probability of Nigerians immigrants coming to the UK on cost effectiveness estimates

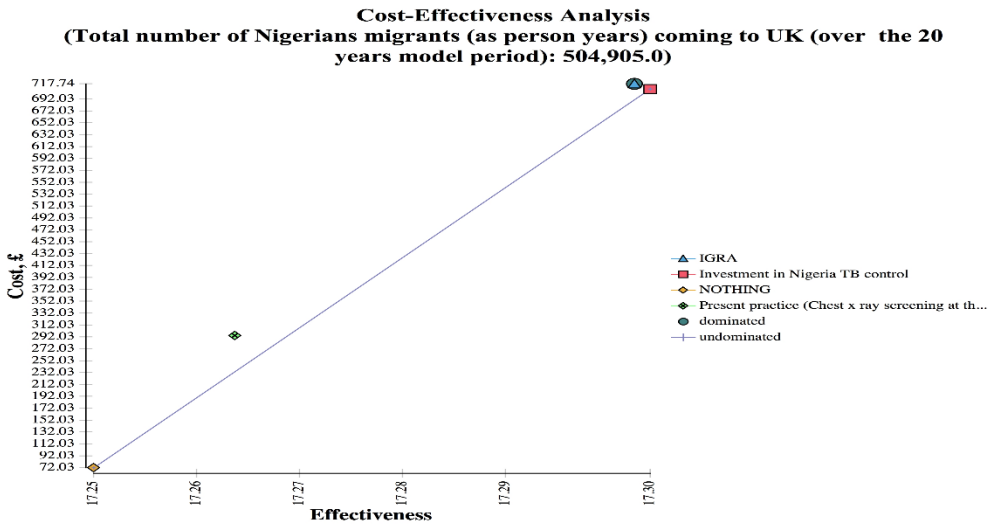


Figure 6.25. Cost-Effectiveness Analysis (CEA) plot assuming about 504,905 Nigerian migrants will live in the UK over the 20 years

Figure 6.25 is the Cost-Effectiveness Analysis (CEA) plot assuming about 504,905 Nigerian migrants will live in the UK over the 20 years (the estimate in the model is that 1.8 million Nigerian migrants will enter the UK over the 20 years modelled). '*Investment in Nigerian TB control'* is most cost-effective. IGRA, 'Nothing' and 'Chest X ray' are dominated.

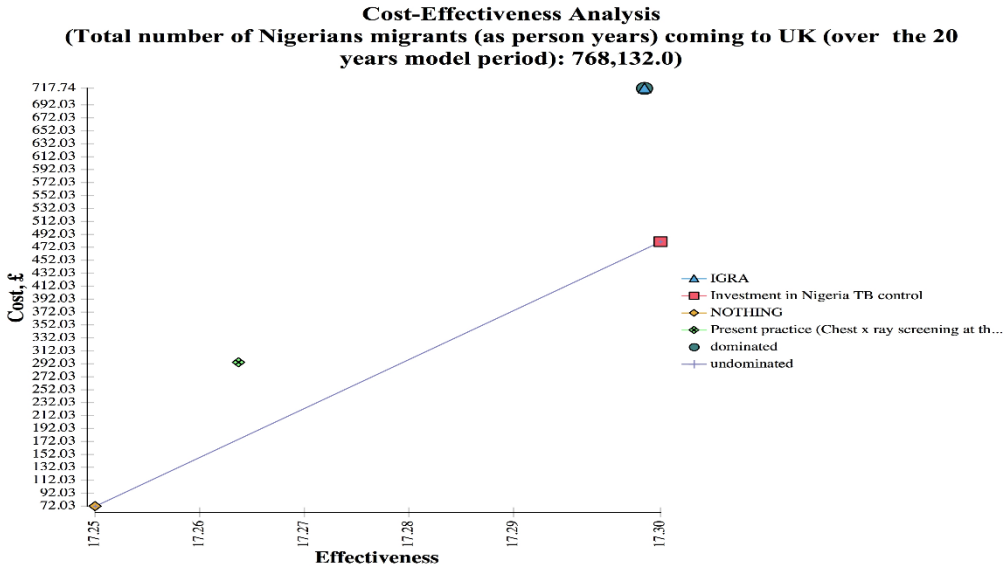


Figure 6.26. CEA plot assuming about 768,132 Nigerian migrants will live in the UK over the 20 years

Figure 6.26 is the CEA plot assuming about 768,132 Nigerian migrants will live in the UK over the 20 years (the estimate in the model is that 1.8 million Nigerian migrants will live in the UK over the 20 years). The *'Investment in Nigerian TB control'* is also most effective, slightly more effective than IGRA, but significantly less expensive. IGRA, 'Nothing' and 'Chest X ray' are dominated.

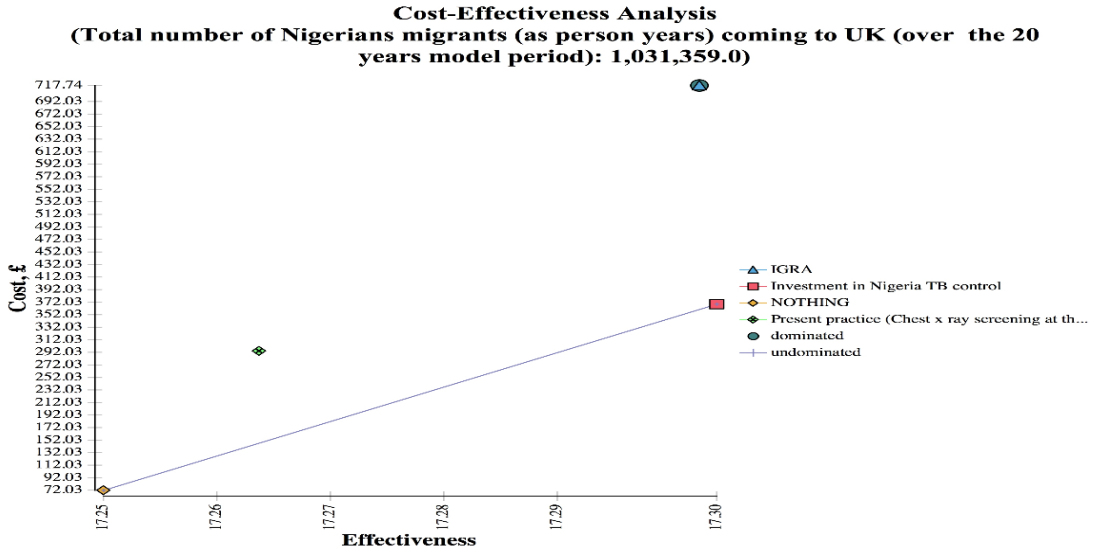


Figure 6.27. CEA plot assuming about 1,031,359 Nigerian migrants will live in the UK over the 20 years

Figure 6.27 is the CEA plot assuming about 1,031,359 Nigerian migrants will live in the UK over the 20 years (the estimate in the model is that 1.8 million Nigerian migrants will live in the UK over the 20 years). '*Investment in Nigerian TB control'* is most effective, significantly more effective than IGRA and less expensive. IGRA, 'Nothing' and 'Chest X ray' are dominated.

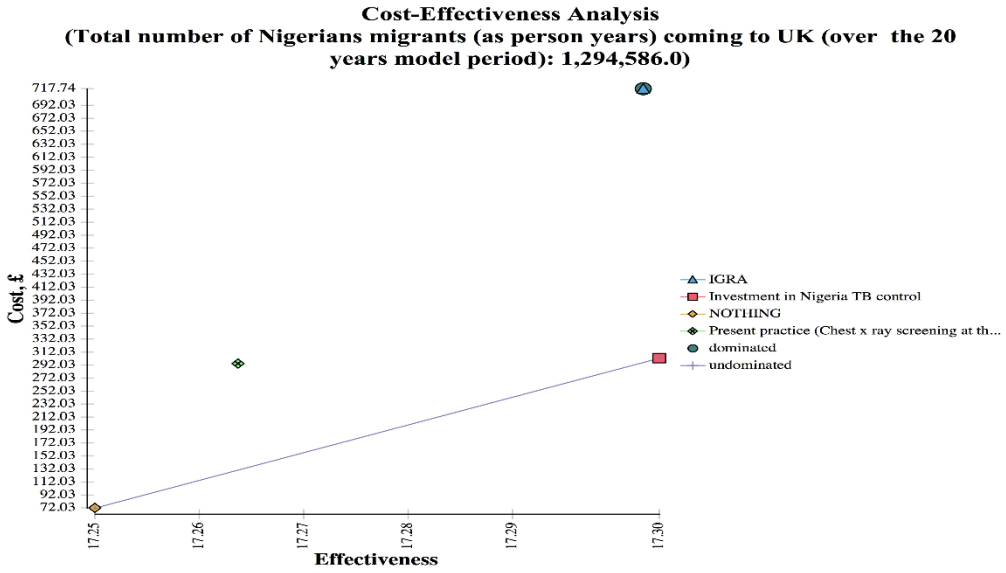


Figure 6.28. CEA plot assuming about 1,294, 586 Nigerian migrants will live in the UK over the 20 years

Figure 6.28 is the CEA plot assuming about 1,294, 586 Nigerian migrants will live in the UK over the 20 years (the estimate in the model is that 1.8 million Nigerian migrants will live in the UK over the 20 years). '*Investment in Nigerian TB control'* is most effective, significantly more effective than IGRA and less expensive. IGRA, 'Nothing' and 'Chest X ray' are dominated.

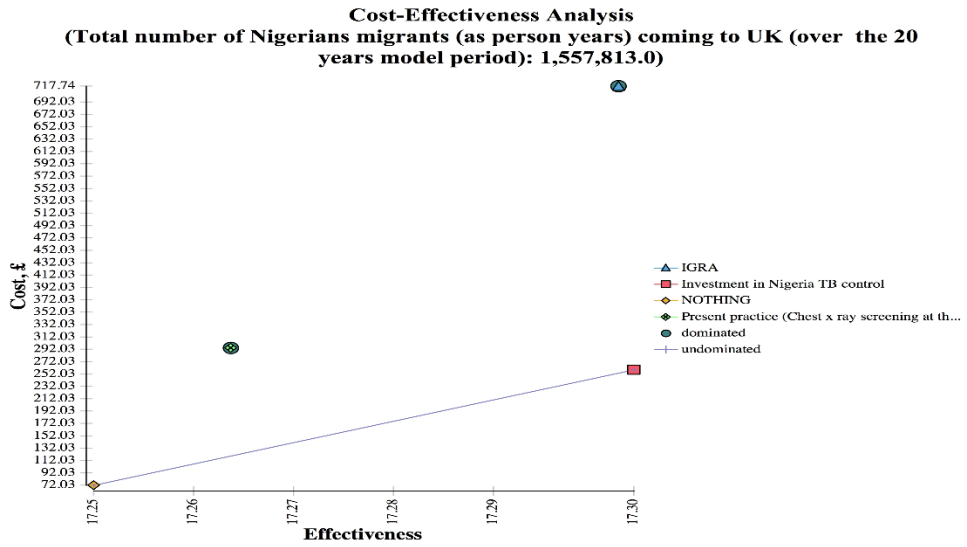


Figure 6.29. CEA plot assuming about 1,557,813 Nigerian migrants will live in the UK over the 20 years

Figure 6.29 is the CEA plot assuming about 1,557,813 Nigerian migrants will live in the UK over the 20 years (the estimate in the model is that 1.8 million Nigerian migrants will live in the UK over the 20 years). '*Investment in Nigerian TB control'* is most effective, significantly more effective than IGRA and less expensive IGRA, 'Nothing' and 'Chest X ray' are dominated.

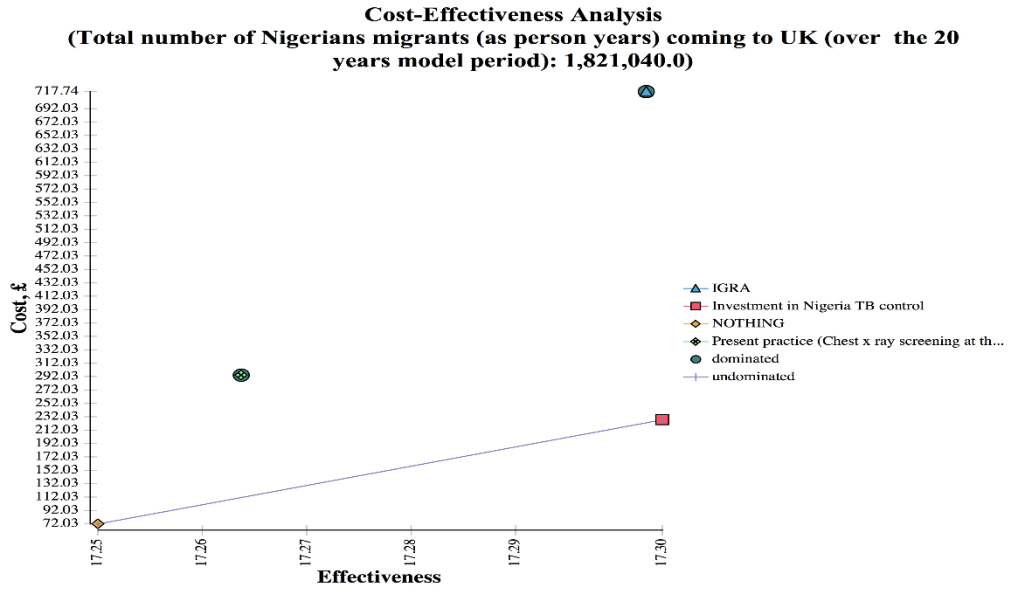


Figure 6.30. CEA plot assuming about 1,821,040 Nigerian migrants will live in the UK over the 20 years

Figure 6.30 is the CEA plot assuming about 1,821,040 Nigerian migrants will live in the UK over the 20 years (the estimate in the model is that 1.8 million Nigerian migrants will live in the UK over the 20 years). *'Investment in Nigerian TB control'* is most effective, significantly more effective than IGRA and less expensive. IGRA, 'Nothing' and 'Chest X ray' are dominated.

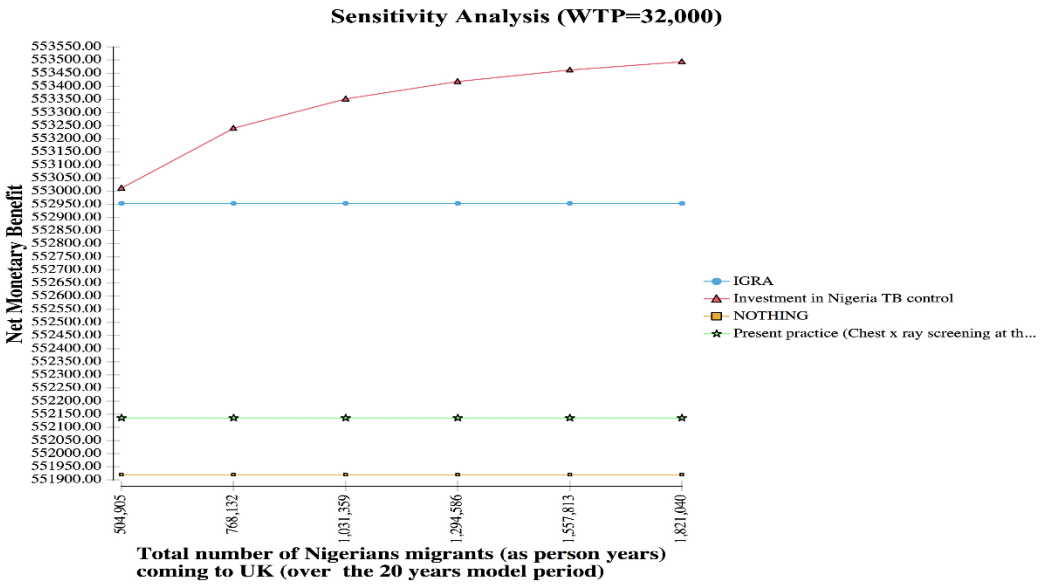


Figure 6.31. Sensitivity Analysis plot showing the annual Net Monetary Benefit in GB Pounds of the 4 alternative interventions, depending on assumed number of Nigerian migrants

Figure 6.31 is the Sensitivity Analysis plot showing the annual Net Monetary Benefit in GB Pounds of the 4 alternative interventions on varied assumptions on number of Nigerian migrants coming into the UK. The range between 100,000 - 1.8million migrants over 20 years (the estimate in the model is 1.8 million). 'Willingness to Pay' pegged at 32,000 GBP per QALY, the '*Investment in TB control in Nigeria'* shows the highest Net Monetary Benefit when the number of migrants living in the UK gets above 448,000 and above.

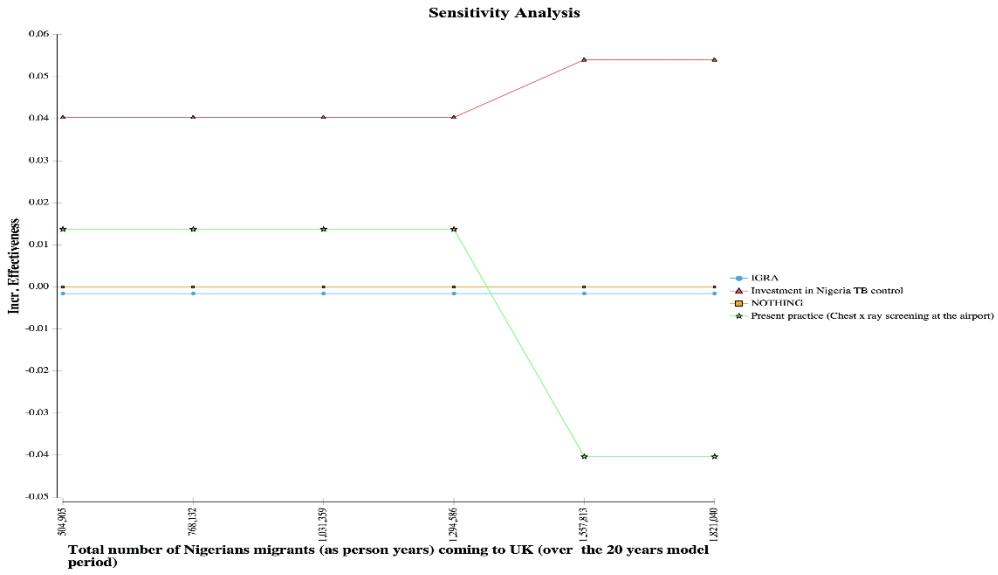


Figure 6.32. Sensitivity Analysis plot showing the incremental effectiveness (QALYs) of the 4 alternative interventions depending on assumed number of Nigerian migrants

Figure 6.32 is the Sensitivity Analysis plot showing the incremental effectiveness (QALYs) of the 4 alternative interventions on varied assumption of the number of Nigerian migrants coming into the UK. The range between 504,905 - 1.8million migrants over 20 years (the estimate in the model is 1.8 million). '*Investment in TB control in Nigeria'* is most cost effective.

6.3.6.3. The probability of active TB among migrants coming in to the UK from Nigeria based on the TB prevalence in Nigeria

The base case analysis is based on the assumption that the prevalence and incidence of latent TB in Nigeria remain unchanged in the model. The probability of TB was calculated based on the expected prevalence of TB in Nigeria after full scale up of TB. This probability was estimated as 0.0017. This is further based on the assumption that with TB control strategy, there

will be a decline of about 6% annually in the incidence of TB in the country, as observed in the studies in Peru and Chile. As already noted in the Study Limitations in *Chapter 5*, the plausability, or otherwise, of this assumption is particularly because of the contextual differences between Nigeria and these countries, and the results should be interpreted with this limitation.

The sensitivity analysis conducted aimed to test the robustness of this key assumption, if the result from the model will significant vary based on the possible inaccuracy in this extrapolation.

As observed in the previous sensitivity analyses, '*Investment in Nigeria TB Control'* strategy remains the most cost-effective alternative in the model either when the probability (prevalence) of TB is very low or when the prevalence is high. This invariably implies that even if the estimated prevalence of TB in Nigeria is an overestimation of the impact of the 'Investment in Nigeria TB Control', i.e. the actual prevalence is higher than the model assumed prevalence, the CEA results from the model will still be valid because the range of possible variability of this parameter would not significantly affect the result (refer to **Table 6.16, Figures 6.33-6.38** for details).

Table 6.16. Probability of active TB among Nigerian migrants

Probability of active TB among Nigeria Migrants	STRATEGY	COST	EFF	CE	INCR-COST	INCR-EFF	INCR-CE	DOMINATED	NMB
0	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
0	Investment in Nigeria TB control	214.324	17.306	12.384	142.294	0.056	2526.667		-214.324

0	Present practice (Chest x ray screening at the air-port)	294.283	17.263	17.047	79.960	-0.043	-1876.611	(Dominated)	-294.283
0	IGRA	717.742	17.302	41.483	503.418	-0.004	-132035.693	(Dominated)	-717.742
0.001144	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
0.001144	Investment in Nige-ria TB control	223.188	17.305	12.898	151.158	0.055	2758.198		-223.188
0.001144	Present practice (Chest x ray screening at the air-port)	294.283	17.263	17.047	71.096	-0.041	-1730.031	(Dominated)	-294.283
0.001144	IGRA	717.742	17.302	41.483	494.554	-0.002	-215105.468	(Dominated)	-717.742
0.002288	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
0.002288	Investment in Nige-ria TB control	232.052	17.303	13.411	160.022	0.053	3002.880		-232.052
0.002288	Present practice (Chest x ray screening at the air-port)	294.283	17.263	17.047	62.231	-0.040	-1572.240	(Dominated)	-294.283
0.002288	IGRA	717.742	17.302	41.483	485.690	-0.001	-618316.644	(Dominated)	-717.742
0.003432	NOTHING	72.030	17.250	4.176	0.000	0.000	0.000		-72.030
0.003432	Investment in Nige-ria TB control	240.916	17.302	13.925	168.887	0.052	3261.869		-240.916
0.003432	Present practice (Chest x ray screening at the air-port)	294.283	17.263	17.047	53.367	-0.038	-1401.901	(Dominated)	-294.283

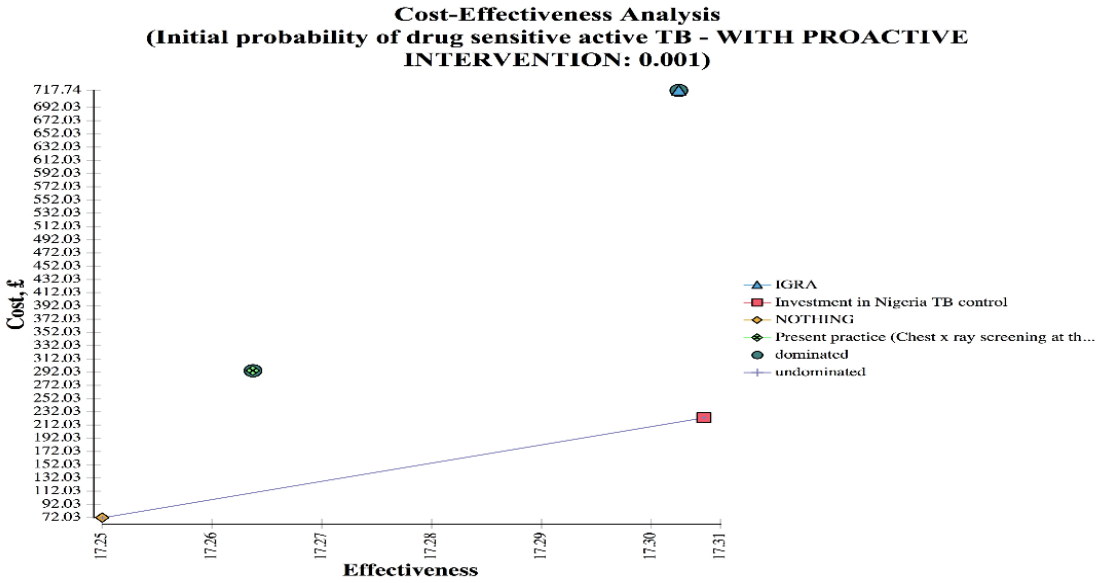


Figure 6.33. CEA plot with the probability of TB among migrants at 0.001

Figure 6.33 is the CEA plot with the probability of TB among migrants at 0.001 (the estimate in the model is 0.0017). '*Investment in TB control in Nigeria'* is most effective, slightly more effective than IGRA but significantly less expensive. Both IGRA and CXR are dominated.

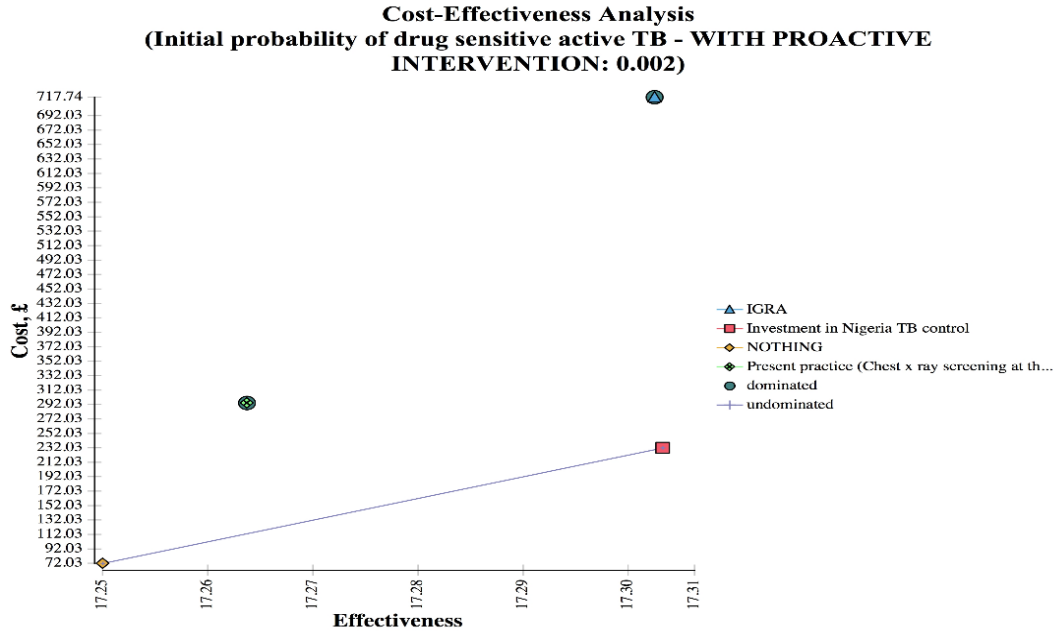


Figure 6.34.CEA plot with the probability of TB among migrants at 0.002

Figure 6.34 is the CEA plot with the probability of TB among migrants at 0.002 (the estimate in the model is 0.0017). '*Investment in TB control in Nigeria'* is most effective, slightly more effective than IGRA but significantly less expensive. Both IGRA and CXR are dominated.

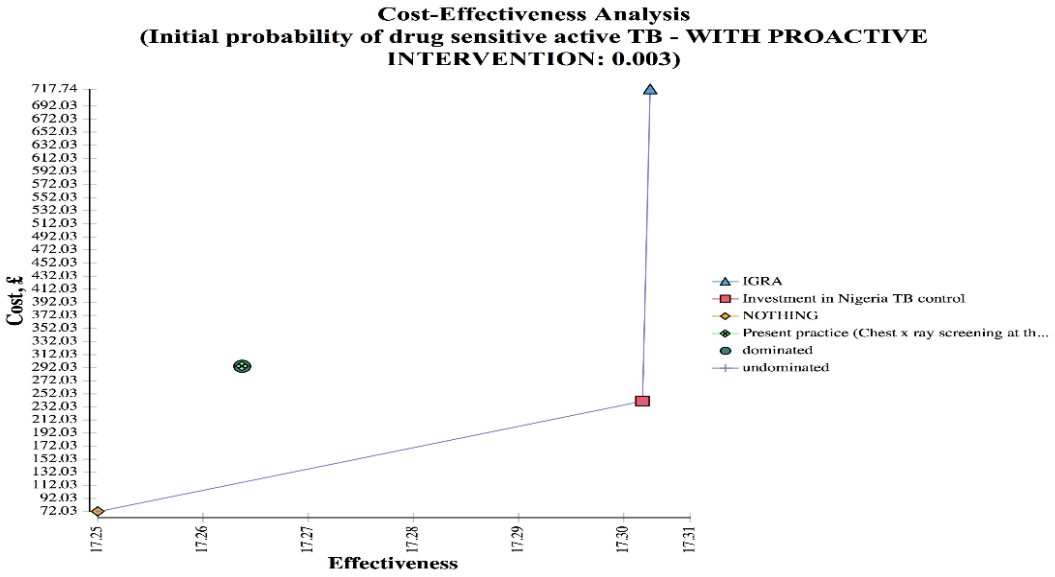


Figure 6.35. CEA plot for the probability of TB among migrants at 0.003

Figure 6.35 is the CEA plot for the probability of TB among migrants at 0.003 (the estimate in the model is 0.0017). '*Investment in TB control in Nigeria'* is most effective, the same as IGRA but significantly less expensive. Chest X ray alternative is dominated.

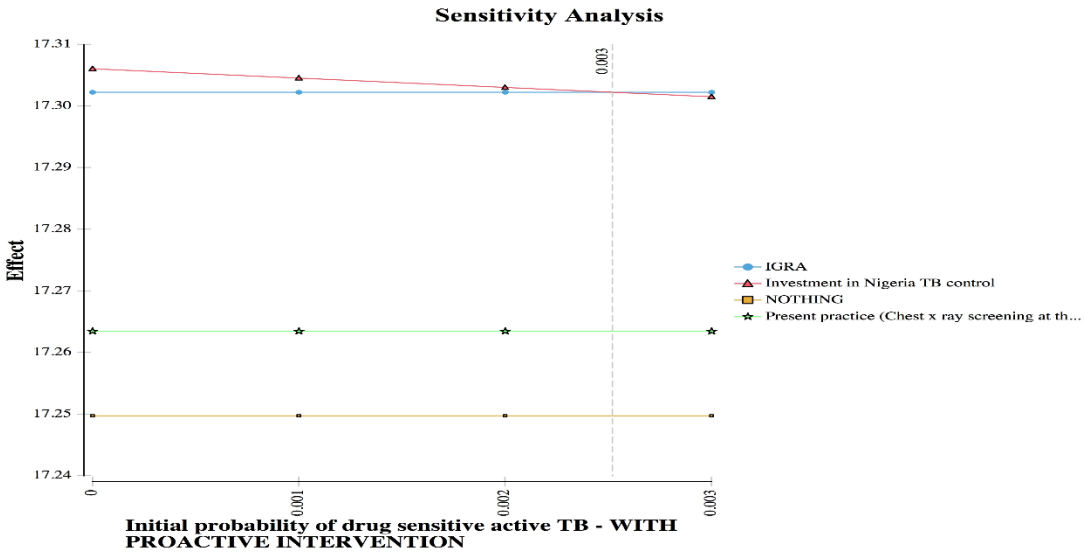


Figure 6.36. Sensitivity Analysis plot showing the effectiveness (QALYs) of the 4 alternative interventions

Figure 6.36 is the Sensitivity Analysis plot showing the effectiveness (QALYs) of the 4 alternative interventions on varied probabilities of TB among migrants. The probability range between 0.0010 - 0.0030 (the estimate in the model is 0.0017). *'Investment in TB control in Nigeria'* is most effective. When the probability of TB among migrants gets to about 0.0027, IGRA becomes most effective.

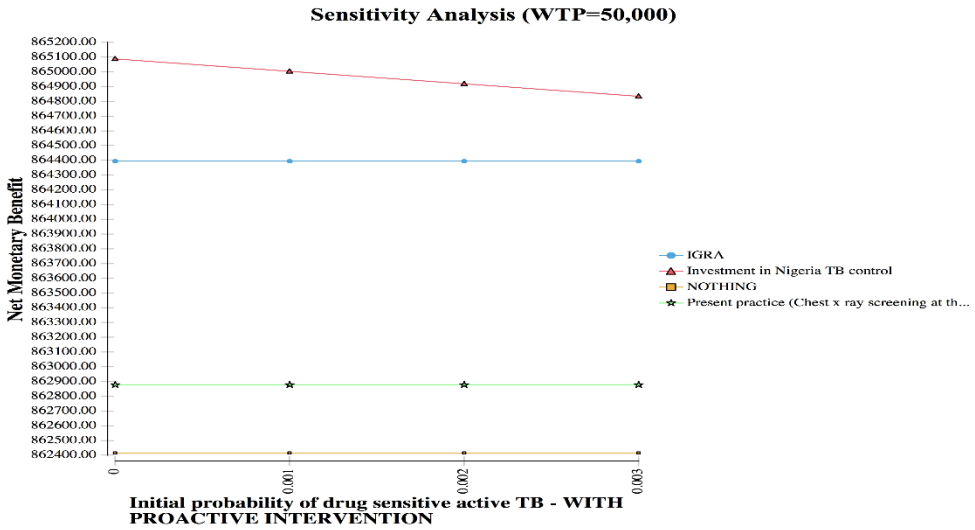


Figure 6.37. Sensitivity Analysis plot showing the annual Net Monetary Benefit in US Dollars of the 4 alternative interventions

Figure 6.37 is the Sensitivity Analysis plot showing the annual Net Monetary Benefit in US Dollars of the 4 alternative interventions on varied probabilities of TB among migrants. The probability range between 0.0010 - 0.0030 (the estimate in the model is 0.0017). '*Investment in TB control in Nigeria*' shows the highest Net Monetary Benefit across the probability scale. The NMB declines gradually with increasing probability of active TB.

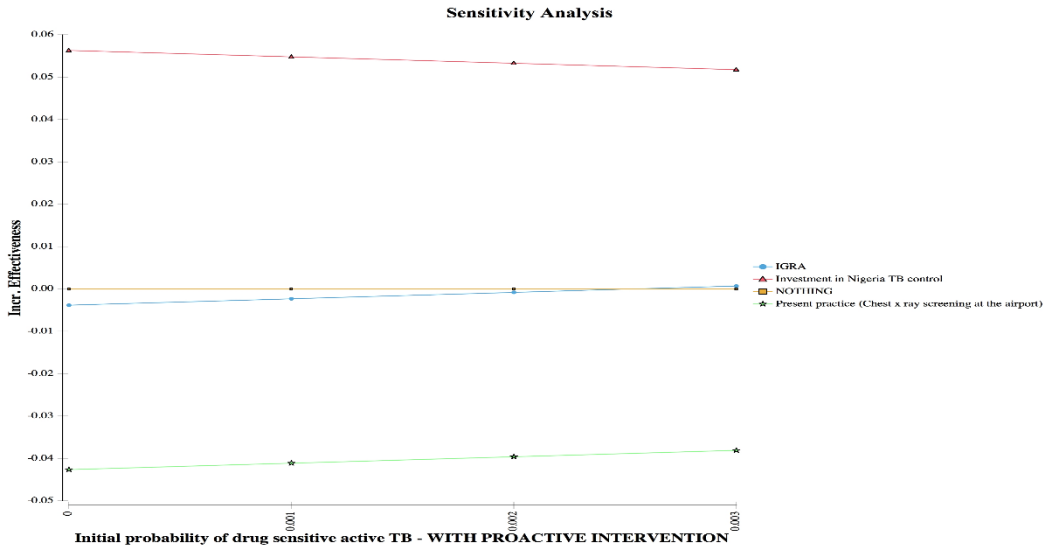


Figure 6.38. Sensitivity Analysis plot showing the incremental effectiveness (QALYs) of the 4 alternative interventions

Figure 6.38 is the Sensitivity Analysis plot showing the incremental effectiveness (QALYs) of the 4 alternative interventions on varied assumption of the number of Nigerian migrants coming in to the UK. The range between 100,000 - 1.8million migrants over 20 years (the estimate in the model is 1.8 million). '*Investment in TB control in Nigeria'* is most cost effective when the number of migrants living in the UK gets above 596,000 and above.

6.3.6.4. Proportion of entrants/migrants chest X ray screened at point of entry (pScr)

The sensitivity of this CE model to changes in the proportion of Nigerian migrants/entrants screened at the airport by chest x ray was evaluated.

As shown in **Table 6.17** below, when 0% of entrants are chest x ray screened, the most cost-effective alternatives when none of the migrants X ray screened are strategies 1 (investment in Nigerian TB control) and strategy 4 ('nothing'). Strategy 2 (CXR) and strategy 3 (IGRA) were dominated.

When 25% of migrants are screened, the Most cost-effective strategies are strategy 1 (Investment in Nigeria control), and strategy 2 (CXR screening), followed by strategy 4 (‘nothing’) in that order. Strategy 3 (IGRA) was dominated.

When 50% of migrants are screened, the most cost-effective strategies is strategy 1 (Investment in Nigeria control) followed by strategy 4 (‘do nothing’) in that order. Strategies 2 (chest x ray screening) and 3 (IGRA) are dominated.

When 75% of migrants are screened, the cost and effectiveness of strategy 2 (CXR screening) is £607 and 17.30 QALYs respectively. Most cost-effective strategies is strategy 1 (Investment in Nigeria control) followed by strategy 4 (‘do nothing’) in that order. Strategies 2 (CXR) and 3 (IGRA) are dominated.

When all migrants are screened, the cost and effectiveness of strategy 2 (CXR screening) is £785 and 17.32 QALYs respectively. Most cost-effective strategy is strategy 1 (Investment in Nigeria control) followed by strategy 2 (CXR) then strategy 4 (‘nothing’) in that order. Strategy 3 (IGRA) is dominated (see **Table 6.17**, and group of figures below—**Figure 6.39**)

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APPENDICES

APPENDIX 1: PROJECTED DEMOGRAPHICS AND BURDEN OF TB IN NIGERIA OVER A PERIOD OF 20 YEARS

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Demographics										
Population estimate	166,949,000	170,955,776	175,058,715	179,260,124	183,562,367	187,967,864	192,479,092	197,098,590	201,828,957	206,672,852
Annual growth rate (%)	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Projected Burden of TB in Nigeria										
A- When there is no any external intervention										
Incidence rate new ss+ (per 100 000 pop)	131	128	124	121	118	115	112	109	106	103
Incidence rate new ss- (per 100 000 pop)	180	175	171	166	162	158	154	150	146	142
Total incidence per 100,000 population	311	303	295	287	280	273	266	259	252	245
Proportion of MDR-TB in population (%)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Number of deaths due to all forms of TB	221,078	220,498	219,920	219,342	218,767	218,193	217,620	217,049	216,480	215,912

B- With external intervention										
Incidence rate new ss+ (per 100 000 pop)	131	128	123	117	110	103	94	86	78	71
Incidence rate new ss- (per 100 000 pop)	180	175	169	161	152	141	130	118	107	98
Total incidence per 100,000 population	311	303	292	279	262	244	224	204	186	169
Proportion of MDR-TB in population (%)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Number of deaths due to all forms of TB	221,078	197,403	158,468	116,854	112,479	107,116	100,912	94,034	87,624	81,652
Projected Disease Control indices										
A- When there is no any external intervention										
Case detection rate new ss+ (%)	23	23	23	23	23	23	23	23	23	23
Case detection rate new ss- (%)	17	17	17	17	17	17	17	17	17	17
Treatment success rate (%)	76	76	76	76	76	76	76	76	76	76

B- With external intervention										
Case detection rate new ss+ (%)	23	33	50	70	70	70	70	70	70	70
Case detection rate new ss- (%)	17	30	50	70	70	70	70	70	70	70
Treatment success rate (%)	76	76	76	80	80	80	80	80	80	80

APPENDIX 2: PROJECTED DEMOGRAPHICS AND BURDEN OF TB IN NIGERIA OVER A PERIOD OF 20 YEARS

	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Demographics										
Population estimate	211,633,000	216,712,192	221,913,285	227,239,204	232,692,944	238,277,575	243,996,237	249,852,147	255,848,598	261,988,964
Annual growth rate (%)	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Projected Burden of TB in Nigeria										
A- When there is no any external intervention										
Incidence rate new ss+ (per 100 000 pop)	101	98	95	93	91	88	86	84	82	79
Incidence rate new ss- (per 100 000 pop)	138	135	131	128	124	121	118	115	112	109
Total incidence per 100,000 population	239	233	227	221	215	209	204	199	194	189
Proportion of MDR-TB in population (%)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Number of deaths due to all forms of TB	215,345	214,780	214,216	213,654	213,094	212,535	211,977	211,421	210,866	210,313
B- With external intervention										
Incidence rate new ss+ (per 100 000 pop)	65	59	54	49	44	40	37	33	30	28

Incidence rate new ss- (per 100 000 pop)	89	81	74	67	61	55	50	46	42	38
Total incidence per 100,000 population	154	140	127	116	105	96	87	79	72	66
Proportion of MDR-TB in population (%)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Number of deaths due to all forms of TB	76,087	70,901	66,068	61,565	57,369	53,458	49,815	46,419	43,255	40,307
Projected Disease Control indices										
A- When there is no any external intervention										
• ase detecti on rate new ss+ (%)	23	23	23	23	23	23	23	23	23	23
• Case detecti on rate new ss- (%)	17	17	17	17	17	17	17	17	17	17
• Treatm ent success rate (%)	76	76	76	76	76	76	76	76	76	76
B- With external intervention										
• Case detecti on rate new ss+ (%)	70	70	70	70	70	70	70	70	70	70

• Case detection rate new ss-(%)	70	70	70	70	70	70	70	70	70	70
• reatment success rate (%)	80	80	80	80	80	80	80	80	80	80

APPENDIX 3: MODELED COST ELEMENTS FOR SCALING UP TB CONTROL SERVICES AND PROGRAMME IN NIGERIA OVER A PERIOD OF 20 YEARS

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
A- NO INTERVENTION										
General use of health services including labs and x rays										
Drugs sensitive patients Hospitalizations, outpatient care, investigation and drugs	20,348,715	20,295,320	20,242,065	20,188,950	20,135,974	20,083,137	20,030,439	19,977,879	19,925,457	19,873,173
MDR-TB Hospitalizations, outpatient care, investigation and drugs	5,668,407	5,653,534	5,638,699	5,623,903	5,609,146	5,594,427	5,579,747	5,565,106	5,550,503	5,535,939
B- INTERVENTION										
General use of health services including labs and x rays										

Drugs sensitive patients Hospitalizations, outpatient care, investigation and drugs	20,348,715	32,493,231	51,297,949	70,157,866	67,531,155	64,311,270	60,586,361	56,456,795	52,608,700	49,022,891
MDR-TB Hospitalizations, outpatient care, investigation and drugs	5,668,407	9,051,425	14,289,732	19,543,414	18,811,709	17,914,767	16,877,143	15,726,797	14,654,859	13,655,984
Cost of drugs										
A- NO INTERVENTION										
First line drugs in US $	1,893,626	1,888,657	1,883,701	1,878,759	1,873,829	1,868,912	1,864,008	1,859,117	1,854,238	1,849,373
Second line drugs in US $	83,949	83,729	83,509	83,290	83,072	82,854	82,636	82,419	82,203	81,988
B- INTERVENTION										
First line drugs in US $	1893626.06	3023779.65	4773723.26	6528803.61	6284365.21	5984726.67	5638091.30	5253799.00	4895700.06	4562009.15
Second line drugs in US $	83949.37	134052.02	211631.57	289438.85	278602.26	265318.50	249951.26	232914.58	217039.12	202245.73
National and State TB control programme in US $ (Assumed to be same with and without the external intervention)										

Staff and Consultants	4,359,689	6,961,639	10,990,528	15,031,245	14,468,475	13,778,618	12,980,560	12,095,805	11,271,355	10,503,100
Routine programme management, supervision activities,meetings, equipment and training	7,299,945	11,656,697	18,402,745	25,168,596	24,226,283	23,071,174	21,734,892	20,253,442	18,872,967	17,586,586
Private Public Mix (PPM)	171,054	178,532	188,595	196,846	196,846	196,846	196,846	196,846	196,846	196,846
Practical Approach to Lung Health (PAL)	207,941	207,941	207,941	207,941	207,941	207,941	207,941	207,941	207,941	207,941
Community based TB Care (CTBC)	271,353	285,288	299,889	315,175	315,175	315,175	315,175	315,175	315,175	315,175
Advocacy, Communication and Social Mobilization (ACSM)	20,143,067	21,177,500	22,261,413	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071
Technical Assistance including Country based and International	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000
M&E, surveillance and Operational Research	1,012,000	1,000,000	1,058,400	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000
Collaborative TB/HIV activities	62,964,014	86,659,047	123,043,685	159,547,674	155,173,107	149,684,603	143,250,293	136,061,558	129,424,613	123,303,330

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
A- NO INTERVENTION										
Drugs sensitive patients Hospitalizations, outpatient care, investigation and drugs	19,821,026	19,769,015	19,717,141	19,665,403	19,613,801	19,562,335	19,511,003	19,459,806	19,408,744	19,357,815
MDR-TB Hospitalizations, outpatient care, investigation and drugs	5,521,413	5,506,924	5,492,474	5,478,062	5,463,687	5,449,351	5,435,052	5,420,790	5,406,566	5,392,379
B- INTERVENTION										
Drugs sensitive patients Hospitalizations, outpatient care, investigation and drugs	45,681,490	42,567,840	39,666,416	36,962,753	34,443,372	32,095,712	29,908,068	27,869,534	25,969,947	24,199,835
MDR-TB Hospitalizations, outpatient care, investigation and drugs	12,725,192	11,857,843	11,049,612	10,296,471	9,594,663	8,940,691	8,331,293	7,763,432	7,234,277	6,741,189
Cost of drugs										

A- NO INTERVENTION										
First line drugs in US $	1,844,520	1,839,680	1,834,853	1,830,038	1,825,236	1,820,447	1,815,670	1,810,905	1,806,154	1,801,414
Second line drugs in US $	81,772	81,558	81,344	81,130	80,917	80,705	80,493	80,282	80,071	79,861
B- INTERVENTION										
First line drugs in US $	4251062.60	3961310.18	3691307.27	3439707.77	3205257.29	2986786.95	2783207.55	2593504.13	2416730.88	2252006.51
Second line drugs in US $	188460.66	175615.19	163645.25	152491.19	142097.39	132412.04	123386.83	114976.79	107139.97	99837.31
National and State TB control programme in US $ (Assumed to be same with and without the external intervention)										
Staff and Consultants	9,787,208	9,120,112	8,498,485	7,919,229	7,379,454	6,876,470	6,407,770	5,971,017	5,564,032	5,184,788
Routine programme management, supervision activities,meetings, equipment and training	16,387,884	15,270,886	14,230,022	13,260,104	12,356,295	11,514,090	10,729,290	9,997,981	9,316,519	8,681,505
Private Public Mix (PPM)	196,846	196,846	196,846	196,846	196,846	196,846	196,846	196,846	196,846	196,846
Practical Approach to Lung Health (PAL)	207,941	207,941	207,941	207,941	207,941	207,941	207,941	207,941	207,941	207,941

Community based TB Care (CTBC)	315,175	315,175	315,175	315,175	315,175	315,175	315,175	315,175	315,175	315,175
Advocacy, Communication and Social Mobilization (ACSM)	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071	23,396,071
Technical Assistance including Country based and International	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000
M&E, surveillance and Operational Research	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000	1,101,000
Collaborative TB/HIV activities	117,664,080	112,475,565	107,708,654	103,336,242	99,333,110	95,675,797	92,342,485	89,312,882	86,568,123	84,090,675

APPENDIX 4: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 0-15 YEARS OF AGE, (WITH NO ADDITIONAL INTERVENTION IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI %	Age midpoint	% of entrants	Expected Number of entrants	Expected number exposed to TB	Number of Infections	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	8	8	7284	1527	458	23	109	326
2013	128	303	2.552	8	8	7284	1487	446	22	106	318
2014	124	295	2.486	8	8	7284	1448	435	21	103	310
2015	121	287	2.421	8	8	7284	1411	423	21	101	302
2016	118	280	2.358	8	8	7284	1374	412	20	98	294
2017	115	273	2.297	8	8	7284	1338	402	20	95	286
2018	112	266	2.237	8	8	7284	1304	391	19	93	279
2019	109	259	2.179	8	8	7284	1270	381	19	90	271
2020	106	252	2.122	8	8	7284	1237	371	18	88	264
2021	103	245	2.067	8	8	7284	1204	361	18	86	257
2022	101	239	2.013	8	8	7284	1173	352	17	84	251
2023	98	233	1.961	8	8	7284	1143	343	17	81	244
2024	95	227	1.910	8	8	7284	1113	334	17	79	238
2025	93	221	1.860	8	8	7284	1084	325	16	77	232

6	91	215	1.812	8	8	7284	1056	317	16	75	226
2027	88	209	1.765	8	8	7284	1028	309	15	73	220
2028	86	204	1.719	8	8	7284	1002	300	15	71	214
2028	84	199	1.674	8	8	7284	976	293	14	70	209
2030	82	194	1.631	8	8	7284	950	285	14	68	203
2031	79	189	1.588	8	8	7284	926	278	14	66	198
									357	**1714**	**5141**

APPENDIX 5: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 16-24 YEARS OF AGE, (WITH NO ADDITIONAL INTERVENTION IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI%	Age midpoint	% of entrants	Number	Total number exposed to TB	Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	20	12	10926	5725	1718	34	163	1469
2013	128	303	2.552	20	12	10926	5576	1673	33	159	1430
2014	124	295	2.486	20	12	10926	5432	1629	32	155	1393
2015	121	287	2.421	20	12	10926	5290	1587	31	151	1357
2016	118	280	2.358	20	12	10926	5153	1546	31	147	1322
2017	115	273	2.297	20	12	10926	5019	1506	30	143	1287
2018	112	266	2.237	20	12	10926	4888	1466	29	139	1254
2019	109	259	2.179	20	12	10926	4761	1428	28	136	1221
2020	106	252	2.122	20	12	10926	4637	1391	28	132	1189
2021	103	245	2.067	20	12	10926	4517	1355	27	129	1159
2022	101	239	2.013	20	12	10926	4399	1320	26	125	1128
2023	98	233	1.961	20	12	10926	4285	1285	25	122	1099
2024	95	227	1.910	20	12	10926	4174	1252	25	119	1071
2025	93	221	1.860	20	12	10926	4065	1220	24	116	1043

2026	91	215	1.812	20	12	10926	3959	1188	23	113	1016
2027	88	209	1.765	20	12	10926	3856	1157	23	110	989
2028	86	204	1.719	20	12	10926	3756	1127	22	107	963
2028	84	199	1.674	20	12	10926	3659	1098	22	104	938
2030	82	194	1.631	20	12	10926	3563	1069	21	102	914
2031	79	189	1.588	20	12	10926	3471	1041	21	99	890
									535	**2570**	**23133**

APPENDIX 6: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 25-44 YEARS OF AGE, (WITH NO ADDITIONAL INTERVENTION IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI %	Age midpoint	% of entrants	Number	Total number exposed to TB	Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	34	53	48258	42988	12896	150	721	11531
2013	128	303	2.552	34	53	48258	41870	12561	146	702	11231
2014	124	295	2.486	34	53	48258	40782	12234	142	684	10939
2015	121	287	2.421	34	53	48258	39721	11916	139	666	10655
2016	118	280	2.358	34	53	48258	38688	11607	135	649	10378
2017	115	273	2.297	34	53	48258	37683	11305	132	632	10108
2018	112	266	2.237	34	53	48258	36703	11011	128	615	9845
2019	109	259	2.179	34	53	48258	35749	10725	125	599	9589
2020	106	252	2.122	34	53	48258	34819	10446	122	584	9340
2021	103	245	2.067	34	53	48258	33914	10174	118	569	9097
2022	101	239	2.013	34	53	48258	33032	9910	115	554	8860
2023	98	233	1.961	34	53	48258	32173	9652	112	539	8630
2024	95	227	1.910	34	53	48258	31337	9401	109	525	8406
2025	93	221	1.860	34	53	48258	30522	9157	107	512	8187

2026	91	215	1.812	34	53	48258	29728	8919	104	498	7974
2027	88	209	1.765	34	53	48258	28955	8687	101	485	7767
2028	86	204	1.719	34	53	48258	28203	8461	98	473	7565
2028	84	199	1.674	34	53	48258	27469	8241	96	461	7368
2030	82	194	1.631	34	53	48258	26755	8027	93	449	7177
2031	79	189	1.588	34	53	48258	26059	7818	91	437	6990
									2364	**11352**	**181636**

APPENDIX 7: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 45-64 YEARS OF AGE, (WITH NO ADDITIONAL INTERVENTION IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI %	Age midpoint	% of entrants	Expected number of entrants	Expected number exposed to TB	Number of Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	54	23	20942	20942	6283	65	221	5747
2013	128	303	2.552	54	23	20942	20942	6283	63	221	5747
2014	124	295	2.486	54	23	20942	20942	6283	62	221	5747
2015	121	287	2.421	54	23	20942	20942	6283	60	221	5747
2016	118	280	2.358	54	23	20942	20942	6283	59	221	5747
2017	115	273	2.297	54	23	20942	20942	6283	57	221	5747
2018	112	266	2.237	54	23	20942	20942	6283	56	221	5747
2019	109	259	2.179	54	23	20942	20942	6283	54	221	5747
2020	106	252	2.122	54	23	20942	20942	6283	53	221	5747
2021	103	245	2.067	54	23	20942	20942	6283	51	221	5747
2022	101	239	2.013	54	23	20942	20942	6283	50	221	5747
2023	98	233	1.961	54	23	20942	20942	6283	49	221	5747
2024	95	227	1.910	54	23	20942	20942	6283	47	221	5747
2025	93	221	1.860	54	23	20942	20942	6283	46	221	5747

2026	91	215	1.812	54	23	20942	20942	6283	45	221	5747
2027	88	209	1.765	54	23	20942	20942	6283	44	221	5747
2028	86	204	1.719	54	23	20942	20942	6283	43	221	5747
2028	84	199	1.674	54	23	20942	20942	6283	42	221	5747
2030	82	194	1.631	54	23	20942	20942	6283	41	221	5747
2031	79	189	1.588	54	23	20942	20942	6283	39	221	5747
									1026	**4421**	**114948**

APPENDIX 8: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 65+ YEARS OF AGE, (WITH NO ADDITIONAL INTERVENTION IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI %	Age midpoint	% of entrants	Expected number of entrants	Expected number exposed to TB	No. of infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	65	4	3642	3642	1093	11	32	1006
2013	128	303	2.552	65	4	3642	3642	1093	11	32	1006
2014	124	295	2.486	65	4	3642	3642	1093	11	32	1006
2015	121	287	2.421	65	4	3642	3642	1093	10	32	1006
2016	118	280	2.358	65	4	3642	3642	1093	10	32	1006
2017	115	273	2.297	65	4	3642	3642	1093	10	32	1006
2018	112	266	2.237	65	4	3642	3642	1093	10	32	1006
2019	109	259	2.179	65	4	3642	3642	1093	9	32	1006
2020	106	252	2.122	65	4	3642	3642	1093	9	32	1006
2021	103	245	2.067	65	4	3642	3642	1093	9	32	1006
2022	101	239	2.013	65	4	3642	3642	1093	9	32	1006
2023	98	233	1.961	65	4	3642	3642	1093	8	32	1006
2024	95	227	1.910	65	4	3642	3642	1093	8	32	1006
2025	93	221	1.860	65	4	3642	3642	1093	8	32	1006
2026	91	215	1.812	65	4	3642	3642	1093	8	32	1006

2027	88	209	1.765	65	4	3642	3642	1093	8	32	1006
2028	86	204	1.719	65	4	3642	3642	1093	7	32	1006
2028	84	199	1.674	65	4	3642	3642	1093	7	32	1006
2030	82	194	1.631	65	4	3642	3642	1093	7	32	1006
2031	79	189	1.588	65	4	3642	3642	1093	7	32	1006
									178	**639**	**20121**

APPENDIX 9: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 0-15 YEARS OF AGE, (WITH THE INTERVENTION, I.E. SCALED UP TB SERVICES IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI %	Age midpoint	% of entrants	Expected Number of entrants	Expected number exposed to TB	Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	8	8	7284	1527	458	23	109	326
2013	128	303	2.552	8	8	7284	1487	446	22	106	318
2014	123	292	2.460	8	8	7284	1434	430	21	102	306
2015	117	279	2.347	8	8	7284	1368	410	20	97	292
2016	110	262	2.206	8	8	7284	1286	386	19	92	275
2017	103	244	2.052	8	8	7284	1196	359	18	85	256
2018	94	224	1.887	8	8	7284	1100	330	16	78	235
2019	86	204	1.718	8	8	7284	1001	300	15	71	214
2020	78	186	1.563	8	8	7284	911	273	14	65	195
2021	71	169	1.422	8	8	7284	829	249	12	59	177
2022	65	154	1.294	8	8	7284	754	226	11	54	161
2023	59	140	1.178	8	8	7284	686	206	10	49	147
2024	54	127	1.072	8	8	7284	625	187	9	45	134
2025	49	116	0.975	8	8	7284	568	171	8	40	121
2026	44	105	0.888	8	8	7284	517	155	8	37	111

2027	40	96	0.808	8	8	7284	471	141	7	34	101
2028	37	87	0.735	8	8	7284	428	128	6	31	92
2028	33	79	0.669	8	8	7284	390	117	6	28	83
2030	30	72	0.609	8	8	7284	355	106	5	25	76
2031	28	66	0.554	8	8	7284	323	97	5	23	69
									256	**1229**	**3688**

APPENDIX 10: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 16-24 YEARS OF AGE, (WITH THE INTERVENTION, I.E SCALED UP TB SERVICES IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear Positives rate	Incidence rate	ARI %	Age midpoint	% of entrants	Expected Number of entrants	Expected number exposed to TB	Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	20	12	10926	5725	1718	34	163	1469
2013	128	303	2.552	20	12	10926	5576	1673	33	159	1430
2014	123	292	2.460	20	12	10926	5376	1613	32	153	1379
2015	117	279	2.347	20	12	10926	5128	1539	30	146	1315
2016	110	262	2.206	20	12	10926	4821	1446	29	137	1237
2017	103	244	2.052	20	12	10926	4483	1345	27	128	1150
2018	94	224	1.887	20	12	10926	4125	1237	24	118	1058
2019	86	204	1.718	20	12	10926	3753	1126	22	107	963
2020	78	186	1.563	20	12	10926	3416	1025	20	97	876
2021	71	169	1.422	20	12	10926	3108	932	18	89	797
2022	65	154	1.294	20	12	10926	2828	849	17	81	726
2023	59	140	1.178	20	12	10926	2574	772	15	73	660
2024	54	127	1.072	20	12	10926	2342	703	14	67	601
2025	49	116	0.975	20	12	10926	2131	639	13	61	547
2026	44	105	0.888	20	12	10926	1940	582	12	55	498

2027	40	96	0.808	20	12	10926	1765	530	10	50	453
2028	37	87	0.735	20	12	10926	1606	482	10	46	412
2028	33	79	0.669	20	12	10926	1462	438	9	42	375
2030	30	72	0.609	20	12	10926	1330	399	8	38	341
2031	28	66	0.554	20	12	10926	1210	363	7	34	310
									384	**1844**	**16596**

APPENDIX 11: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 25-44 YEARS OF AGE, (WITH THE INTERVENTION, I.E SCALED UP TB SERVICES IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positives rate	Incidence rate	ARI %	Age midpoint	% of entrants	Expected Number of entrants	Total number exposed to TB	Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	34	53	48258	42988	12896	150	721	11531
2013	128	303	2.552	34	53	48258	41870	12561	146	702	11231
2014	123	292	2.460	34	53	48258	40363	12109	141	677	10827
2015	117	279	2.347	34	53	48258	38506	11552	134	646	10329
2016	110	262	2.206	34	53	48258	36196	10859	126	607	9709
2017	103	244	2.052	34	53	48258	33662	10099	118	564	9029
2018	94	224	1.887	34	53	48258	30969	9291	108	519	8307
2019	86	204	1.718	34	53	48258	28182	8455	98	472	7559
2020	78	186	1.563	34	53	48258	25646	7694	90	430	6879
2021	71	169	1.422	34	53	48258	23337	7001	81	391	6260
2022	65	154	1.294	34	53	48258	21237	6371	74	356	5697
2023	59	140	1.178	34	53	48258	19326	5798	67	324	5184
2024	54	127	1.072	34	53	48258	17586	5276	61	295	4717
2025	49	116	0.975	34	53	48258	16004	4801	56	268	4293

2026	44	105	0.888	34	53	48258	14563	4369	51	244	3906
2027	40	96	0.808	34	53	48258	13253	3976	46	222	3555
2028	37	87	0.735	34	53	48258	12060	3618	24	202	3235
2028	33	79	0.669	34	53	48258	10974	3292	38	184	2944
2030	30	72	0.609	34	53	48258	9987	2996	35	167	2679
2031	28	66	0.554	34	53	48258	9088	2726	32	152	2438
									1678	**8144**	**130308**

APPENDIX 12: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 45-64 YEARS OF AGE, (WITH THE INTERVENTION, I.E SCALED UP TB SERVICES IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI%	Age midpoint	% of entrants	Number	Total number exposed to TB	Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	54	23	20942	20942	6283	65	221	5747
2013	128	303	2.552	54	23	20942	20942	6283	63	221	5747
2014	123	292	2.460	54	23	20942	20942	6283	61	221	5747
2015	117	279	2.347	54	23	20942	20942	6283	58	221	5747
2016	110	262	2.206	54	23	20942	20942	6283	55	221	5747
2017	103	244	2.052	54	23	20942	20942	6283	51	221	5747
2018	94	224	1.887	54	23	20942	20942	6283	47	221	5747
2019	86	204	1.718	54	23	20942	20942	6283	43	221	5747
2020	78	186	1.563	54	23	20942	17676	5303	39	187	4851
2021	71	169	1.422	54	23	20942	16085	4825	35	170	4414
2022	65	154	1.294	54	23	20942	14637	4391	32	155	4017
2023	59	140	1.178	54	23	20942	13320	3996	29	141	3656
2024	54	127	1.072	54	23	20942	12121	3636	27	128	3327
2025	49	116	0.975	54	23	20942	11030	3309	24	116	3027
2026	44	105	0.888	54	23	20942	10038	3011	22	106	2755
2027	40	96	0.808	54	23	20942	9134	2740	20	96	2507
2028	37	87	0.735	54	23	20942	8312	2494	18	88	2281
2028	33	79	0.669	54	23	20942	7564	2269	17	80	2076
2030	30	72	0.609	54	23	20942	6883	2065	15	73	1889
2031	28	66	0.554	54	23	20942	6264	1879	14	66	1719
									736	**3173**	**82498**

APPENDIX 13: PROJECTION OF TB AMONG MIGRANTS COMING TO THE UK, 65+ YEARS OF AGE, (WITH THE INTERVENTION, I.E SCALED UP TB SERVICES IN NIGERIA) OVER A PERIOD OF 20 YEARS

Year	Smear positive rate	Incidence rate	ARI%	Age midpoint	% of entrants	Number	Total number exposed to TB	Infection	Active TB	LTB <2yr	LTB >2yr
2012	131	311	2.620	65	4	3642	3642	1093	11	32	1006
2013	128	303	2.552	65	4	3642	3642	1093	11	32	1006
2014	123	292	2.460	65	4	3642	3642	1093	11	32	1006
2015	117	279	2.347	65	4	3642	3642	1093	10	32	1006
2016	110	262	2.206	65	4	3642	3642	1093	10	32	1006
2017	103	244	2.052	65	4	3642	3642	1093	9	32	1006
2018	94	224	1.887	65	4	3642	3642	1093	8	32	1006
2019	86	204	1.718	65	4	3642	3642	1093	7	32	1006
2020	78	186	1.563	65	4	3642	3642	1093	7	32	1006
2021	71	169	1.422	65	4	3642	3642	1093	6	32	1006
2022	65	154	1.294	65	4	3642	3642	1093	6	32	1006
2023	59	140	1.178	65	4	3642	2788	837	5	24	770
2024	54	127	1.072	65	4	3642	2537	761	5	22	701
2025	49	116	0.975	65	4	3642	2309	693	4	20	638
2026	44	105	0.888	65	4	3642	2101	630	4	18	580
2027	40	96	0.808	65	4	3642	1912	574	3	17	528
2028	37	87	0.735	65	4	3642	1740	522	3	15	481
2028	33	79	0.669	65	4	3642	1583	475	3	14	437
2030	30	72	0.609	65	4	3642	1441	432	3	13	398
2031	28	66	0.554	65	4	3642	1311	393	2	11	362
									128	**507**	**15963**

APPENDIX 14: PROJECTION OF FUNDS IN GB £ REQUIRED FOR SCALING UP TB CONTROL SERVICES AND PROGRAMME IN NIGERIA OVER A PERIOD OF 20 YEARS

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
INTERVENTION: TOTAL COST in GB £	76,822,658	107,838,232	154,549,540	203,890,020	201,318,491	198,737,485	196,152,790	193,569,808	190,993,581	188,428,805
AVAILABLE RESOURCES in GB £	76,822,658	84,300,246	95,127,979	106,509,033	106,706,395	106,831,498	106,889,477	106,885,183	106,823,196	106,707,844
FUNDING GAP	0	23,537,986	59,421,561	97,380,987	94,612,096	91,905,987	89,263,313	86,684,626	84,170,385	81,720,961
FUNDING GAP (DISCOUNTED)	0	22,831,846	57,638,914	94,459,558	91,773,733	89,148,807	86,585,413	84,084,087	81,645,273	79,269,332

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
INTERVENTION: TOTAL COST in GB £	183,123,724	178,044,917	173,184,575	168,535,199	164,089,585	159,840,818	155,782,256	151,907,527	148,210,513	144,685,342
AVAILABLE RESOURCES in GB £	105,165,145	103,680,204	102,250,860	100,875,030	99,550,711	98,275,975	97,048,965	95,867,894	94,731,042	93,636,754
FUNDING GAP	77,958,579	74,364,713	70,933,716	67,660,169	64,538,874	61,564,843	58,733,292	56,039,634	53,479,471	51,048,588
FUNDING GAP (DISCOUNTED)	75,619,822	72,133,772	68,805,704	65,630,364	62,602,708	59,717,898	56,971,293	54,358,445	51,875,086	49,517,130

APPENDIX 15: PROJECTION OF TREATMENT COVERAGE AND TB CONTROL WITH AND WITHOUT INTERVENTION IN NIGERIA OVER A PERIOD OF 20 YEARS

Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
A- EXPECTED NUMBER OF TB CASES, WITHOUT INTERVENTION										
Expected Number of NEW smear Positive cases to be treated	50,302	50,170	50,038	49,907	49,776	49,645	49,515	49,385	49,255	49,126
Expected Number of NEW smear negative cases to be treated	51,086	50,952	50,819	50,685	50,552	50,420	50,287	50,155	50,024	49,893
Total Number of New cases expected to be treated (SS+ and SS-)	101,388	101,122	100,857	100,592	100,328	100,065	99,802	99,540	99,279	99,019
Total number of New cases expected NOT to be treated (SS+& SS-)	417,823	416,727	415,633	414,543	413,455	412,370	411,288	410,209	409,132	408,059
Expected Number of total NEW smear Positive cases in year (treated and not treated)	218,703	218,129	217,557	216,986	216,417	215,849	215,282	214,718	214,154	213,592
Expected Number of total NEW smear negative cases in year (treated and not treated)	300,508	299,720	298,933	298,149	297,366	296,586	295,808	295,032	294,258	293,485

Total number of new cases in a year	519,211	517,849	516,490	515,135	513,783	512,435	511,090	509,749	508,412	507,078
Estimated Number of MDR TB cases in year (treated and not treated)	9,346	9,321	9,297	9,272	9,248	9,224	9,200	9,175	9,151	9,127
Expected number of new cases to be treated per 100,000 population	61	59	58	56	55	53	52	51	49	48
Expected number of new cases NOT to be treated per 100,000 population	250	244	237	231	225	219	214	208	203	197
Reduction (from 2012 rate) in incidence per100,000 in percentage	0%	-8%	-16%	-24%	-31%	-38%	-45%	-52%	-59%	-66%
B- EXPECRED NUMBER OF TB CASES, WITH INTERVENTION										
Expected Number of NEW smear Positive cases to be treated	50302	71983	107662	147244	141731	134973	127156	118489	110413	102887
Expected Number of NEW smear negative cases to be treated	51086	89916	147932	202320	194745	185460	174718	162809	151712	141371
Total Number of New cases expected to be treated (SS+ and SS-)	101388	161899	255594	349564	336476	320433	301873	281298	262125	244258

Total number of New cases expected NOT to be treated (SS+&SS-)	417823	355950	255594	149813	144204	137328	129374	120556	112339	104682
Expected Number of total NEW smear Positive cases in year (treated and not treated)	218703	218129	215323	210348	202473	192819	181651	169270	157732	146981
Expected Number of total NEW smear negative cases in year (treated and not treated)	300508	299720	295864	289028	278207	264942	249597	232584	216731	201959
Total number of new cases in a year	519211	517849	511187	499377	480680	457761	431248	401854	374464	348940
Estimated Number of MDR TB cases in year (treated and not treated)	9346	9321	9201	8989	8652	8240	7762	7233	6740	6281
Expected number of new cases to be treated per 100,000 population	61	95	146	195	183	170	157	143	130	118
Expected number of new cases NOT to be treated per 100,000 population	250	208	146	84	79	73	67	61	56	51
Reduction (from 2012 rate) in incidence per100,000 in percentage	0%	-8%	-19%	-32%	-49%	-67%	-87%	-107%	-125%	-142%
Mortality and morbidity averted										

NUMBER OF CASES AVERTED FOR THE YEAR	0	0	5,303	15,758	33,103	54,674	79,843	107,895	133,948	158,137
CUMMULATIVE NUMBER OF CASES AVERTED FOR THE YEAR	0	0	5,303	21,061	54,164	108,837	188,680	296,575	430,523	588,661
NUMBER OF DEATHS AVERTED FOR THE YEAR	0	23,095	61,451	102,488	106,288	111,077	116,708	123,015	128,855	134,260
CUMMULATIVE NUMBER OF DEATHS AVERTED FOR THE YEAR	0	23,095	84,546	187,035	293,322	404,399	521,107	644,123	772,978	907,238

APPENDIX 16: PROJECTION OF TREATMENT COVERAGE AND TB CONTROL WITH AND WITHOUT INTERVENTION IN NIGERIA OVER A PERIOD OF 20 YEARS

Year	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
A-EXPECTED NUMBER OF TB CASES, WITHOUT INTERVENTION										
Expected Number of NEW smear Positive cases to be treated	48,997	48,869	48,740	48,613	48,485	48,358	48,231	48,104	47,978	47,852
Expected Number of NEW smear negative cases to be treated	49,762	49,631	49,501	49,371	49,241	49,112	48,983	48,855	48,727	48,599
Total Number of New cases expected to be treated (SS+ and SS-)	98,759	98,500	98,241	97,984	97,726	97,470	97,214	96,959	96,705	96,451
Total number of New cases expected NOT to be treated (SS+&SS-)	406,988	405,920	404,855	403,793	402,733	401,676	400,622	399,571	398,523	397,477
Expected Number of total NEW smear Positive cases in year (treated and not treated)	213,032	212,473	211,915	211,359	210,805	210,251	209,700	209,149	208,601	208,053

Expected Number of total NEW smear negative cases in year (treated and not treated)	292,715	291,947	291,181	290,417	289,655	288,895	288,137	287,381	286,627	285,875
Total number of new cases in a year	505,747	504,420	503,096	501,776	500,460	499,146	497,837	496,530	495,227	493,928
Estimated Number of MDR TB cases in year (treated and not treated)	9,103	9,080	9,056	9,032	9,008	8,985	8,961	8,938	8,914	8,891
Expected number of new cases to be treated per 100,000 population	47	45	44	43	42	41	40	39	38	37
Expected number of new cases NOT to be treated per 100,000 population	192	187	182	178	173	169	164	160	156	152
Reduction (from 2012 rate) in incidence per100,000 in percentage	-72%	-78%	-84%	-90%	-96%	-102%	-107%	-112%	-117%	-122%
B- EXPECRED NUMBER OF TB CASES, WITH INTERVENTION										

Expected Number of NEW smear Positive cases to be treated	95874	89339	83250	77576	72288	67361	62770	58491	54504	50789
Expected Number of NEW smear negative cases to be treated	131735	122756	114389	106592	99327	92557	86248	80370	74892	69787
Total Number of New cases expected to be treated (SS+ and SS-)	227609	212096	197639	184168	171615	159918	149018	138861	129396	120576
Total number of New cases expected NOT to be treated (SS+&SS-)	97547	90898	84703	78929	73549	68536	63865	59512	55455	51676
Expected Number of total NEW smear Positive cases in year (treated and not treated)	136963	127628	118929	110822	103269	96230	89671	83559	77864	72556
Expected Number of total NEW smear negative cases in year (treated and not treated)	188193	175366	163413	152275	141896	132224	123212	114814	106988	99696
Total number of new cases in a year	325156	302994	282342	263097	245165	228454	212883	198373	184852	172252
Estimated Number of MDR TB cases in year (treated and not treated)	5853	5454	5082	4736	4413	4112	3832	3571	3327	3101

Expected number of new cases to be treated per 100,000 population	108	98	89	81	74	67	61	56	51	46
Expected number of new cases NOT to be treated per 100,000 population	46	42	38	35	32	29	26	24	22	20
Reduction (from 2012 rate) in incidence per100,000 in percentage	-157%	-171%	-184%	-195%	-206%	-215%	-224%	-232%	-239%	-245%
Mortality and morbidity averted										
NUMBER OF CASES AVERTED FOR THE YEAR	180,591	201,426	220,755	238,679	255,295	270,692	284,954	298,158	310,376	321,676
CUMMULATIVE NUMBER OF CASES AVERTED FOR THE YEAR	769,251	970,677	1,191,432	1,430,111	1,685,406	1,956,098	2,241,052	2,539,210	2,849,585	3,171,261
NUMBER OF DEATHS AVERTED FOR THE YEAR	139,259	143,880	148,149	152,090	155,725	159,076	162,162	165,001	167,611	170,006
CUMMULATIVE NUMBER OF DEATHS AVERTED FOR THE YEAR	1,046,496	1,190,376	1,338,524	1,490,614	1,646,339	1,805,416	1,967,578	2,132,579	2,300,190	2,470,196

APPENDIX 17: SENSITIVITY ANALYSIS TABLE FOR VARIABLE 'PROPORTION OF ENTRANTS/MIGRANTS THAT ARE HIV POSITIVES (PPHIV)

ppHIV	STRATEGY	COST	EFF	CE	INCRCOST	INCREFF	INCRCE	DOMINATED
0	NOTHING	64.8226	17.25028	3.75777	0	0	0	
0	Investment in Nigeria TB control	251.40248	17.30412	14.52848	186.57988	0.05384	3465.45014	
0	Present practice (Chest x ray screening at the airport)	269.27632	17.26609	15.59567	17.87384	-0.03803	-469.98846	(Dominated)
0	IGRA	619.10504	17.31165	35.76234	367.70256	0.00753	48847.19485	
0.025	NOTHING	68.43252	17.25001	3.9671	0	0	0	
0.025	Investment in Nigeria TB control	253.62752	17.30395	14.6572	185.19501	0.05394	3433.13994	
0.025	Present practice (Chest x ray screening at the airport)	285.73664	17.26477	16.55028	32.10912	-0.03919	-819.32899	(Dominated)
0.025	IGRA	668.77915	17.30692	38.64229	415.15162	0.00297	139785.7409	
0.05	NOTHING	72.02958	17.24974	4.17569	0	0	0	
0.05	Investment in Nigeria TB control	255.84464	17.30379	14.78547	183.81506	0.05405	3401.06238	
0.05	Present practice (Chest x ray screening at the airport)	301.99305	17.26345	17.4932	46.1484	-0.04034	-1144.04	(Dominated)

0.05	IGRA	717.74166	17.30225	41.48257	461.89702	-0.00154	-299503.4286	(Dominated)
0.075	NOTHING	75.61385	17.24948	4.38355	0	0	0	
0.075	Investment in Nigeria TB control	258.05388	17.30362	14.91328	182.44002	0.05415	3369.21508	
0.075	Present practice (Chest x ray screening at the airport)	318.04825	17.26215	18.4246	59.99437	-0.04148	-1446.47681	(Dominated)
0.075	IGRA	766.00241	17.29762	44.2837	507.94854	-0.00601	-84527.86014	(Dominated)
0.1	NOTHING	79.18541	17.24921	4.59067	0	0	0	
0.1	Investment in Nigeria TB control	260.25527	17.30346	15.04065	181.06987	0.05425	3337.5957	
0.1	Present practice (Chest x ray screening at the airport)	333.90493	17.26086	19.34463	73.64966	-0.0426	-1728.70506	(Dominated)
0.1	IGRA	813.57112	17.29303	47.04619	553.31585	-0.01043	-53041.93886	(Dominated)

APPENDIX 18: SENSITIVITY ANALYSIS TABLE VARIABLE 'PROPORTION OF ENTRANTS/MIGRANTS THAT HAVE DRUG RESISTANT TB' (PDRA)

pDRA	**STRATEGY**	**COST**	**EFF**	**CE**	**INCRCOST**	**INCREFF**	**INCRCE**
0	NOTHING	70.36942	17.24979	4.07944	0	0	0
0	Present practice (Chest x ray screening at the airport)	227.90795	17.2637	13.20157	157.53852	0.01392	11320.64743
0	Investment in Nigeria TB control	254.8257	17.30382	14.72656	26.91775	0.04011	671.04742
0	IGRA	717.58383	17.30225	41.47344	462.75813	-0.00157	-295685.916
0.02	NOTHING	72.21404	17.24974	4.18638	0	0	0
0.02	Present practice (Chest x ray screening at the airport)	229.11991	17.26366	13.2718	156.90587	0.01393	11267.17984
0.02	Investment in Nigeria TB control	255.95786	17.30379	14.79201	26.83795	0.04012	668.90247
0.02	IGRA	717.7592	17.30225	41.48358	461.80134	-0.00154	-299934.5811
0.04	NOTHING	74.05866	17.24969	4.29333	0	0	0
0.04	Present practice (Chest x ray screening at the airport)	230.33187	17.26362	13.34203	156.27321	0.01394	11213.7883
0.04	Investment in Nigeria TB control	257.09001	17.30376	14.85747	26.75815	0.04013	666.75854
0.04	IGRA	717.93456	17.30224	41.49373	460.84455	-0.00151	-304325.5184
0.06	NOTHING	75.90326	17.24964	4.40028	0	0	0

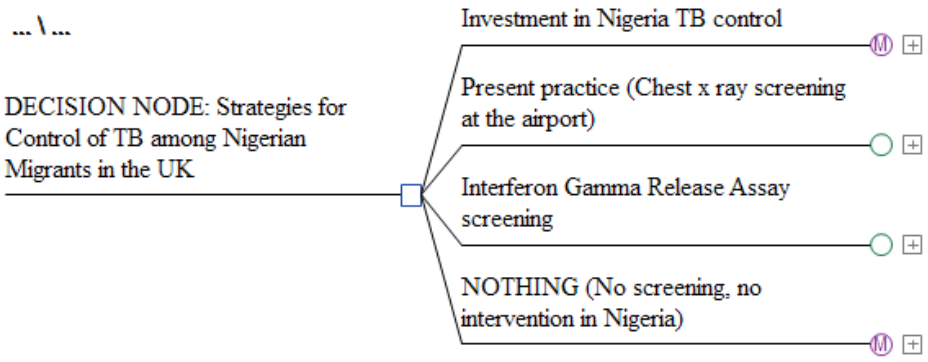
0.06	Present practice (Chest x ray screening at the airport)	231.54382	17.26358	13.41227	155.64056	0.01395	11160.47263
0.06	Investment in Nigeria TB control	258.22216	17.30373	14.92292	26.67834	0.04014	664.61563
0.06	IGRA	718.10992	17.30224	41.50388	459.88776	-0.00149	-308866.0086
0.08	NOTHING	77.74786	17.24959	4.50723	0	0	0
0.08	Present practice (Chest x ray screening at the airport)	232.75577	17.26354	13.4825	155.0079	0.01396	11107.23267
0.08	Investment in Nigeria TB control	259.35431	17.30369	14.98838	26.59854	0.04015	662.47375
0.08	IGRA	718.28528	17.30223	41.51403	458.93098	-0.00146	-313563.8231
0.1	NOTHING	79.59246	17.24954	4.61418	0	0	0
0.1	Present practice (Chest x ray screening at the airport)	233.96771	17.2635	13.55274	154.37525	0.01397	11054.06825
0.1	Investment in Nigeria TB control	260.48645	17.30366	15.05383	26.51874	0.04016	660.33288
0.1	IGRA	718.46065	17.30223	41.52417	457.9742	-0.00144	-318427.2851
0.12	NOTHING	81.43704	17.24949	4.72113	0	0	0
0.12	Present practice (Chest x ray screening at the airport)	235.17964	17.26346	13.62297	153.7426	0.01398	11000.97923
0.12	Investment in Nigeria TB control	261.61859	17.30363	15.11929	26.43894	0.04017	658.19303
0.12	IGRA	718.63601	17.30222	41.53432	457.01742	-0.00141	-323465.3116
0.14	NOTHING	83.28162	17.24944	4.82808	0	0	0
0.14	Present practice (Chest x ray screening at the airport)	236.39157	17.26343	13.6932	153.10996	0.01399	10947.96543

0.14	Investment in Nigeria TB control	262.75072	17.3036	15.18474	26.35915	0.04018	656.0542
0.14	IGRA	718.81137	17.30222	41.54447	456.06065	-0.00139	-328687.4709
0.16	NOTHING	85.12619	17.24939	4.93503	0	0	0
0.16	Present practice (Chest x ray screening at the airport)	237.6035	17.26339	13.76344	152.47731	0.014	10895.0267
0.16	Investment in Nigeria TB control	263.88285	17.30357	15.25019	26.27935	0.04019	653.91639
0.16	IGRA	718.98673	17.30221	41.55462	455.10388	-0.00136	-334104.0493
0.18	NOTHING	86.97075	17.24934	5.04198	0	0	0
0.18	Present practice (Chest x ray screening at the airport)	238.81542	17.26335	13.83367	151.84467	0.01401	10842.16288
0.18	Investment in Nigeria TB control	265.01497	17.30354	15.31565	26.19955	0.0402	651.7796
0.18	IGRA	719.16208	17.30221	41.56476	454.14711	-0.00134	-339726.1067

APPENDIX 19: DECISION TREE AND SENSITIVITY ANALYSES

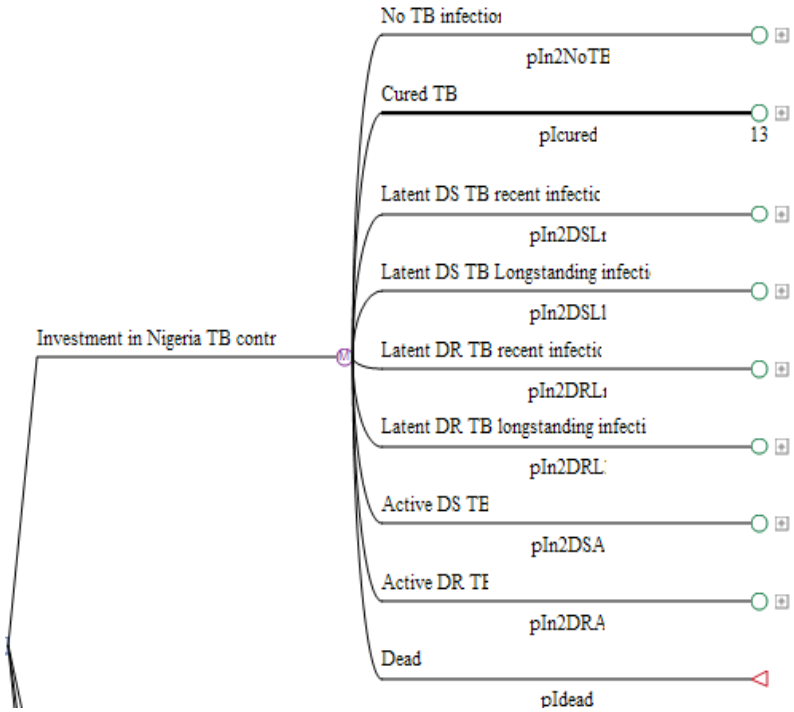
Model framework and decision tree

The approach employed is the use of ***Main decision branches***. A decision-analysis model incorporating multiple Markov processes using TreeAge™ Software. A decision node compares the four competing alternative strategies.



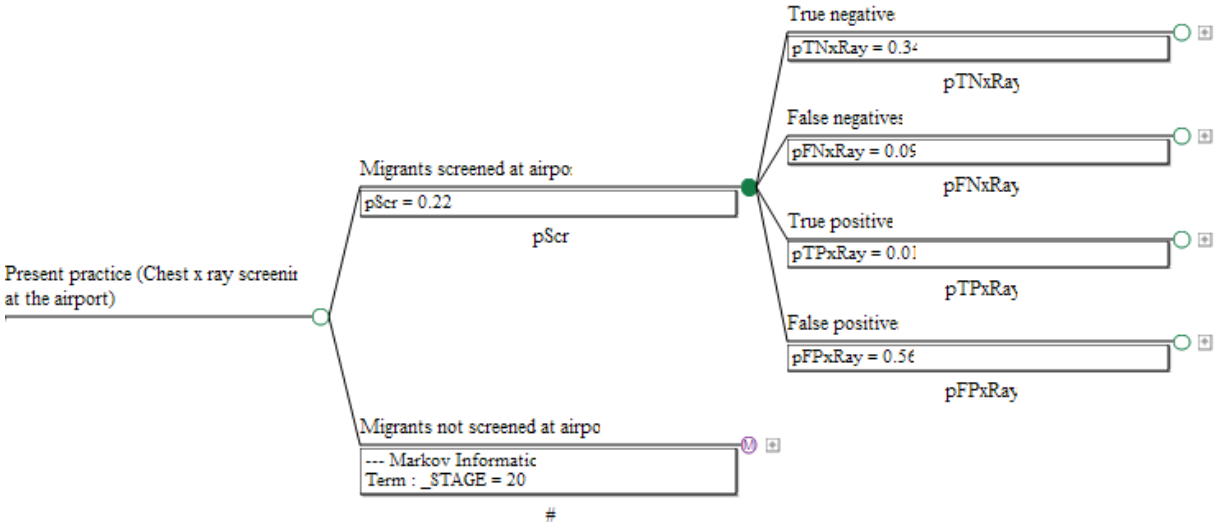
Description	**Code**	**Estimates**	**Range**	**Reference**
-Funding gap for scaling up TB control to 100% implementation (based on the WHO Stop TB strategy) in Nigeria over 20 years	cInvTBng	£323,198,394 NB: In this study only 25% of this total cost is assumed to be paid by the UK government)		Calculated
-Cost of chest x-ray screening at the airport	cXraySc	£28 (2008 £)		143
-Cost of IGRA (QuantiFERON) screening at the airport	cIGRAsc	£45 (2008 £)	22.5-90	143

A. *Investment in Nigeria TB control*



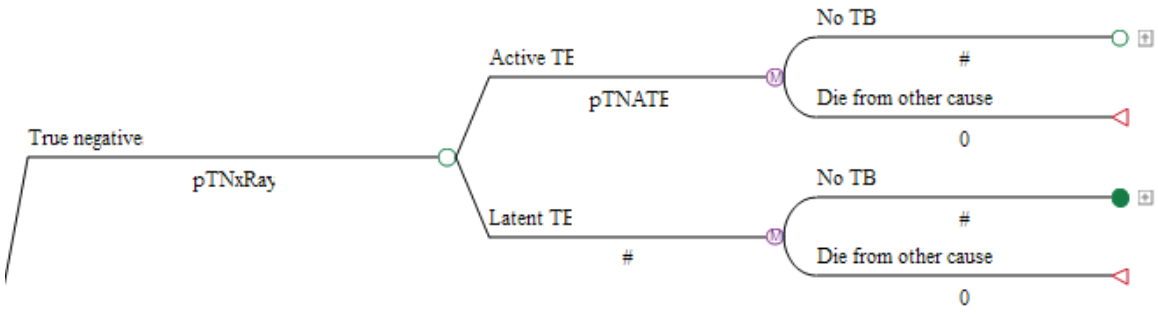
Description	Code	Estimates	Reference
Initial probability of drug sensitive latent TB (Recent)- Alternative 1	pIn2DSLr	0.008033389	Calculated
Initial probability of drug sensitive latent TB (Longstanding) - Alternative 1	pIn2DSLl	0.134301825	Calculated
Initial probability of drug resistant latent TB (Recent) - Alternative 1	pIn2DRLr	0.000147252	Calculated
Initial probability of drug resistant latent TB (Longstanding) - Alternative 1	pIn2DRLl	0.002461744	Calculated
Initial probability of drug sensitive active TB- Alternative 1	pIn2DSA	0.001716078	Calculated
Initial probability of drug resistant active TB- Alternative 1	pIn2DRA	0.000031455	Calculated
Initial probability of NO TB- Alternative 1	pIn2NoTB	0.853308257	Calculated
Initial probability of cured TB- Alternative 1	pIcured	0	Assumed
Initial probability of death from TB- Alternative 1	pIdeath	0	Assumed

B. *Present practice (CXR screening at the airport)*



CXR screening	pScr	0.2162	
a) True Positives	pTPxRay	0.0122690081	Calculated
b) False Positives	pFPxRay	0.5641932951	Calculated
c) True Negatives	pTNxRay	0.3341794321	Calculated
d) False Negatives	pFNxRay	0.0893582647	Calculated

i. True negative, CXR

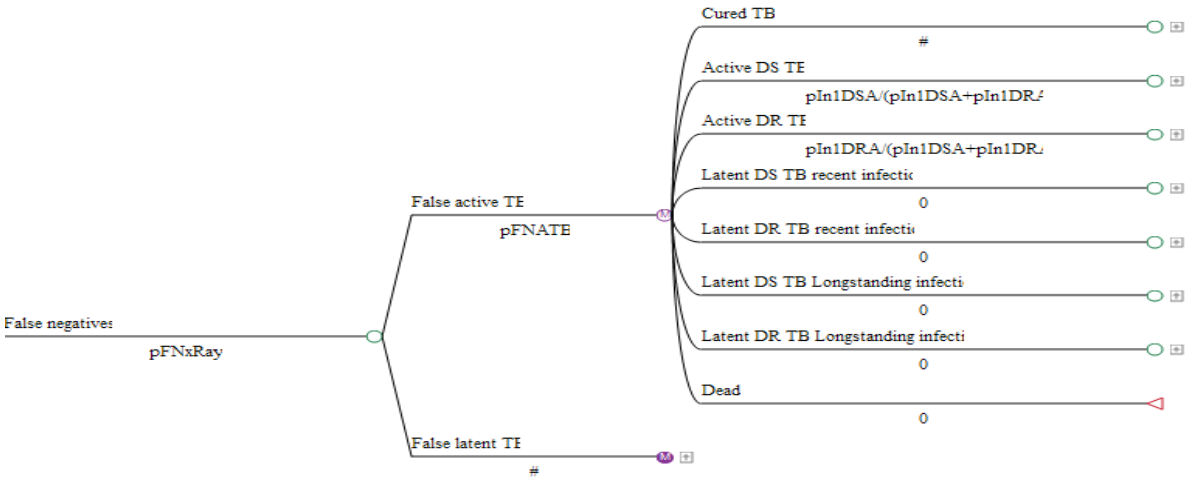


- For true negative chest x ray screenings, the probability of being active TB is 'pTNATB'

Chest X ray screening			
True Negative Active TB	pTNATB	1	Calculated
True Negative Latent TB	pTNLTB	0	Calculated

-
-

ii. False negative, chest x ray (Active TB)



Chest X ray screening			
False Negative Active TB	pFTATB	0	Calculated
False Negative Latent TB	pFNLTB	1	Calculated

- For false negative chest x ray screenings, the probability of being active TB is 'pFNATB'
- Among false negatives active TB, the probability of active drug sensitive TB = pIn1DSA/(pIn1DSA+pIn1DRA)

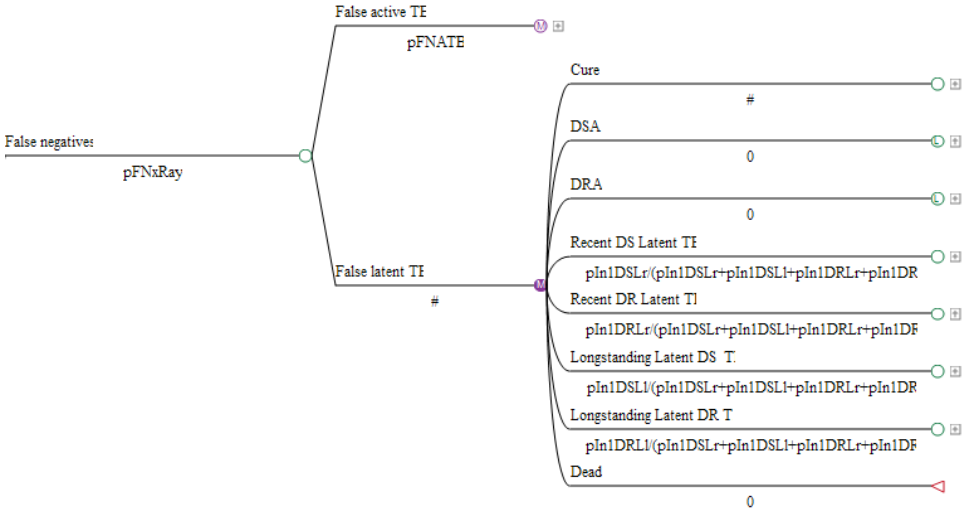
And

- probability of active drug resistant TB = pIn1DRA/(pInDSA+pIn1DRA)

Where

- 'pIn1DSA' is the initial annual probability of drug sensitive active TB and 'pInDRA' initial annual probability of drug resistant active TB in absence of any significant change in Nigeria TB control.
- The probability of false negative being a cured TB is also assumed to be zero.

iii. False negative, chest x ray (Latent TB)



- Among false negatives latent TB, the probability of recently acquired drug sensitive latent TB = pIn1DSLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

- probability of longstanding drug sensitive latent TB = pIn1DSLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)
- probability of recently acquired drug resistant latent TB = pIn1DRLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

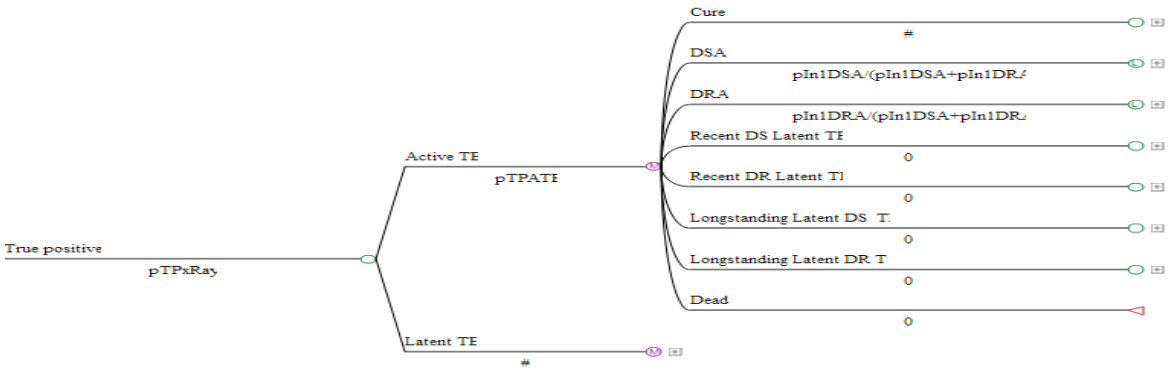
And

- probability of longstanding drug resistant latent TB = pIn1DRLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

Where

- 'pIn1DSA' is the initial annual probability of drug sensitive active TB and 'pInDRA' initial annual probability of drug resistant active TB in absence of any significance change in Nigeria TB control.
- The probability of false negative being a cured TB is also assumed to be zero.

iv. True positive, chest x ray (Active TB)



Chest X ray screening			
True Positive Active TB	pTPATB	0.0998229216	Calculated
True Positive Latent TB	pTPLTB	0.9001770784	Calculated

- For true positive chest x ray screenings, the probability of being active TB is 'pTPATB'
- Among true positive active TB, the probability of active drug sensitive TB = pIn1DSA/(pIn1DSA+pIn1DRA)

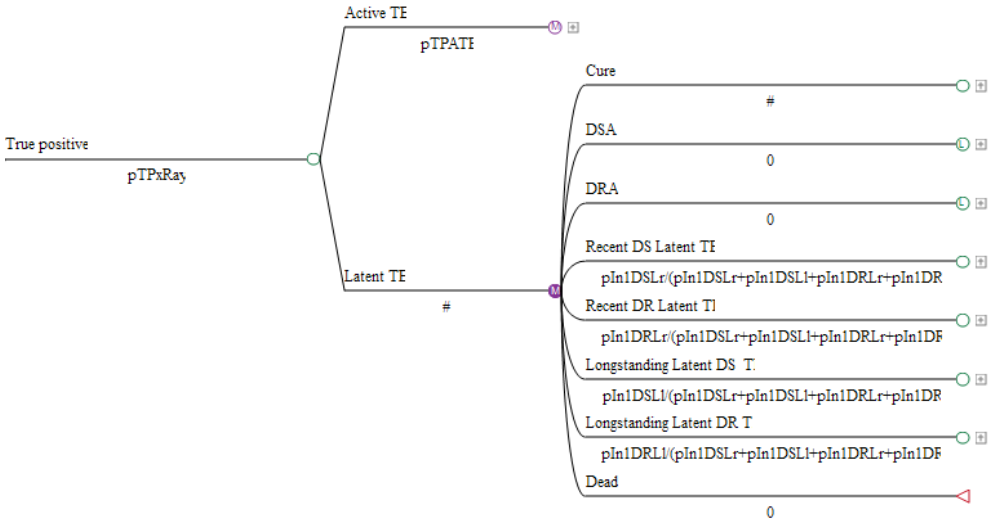
And

- The probability of active drug resistant TB = pIn1DRA/(pInDSA+pIn1DRA)

Where

- 'pIn1DSA' is the initial annual probability of drug sensitive active TB and 'pInDRA' initial annual probability of drug resistant active TB in absence of any significant change in Nigeria TB control.
- The probability of true positive being a cured TB is also assumed to be zero.

v. True positive, chest x ray (Latent TB)



- Among true positive latent TB, the probability of recently acquired drug sensitive latent TB = pIn1DSLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

- probability of longstanding drug sensitive latent TB = pIn1DSLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)
- probability of recently acquired drug resistant latent TB = pIn1DRLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

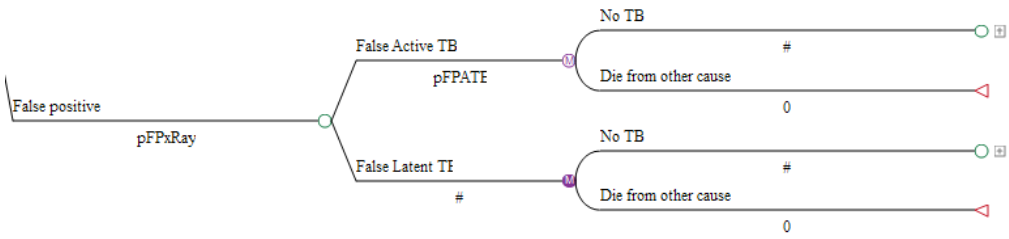
And

- The probability of longstanding drug resistant latent TB = pIn1DRLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

Where

- 'pIn1DSA' is the initial annual probability of drug sensitive active TB and 'pInDRA' initial annual probability of drug resistant active TB in absence of any significant change in Nigeria TB control.
- The probability of true positive being a cured TB is also assumed to be zero.

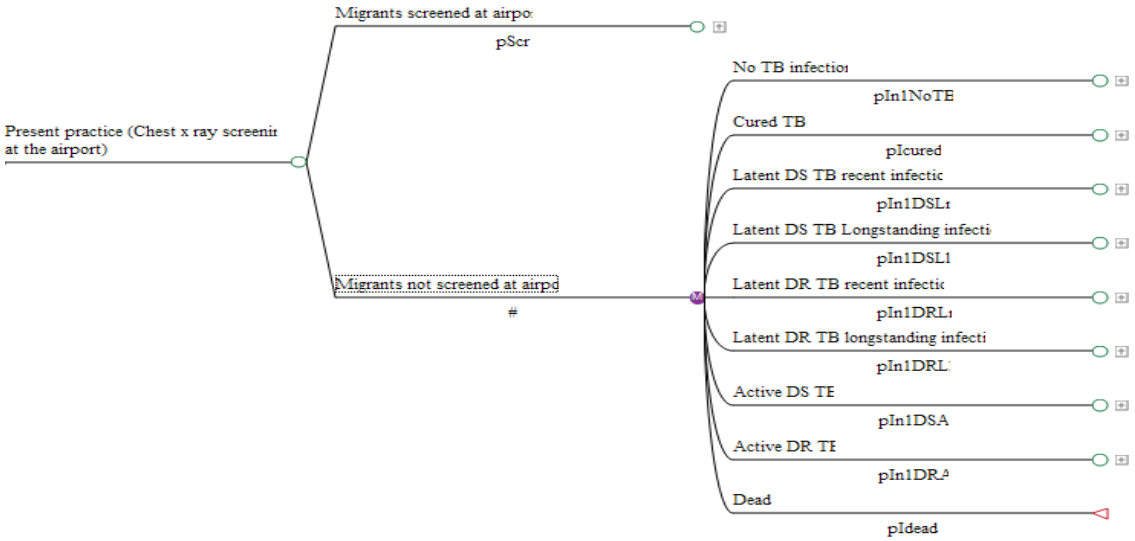
vi. False positive for chest x ray



Chest X ray screening			
False Positive Active TB	pFPATB	0.2917366107	Calculated
False Positive Latent TB	pFPLTB	0.7082633893	Calculated

- For false positives chest x ray screenings, the probability of being active TB is 'pFPATB'.
- It's assumed that the false positive latent TB is deliberately let to pass without any further investigation.

vii. Migrants' not screened at the airport



Description	Code	Estimates	Reference
Initial probability of drug sensitive latent TB (Recent)- Scenario 2 (Situation remains same in Nig.)	pIn1DSLr	0.011160324	Calculated
Initial probability of drug sensitive latent TB (Longstanding) - Scenario 2 (Situation remains same in Nig.)	pIn1DSLl	0.186830273	Calculated
Initial probability of drug resistant latent TB (Recent) - Scenario 2 (Situation remains same in Nig.)	pIn1DRLr	0.000204568	Calculated
Initial probability of drug resistant latent TB (Longstanding) - Scenario 2 (Situation remains same in Nig.)	pIn1DRLl	0.003409924	Calculated
Initial probability of drug sensitive active TB- Scenario 2 (Situation remains same in Nig.)	pIn1DSA	0.002405366	Calculated
Initial probability of drug resistant active TB- Scenario 2 (Situation remains same in Nig.)	pIn1DRA	0.000044090	Calculated

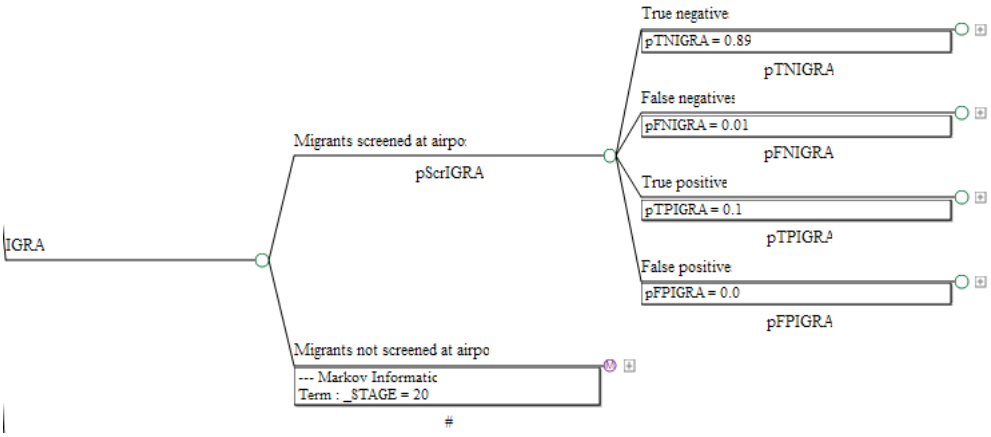
Initial probability of NO TB- Scenario 2 (Situation remains same in Nig.)	pIn1NoTB	0.796745454	Calculated
Initial probability of cured TB- Scenario 2 (Situation remains same in Nig.)	pIcured	0	Assumed
Initial probability of death from TB- Scenario 2 (Situation remains same in Nig.)	pIdeath	0	Assumed

For entrants that are not screened at the point of entry, and no scale up of TB control in Nigeria.

- 'pIn1NoTB' is the initial annual probability of Nigerian entrant being not infected with any form of TB.
- 'pIcured', the initial annual probability of Nigeria entrants being cured for previous TB infection.
- 'pIn1DSLr', the initial annual probability of Nigerian entrant having drug sensitive latent TB infected less than 2 years (recent infection) before entering the UK.
- 'pIn1DSLl', the initial annual probability of Nigerian entrant having drug sensitive latent TB infected more than 2 years (longstanding infection) before entering the UK.
- 'pIn1DRLr', the initial annual probability of Nigerian entrant having drug resistant latent TB 'recently' infected before entering the UK.
- 'pIn1DRLl', the initial annual probability of Nigerian entrant having 'longstanding' drug resistant latent TB before entering the UK.
- 'pIn1DSA', the initial annual probability of Nigerian entrant having drug sensitive active TB on entering the UK.
- 'pIn1DRA', the initial annual probability of Nigerian entrant having drug resistant active TB on entering the UK.

- ‘pIdead’ is the probability of been dead on arrival to the UK.

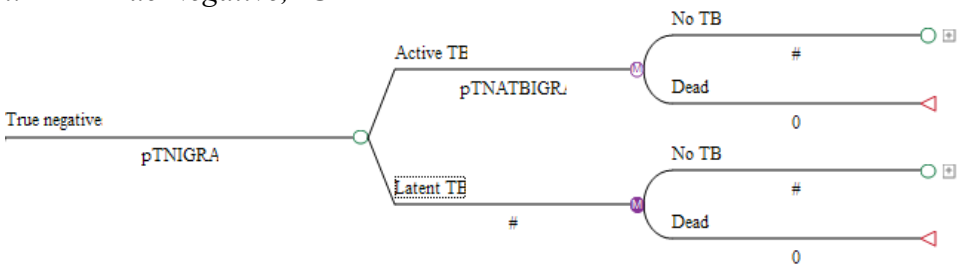
C. Interferon Gamma Release Assay screening



IGRA screening	pScrIGRA	0.90	
a) True Positives	pTPIGRA	0.0963866946	Calculated
b) False Positives	pFPIGRA	0.0089837274	Calculated
c) True Negatives	pTNIGRA	0.8893889997	Calculated
d) False Negatives	pFNIGRA	0.0052405783	Calculated

- ‘pScrIGRA’ is the probability of entrant been interferon gamma release assay (IGRA) screened at point of entry.
- ‘pTNIGRA’ the probability of IGRA true negative result for either active or latent infections.
- ‘pTPIGRA’ the probability of IGRA screening result true positive for either active or latent infections.
- ‘pFPIGRA’ the probability of IGRA screening result false positive for either active or latent infections.

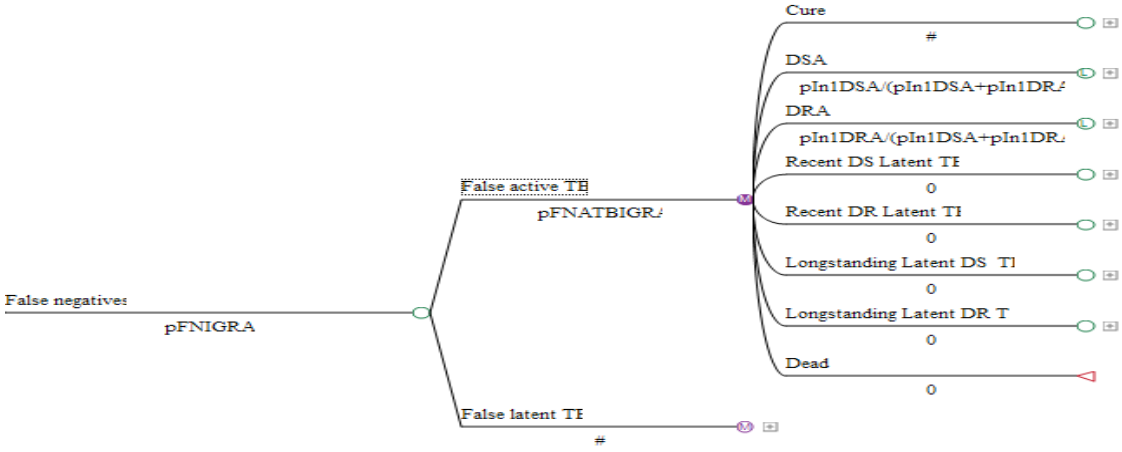
i. True Negative, IGRA



IGRA Screening			
True Negative Active TB	pTNATBIGRA	0.5551985904	Calculated
True Negative Latent TB	pTNLTBIGRA	0.4448014096	Calculated

- For true negative IGRA screenings, the probability of being active TB is 'pTNATBIGRA'

ii. False Negative, IGRA (Active TB)



IGRA Screening			
False Negative Active TB	pFNATBIGRA	0.0420661700	Calculated
False Negative Latent TB	pFNLTBIGRA	0.9579338300	Calculated

- For false negative IGRA screenings, the probability of being active TB is 'pFNATBIGRA'
- Among false negatives active TB, the probability of active drug sensitive TB = pIn1DSA/(pIn1DSA+pIn1DRA)

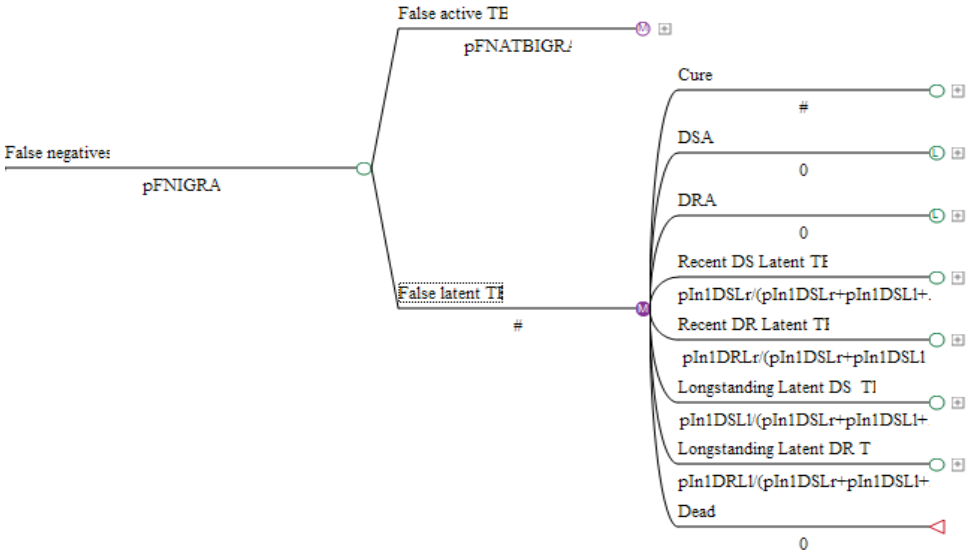
And

- The probability of active drug resistant TB = pIn1DRA/(pInDSA+pIn1DRA)

Where

- 'pIn1DSA' is the initial annual probability of drug sensitive active TB and 'pInDRA' initial annual probability of drug resistant active TB in absence of any significance change in Nigeria TB control.
- The probability of false negative being a cured TB is also assumed to be zero.

iii. False negative (Latent TB)



- Among false negatives latent TB, the probability of recently acquired drug sensitive

latent TB = pIn1DSLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

- The probability of longstanding drug sensitive latent TB = pIn1DSLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)
- The probability of recently acquired drug resistant latent TB = pIn1DRLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

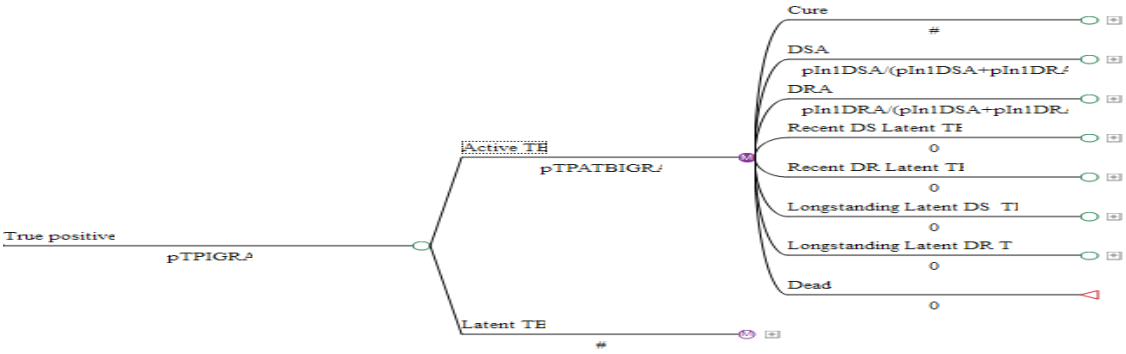
And

- The probability of longstanding drug resistant latent TB = pIn1DRLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

Where

- 'pIn1DSA' is the initial annual probability of drug sensitive active TB and 'pInDRA' initial annual probability of drug resistant active TB in absence of any significant change in Nigeria TB control.
- The probability of false negative being a cured TB is also assumed to be zero.

iv. True positive, IGRA (Active TB)



IGRA Screening			
True Positive Active TB	pTPATBIGRA	0.0104192512	Calculated
True Positive Latent TB	pTPLTBIGRA	0.9895807488	Calculated

- For true positive IGRA screenings, the probability of being active TB is ‘pTPATBIGRA’
- Among true positive active TB, the probability of active drug sensitive TB = pIn1DSA/(pIn1DSA+pIn1DRA)

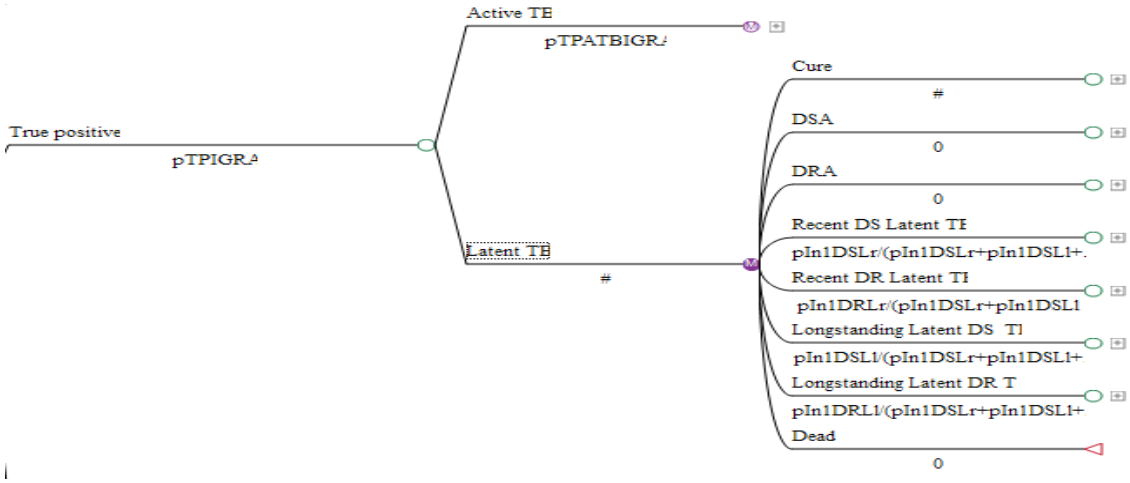
And

- The probability of active drug resistant TB = pIn1DRA/(pInDSA+pIn1DRA)

Where

- ‘pIn1DSA’ is the initial annual probability of drug sensitive active TB and ‘pInDRA’ initial annual probability of drug resistant active TB in absence of any significance change in Nigeria TB control.
- The probability of true positive being a cured TB is also assumed to be zero.

v. True Positive, IGRA (Latent TB)



- Among true positive latent TB, the probability of recently acquired drug sensitive latent TB = pIn1DSLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)
- probability of longstanding drug sensitive latent TB =

pIn1DSLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

- probability of recently acquired drug resistant latent TB = pIn1DRLr/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

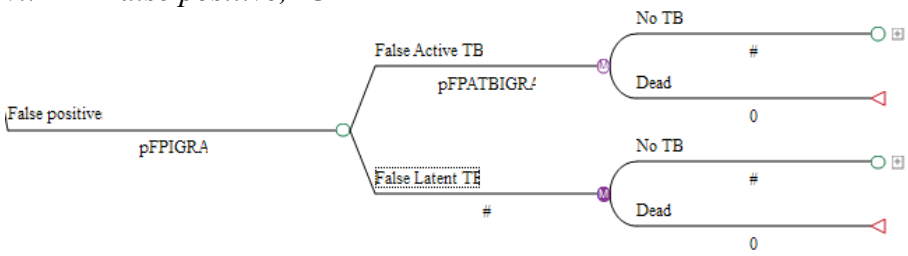
And

- The probability of longstanding drug resistant latent TB = pIn1DRLl/(pIn1DSLr+pIn1DSLl+pIn1DRLr+pIn1DRLl)

Where

- 'pIn1DSA' is the initial annual probability of drug sensitive active TB and 'pInDRA' initial annual probability of drug resistant active TB in absence of any significant change in Nigeria TB control.
- The probability of true positive being a cured TB is also assumed to be zero.

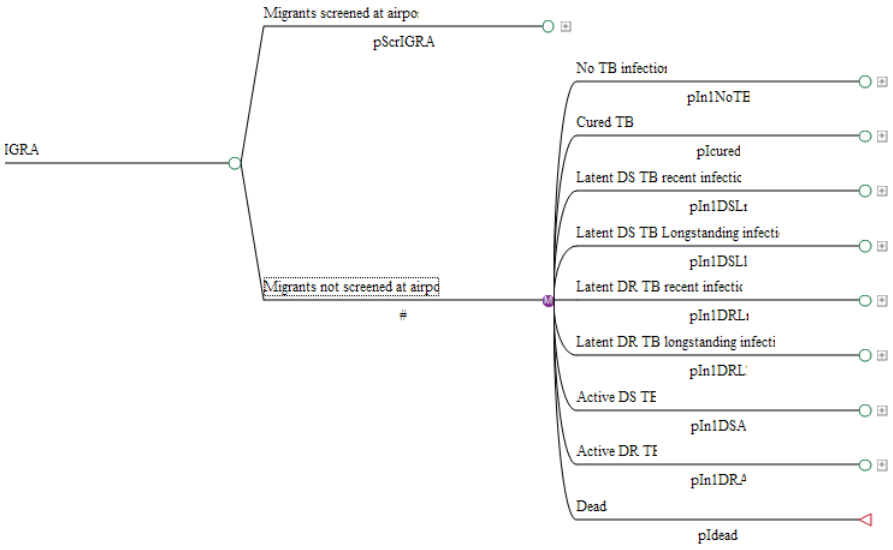
vi. False positive, IGRA



IGRA Screening			
False Positive Active TB	pFPATBIGRA	0.5551985966	Calculated
False Positive Latent TB	pFPATBIGRA	0.4448014034	Calculated

- For false positives IGRA screenings, the probability of being active TB is 'pFPATBIGRA'.

vii. Migrants not screened at airports for IGRA



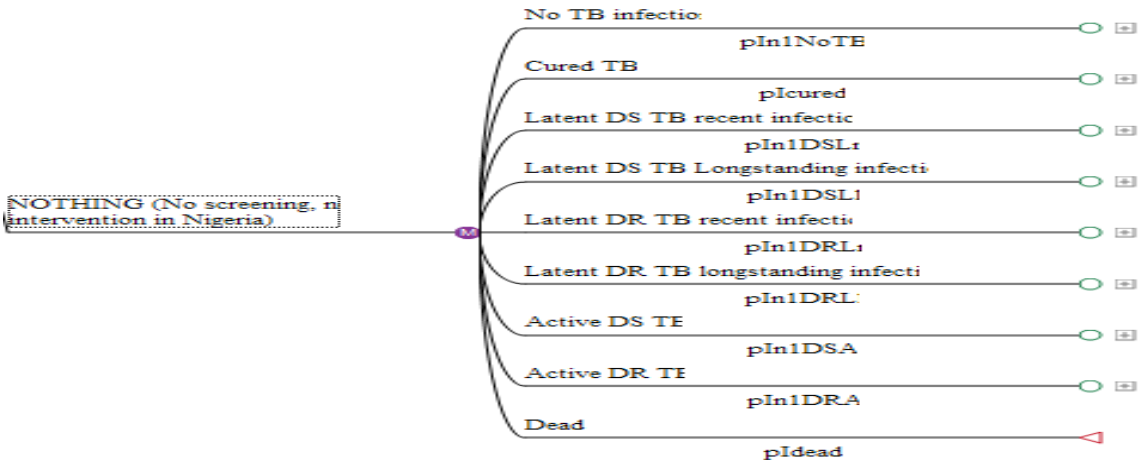
For entrants that are not screened at the point of entry, and no scale up of TB control in Nigeria.

- 'pIn1NoTB' is the initial annual probability of Nigerian entrant being not infected with any form of TB.
- 'pIcured', the initial annual probability of Nigeria entrant being cured for previous TB infection.
- 'pIn1DSLr', the initial annual probability of Nigerian entrant having drug sensitive latent TB infected less than 2 years (recent infection) before entering the UK.
- 'pIn1DSLl', the initial annual probability of Nigerian entrant having drug sensitive latent TB infected more than 2 years (longstanding infection) before entering the UK.
- 'pIn1DRLr', the initial annual probability of Nigerian entrant having drug resistant latent TB 'recently' infected before entering the UK.

- ‘pIn1DRLl’, the initial annual probability of Nigerian entrant having ‘longstanding’ drug resistant latent TB before entering the UK.
- ‘pIn1DSA’, the initial annual probability of Nigerian entrant having drug sensitive active TB on entering the UK.
- ‘pIn1DRA’, the initial annual probability of Nigerian entrant having drug resistant active TB on entering the UK.
- ‘pIdead’ is the probability of been dead on arrival to the UK.

Description	**Code**	**Estimates**	**Reference**
Initial probability of drug sensitive latent TB (Recent)- Scenario 2 (Situation remains same in Nig.)	pIn1DSLr	0.011160324	Calculated
Initial probability of drug sensitive latent TB (Longstanding) - Scenario 2 (Situation remains same in Nig.)	pIn1DSLl	0.186830273	Calculated
Initial probability of drug resistant latent TB (Recent) - Scenario 2 (Situation remains same in Nig.)	pIn1DRLr	0.000204568	Calculated
Initial probability of drug resistant latent TB (Longstanding) - Scenario 2 (Situation remains same in Nig.)	pIn1DRLl	0.003409924	Calculated
Initial probability of drug sensitive active TB- Scenario 2 (Situation remains same in Nig.)	pIn1DSA	0.002405366	Calculated
Initial probability of drug resistant active TB- Scenario 2 (Situation remains same in Nig.)	pIn1DRA	0.000044090	Calculated
Initial probability of NO TB- Scenario 2 (Situation remains same in Nig.)	pIn1NoTB	0.796745454	Calculated
Initial probability of cured TB- Scenario 2 (Situation remains same in Nig.)	pIcured	0	Assumed
Initial probability of death from TB- Scenario 2 (Situation remains same in Nig.)	pIdeath	0	Assumed

D. Nothing (No screening, no intervention in Nigeria)



Description	Code	Estimates	Reference
Initial probability of drug sensitive latent TB (Recent)- Scenario 2 (Situation remains same in Nig.)	pIn1DSLr	0.011160324	Calculated
Initial probability of drug sensitive latent TB (Longstanding) - Scenario 2 (Situation remains same in Nig.)	pIn1DSLl	0.186830273	Calculated
Initial probability of drug resistant latent TB (Recent) - Scenario 2 (Situation remains same in Nig.)	pIn1DRLr	0.000204568	Calculated
Initial probability of drug resistant latent TB (Longstanding) - Scenario 2 (Situation remains same in Nig.)	pIn1DRLl	0.003409924	Calculated
Initial probability of drug sensitive active TB- Scenario 2 (Situation remains same in Nig.)	pIn1DSA	0.002405366	Calculated
Initial probability of drug resistant active TB- Scenario 2 (Situation remains same in Nig.)	pIn1DRA	0.000044090	Calculated
Initial probability of NO TB- Scenario 2 (Situation remains same in Nig.)	pIn1NoTB	0.796745454	Calculated
Initial probability of cured TB- Scenario 2 (Situation remains same in Nig.)	pIcured	0	Assumed
Initial probability of death from TB- Scenario 2 (Situation remains same in Nig.)	pIdeath	0	Assumed

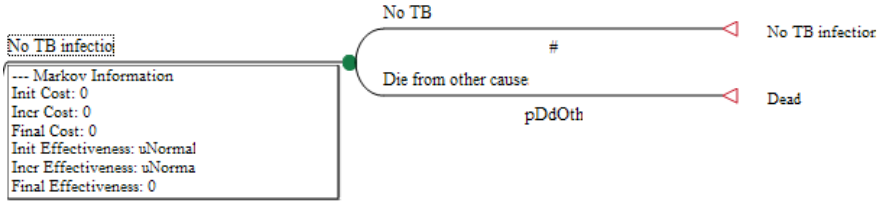
When no significant change in TB control in Nigeria is achieved and no any form of screening

at the point of entry into the UK.

- ‘pIn1NoTB’ is the initial annual probability of Nigerian entrant being not infected with any form of TB.
- ‘pIcured’, the initial annual probability of Nigeria entrant being cured for previous TB infection.
- ‘pIn1DSLr’, the initial annual probability of Nigerian entrant having drug sensitive latent TB infected less than 2 years (recent infection) before entering the UK.
- ‘pIn1DSLl’, the initial annual probability of Nigerian entrant having drug sensitive latent TB infected more than 2 years (longstanding infection) before entering the UK.
- ‘pIn1DRLr’, the initial annual probability of Nigerian entrant having drug resistant latent TB ‘recently’ infected before entering the UK.
- ‘pIn1DRLl’, the initial annual probability of Nigerian entrant having ‘longstanding’ drug resistant latent TB before entering the UK.
- ‘pIn1DSA’, the initial annual probability of Nigerian entrant having drug sensitive active TB on entering the UK.
- ‘pIn1DRA’, the initial annual probability of Nigerian entrant having drug resistant active TB on entering the UK.
- ‘pIdead’ is the probability of been dead on arrival to the UK.

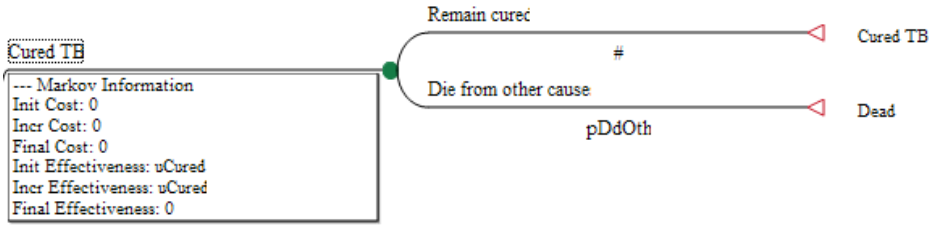
Health states and transitions

'No TB infection' or 'No TB'



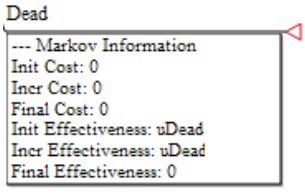
This is a health state in which there is absence of TB infection. Both initial and incremental costs in this state are zero and the utility is 'uNormal' which was assumed to be 1.0 QALY. Migrants in this state either die from other causes at the end of a year cycle or return back to the next cycle as 'No TB infection'.

'Cured TB'



This is a state of having previously experienced TB infection but fully cured. Both initial and incremental costs in this state are zero and utility is 0.95 QALY (144), 'uCured'. Migrants in this state either die from other causes, probability of death from other causes, 'pDdOther', assumed to be 0.015/cycle (40), or return back to the next cycle as 'Cured TB'.

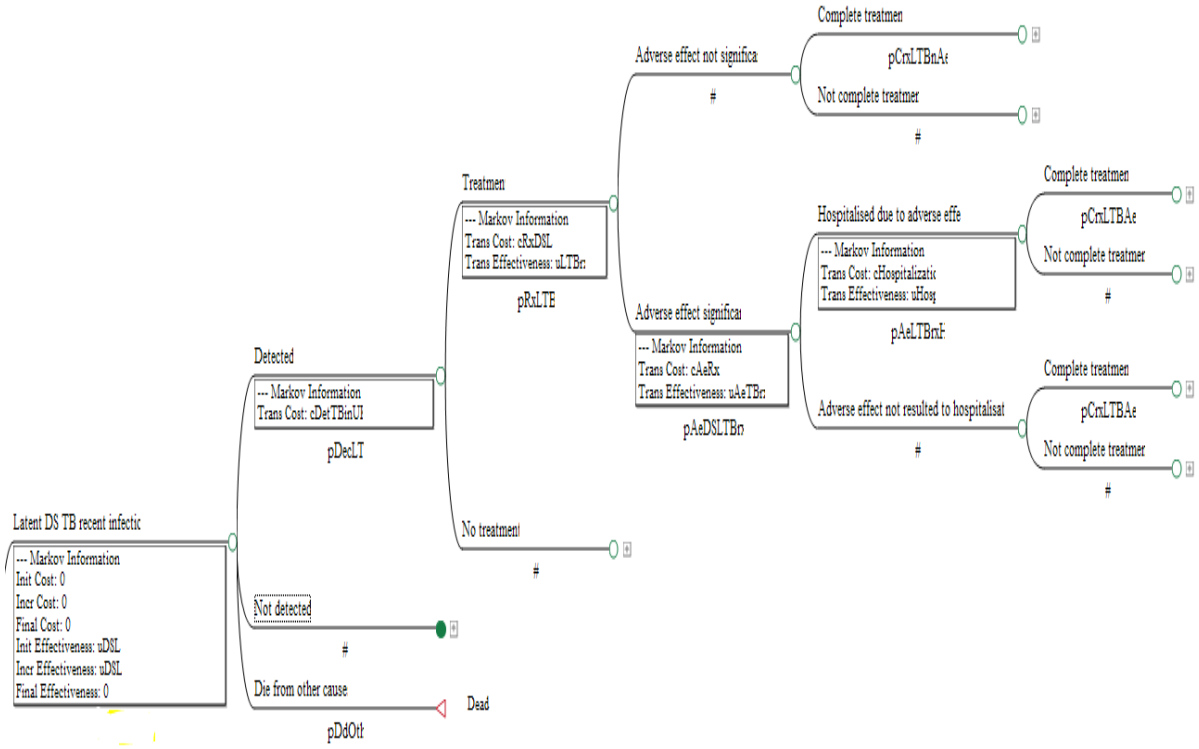
'Dead'



This is a state of having died from TB infection or any other cause of death. Both initial and

incremental costs as well as utility, 'uDead' are zero. This is an absorbing state, once in the state remain in that state throughout remaining cycles.

'Latent DS TB recent infection'

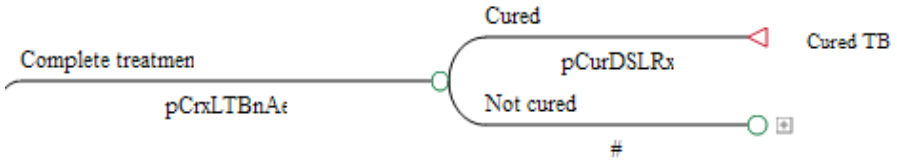


- This is a state of recent acquisition (less than 2 years) of latent drug sensitive TB infection.
- The initial cost per entrant if investment (by bridging funding gap to scale up TB services) in Nigeria was estimated as the total fund to be provided (assumed to be 25% of the total funding gap) divided by the expected number of migrants coming into the UK from Nigeria over the 20 years period, i.e. 'cNigTBgap/TotNigMig', which equals '(£326,167,296.39/1,821,040) = £179.11'
- For the chest x ray and IGRA screening alternatives, cost of screening at the point of

entry, ‘cXraySc’ and ‘cIGRAsc’ were estimated as £25 and £45 respectively (143).

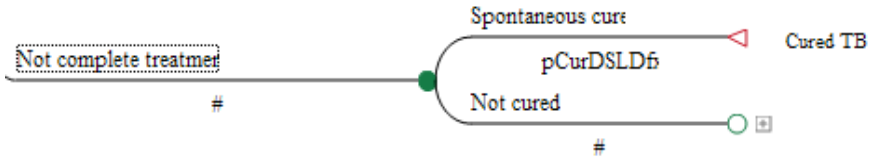
- Both initial and incremental utility, ‘uDSL’, in all strategies is 0.97 QALY (144).
- Migrants with latent TB are either detected not detected or die from other causes at the end of a year cycle. The annual probability of detection, ‘pDecLT’, in unscreened migrants and there contacts is assumed to be 0.10 and the probability of detection in entrants that were screened on arrival depends on the sensitivity and specificity of the screening test. The cost of detection while in the UK, ‘cDecTBinUK’, is assumed to be GB £286 (143).
- The probability of treatment for latent TB when detected in UK, ‘pRxLTB’, is 0.95 (144, 145). The costs for drug sensitive and resistant latent TB treatment in the UK, ‘cRxDSL’ and ‘cRxDRL’ are GB £130 (143) and GB £780 (146) respectively while the utility for the treatment of both drug sensitive and resistant latent TB, ‘uLTBrx’ was assumed to be 0.95 QALY (144).
- The probability of adverse effect following treatment for drug sensitive and resistant latent TB, ‘pAeDSLTBrx’ and ‘pAeDRLTBrx’, are 0.02 (143) and 0.04 (Assumed) respectively. The cost and utility for treating the adverse effect, ‘cAeRx’ and ‘uAeTBrx’ are GB £362 + £1000, ‘cHospitalization’, when hospitalized (3,4) and 0.75 QALY or 0.50 QALY, ‘uHosp’, when hospitalized (143). The probability of hospitalization due to adverse effect, ‘pAeLTBrxH’, is assumed to be 0.15 (147-149).

i) **'Complete treatment'**



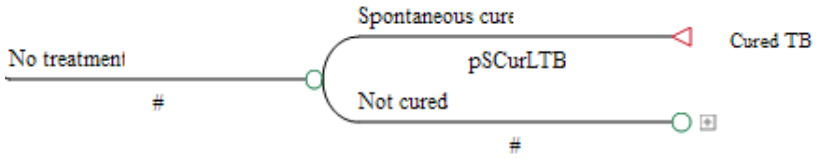
- The probability of treatment completion following latent TB treatment is either 'pCrxLTBnAe' estimated as 0.94 (150-153) when there is no serious treatment adverse effect or 'pCrxLTBAe' estimated as 0.80 (147,148,153) when there is adverse effect.
- The probabilities of cure following completion of treatment for drug sensitive latent TB, 'pCurDSLRx', was estimated at 0.65 (154, 155) and assumed to be 0.325, 'pCurDRLRx' when is drug resistant.

ii) **'Not complete treatment' or 'default treatment'**



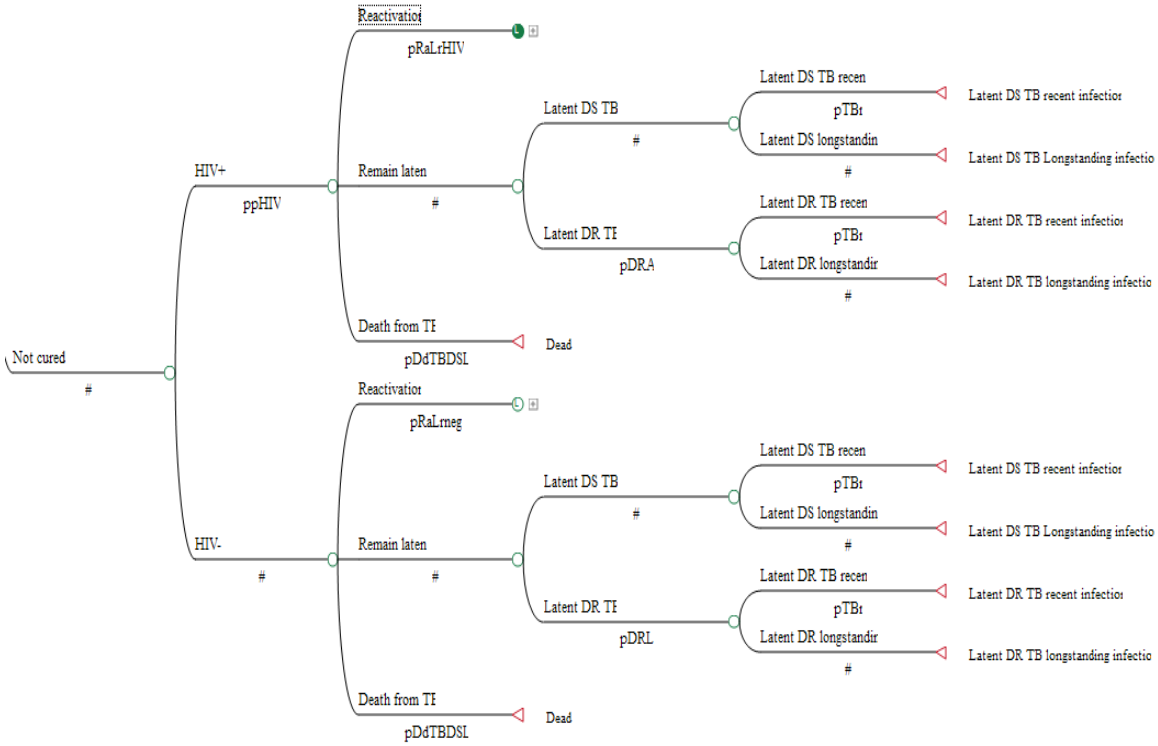
- The probabilities of cure following treatment default for drug sensitive latent TB, 'pCurDSLDfx', was estimated at 0.21 (154) and assumed to be 0.105, coded 'pCurDRLDfx' when is drug resistant.

iii) **'No treatment' or 'No detected'**



- The probability of spontaneous cure for latent TB when not detected or detected but not treatment was given for drug sensitive latent TB, 'pSCurLTB', is assumed to be 0.20.

iv) **'Not cured'**

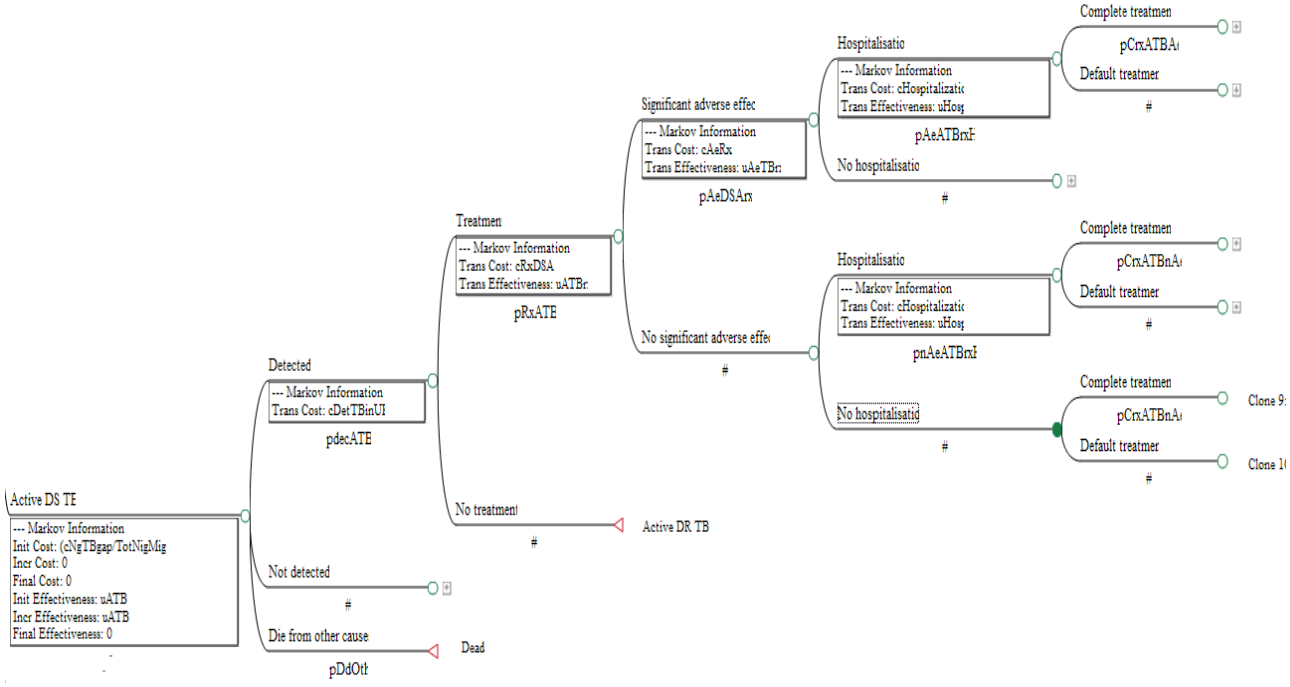


- What follows uncured latent TB is significantly influenced by the patient HIV status. The probability of Nigerian migrant being HIV positive, 'ppHIV', was estimated at 0.05 based on the HIV prevalence rate in Nigeria. The probability of reactivation of 'uncured' HIV positives recently acquired latent TB, 'pRalrHIV' was estimated as 0.33 per year (40) which is higher than when the subjects are HIV negative, 'pRalrneg',

0.05 per year (40).

- The probability of reactivation of 'uncured' HIV positives that have longstanding latent TB infection, 'pRallHIV' was estimated as 0.034 per year (40, 156-158) which is higher than when the subjects are HIV negative, 'pRallneg', 0.001 per year (23, 40, 134).
- Probability of death from latent TB, 'pDdTBDSL' or 'pDdTBDRL' are assumed to be zero and the probability of becoming drug resistant following completed treatment for drug sensitive TB, 'pDRLfromDSL', is assumed to be 0.09 (52) and probability of drug resistant latent TB remaining resistant if uncured is assumed to be 0.99. The probability of subject becoming drug resistant latent TB following treatment default for drug sensitive latent TB, 'pDRLfromDSLDfx', is assumed to be as high as 0.40.
- The probability of latent TB being drug resistant, 'pDRL', was assumed to be 0.018 based on the reported prevalence of drug resistance in Nigerian population (52) and the probability of a latent TB being recently acquired, 'pTBr', is estimated to be 0.046.

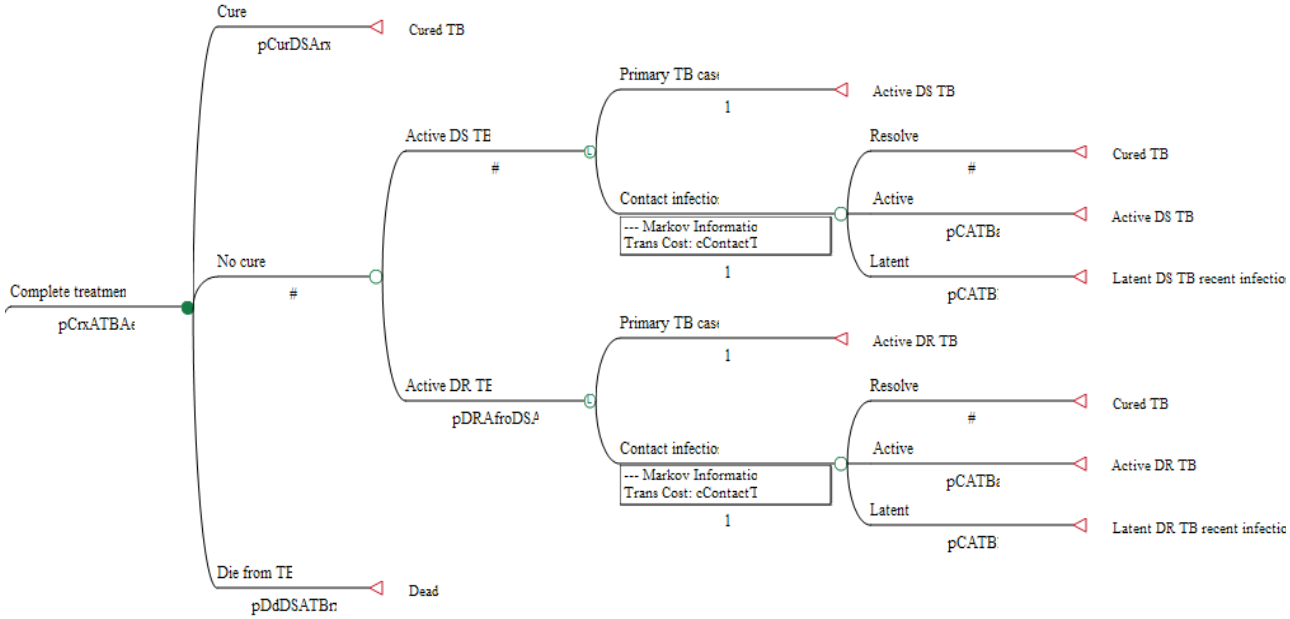
Active TB



- The presumed cost per entrant when UK invests (in bridging funding gap to scale up TB services) in Nigeria was estimated as the total fund to be provided by UK (which is 25% of the total funding gap) divided by the expected number of migrants coming into the UK from Nigeria over the 20 years period, i.e. 'cNigTBgap/TotNigMig', which equals '(£326,167,296.39/1,821,040) = £179.11'.
- Both initial and incremental utilities for active TB, 'uATB', are 0.68 (146).
- For the chest x ray and IGRA screening alternatives, cost of screening at the point of entry, 'cXraySc' and 'cIGRAsc' were estimated at £25 and £45 respectively (143).
- The annual probability of detection of active TB depends on the sensitivity and specificity of the screening test, however, when not screened the probability of detection of active TB is assumed to be 0.95.

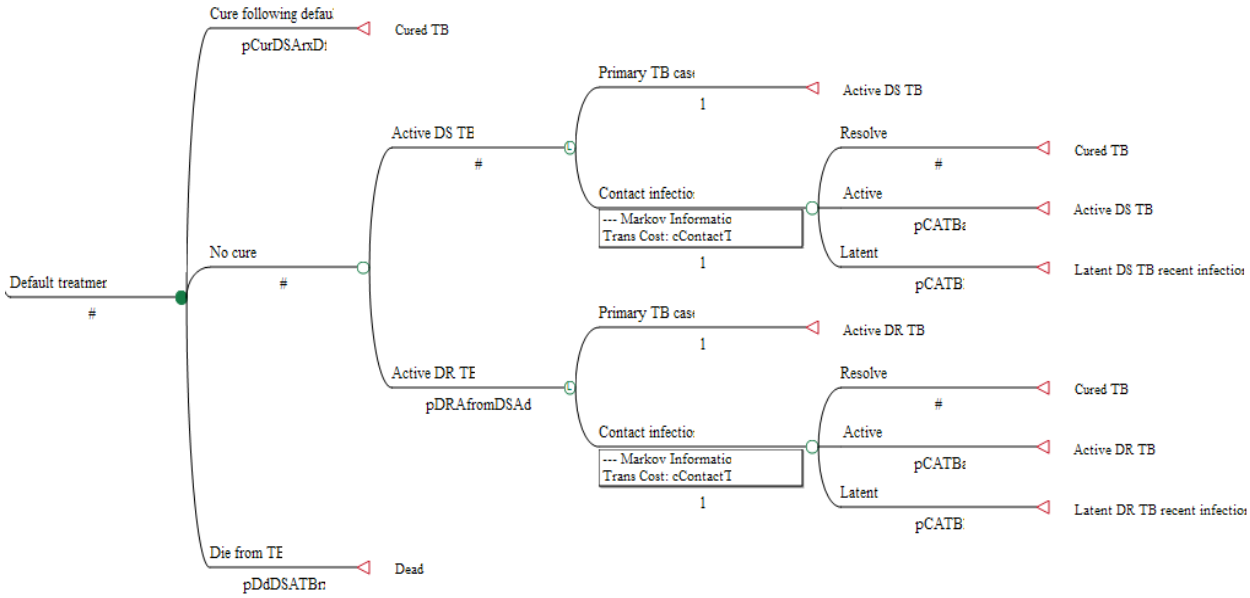
- The cost of detection while in the UK, ‘cDecTBinUK’, is assumed to be GB £286 (143).
- The probability of treatment for active TB when detected in UK, ‘pRxATB’, is assumed to be 1.0.
- The costs treatment for drug sensitive and resistant active TB in the UK, ‘cRxDSA’ and ‘cRxDRA’ are GB £5522 and GB £31,329 (157) respectively while the utility for the treatment of both drug sensitive and resistant active TB, ‘uATBrx’ was assumed to be 0.79 QALY (146, 153).
- The probability of adverse effect following treatment for drug sensitive and resistant active TB, ‘pAeDSATBrx’ and ‘pAeDRATBrx’, are 0.02 (143, 158) and 0.04 (Assumed) respectively.
- The cost for treating the adverse effect, ‘cAeRx’ GB £362 + £1000, ‘cHospitalization’, when hospitalized (143)
- Utility for treating the adverse effect and ‘uAeTBrx’ are and 0.75 QALY or 0.50 QALY, ‘uHosp’, when hospitalized (144).
- The probability of hospitalization due to adverse effect, ‘pAeATBrxH’, is 0.9 (40, 159).

(i) **'Complete treatment'**



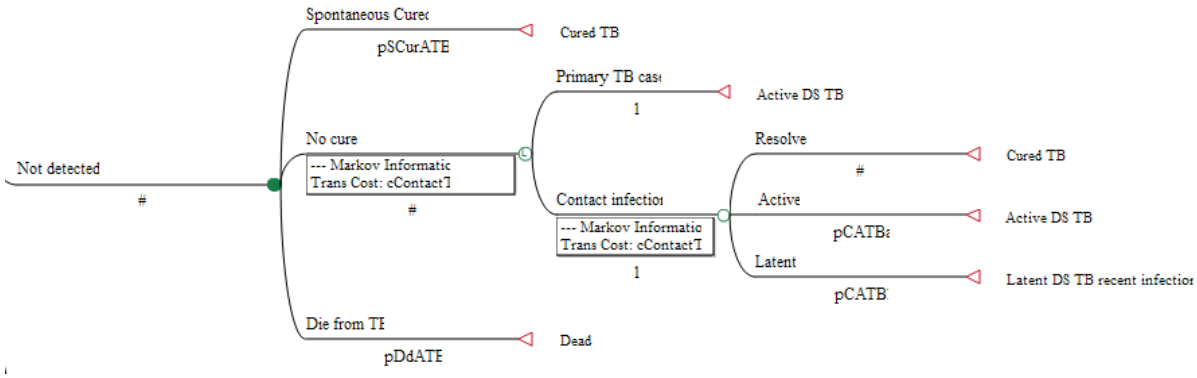
- The probabilities of completion of active TB treatment with and without adverse effect, 'pCrxATBAe' and 'pCrxATBAe', were assumed to be 0.95 and 0.85 respectively.
- The probabilities of cure following completion of treatment for drug sensitive active TB, 'pCurDSARx', was estimated at 0.80 (160) and for drug resistant active TB, 'pCurDRARx', is 0.48 (161, 162).

(ii) **'Not complete treatment' or 'Default treatment'**



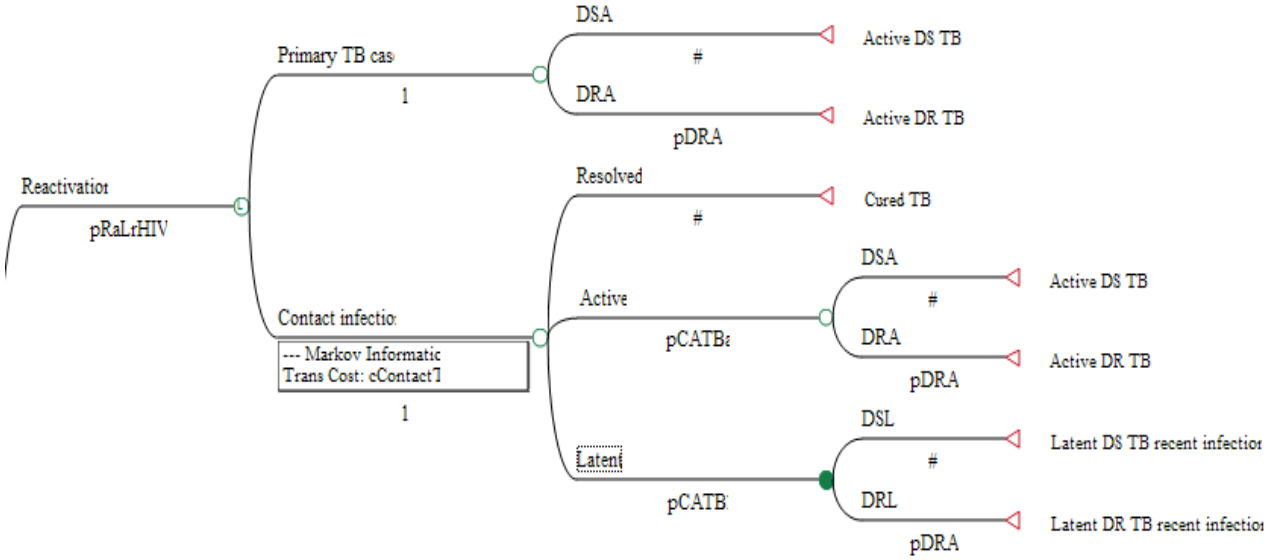
- The probabilities of cure following default treatment for drug sensitive active TB, 'pCurDSADfx', was estimated at 0.62 (161-166) and for drug resistant active TB, 'pCurDRADfx', is assumed to be 0.24.
- Probability of becoming drug resistant following default treatment for drug sensitive active TB, 'pDRAfromDSAdf', is assumed to be 0.40.

(iii)**'No detected'**



- The probability of spontaneous cure for active TB, 'pSCurATB', is 0.20 (157) and probability of death from active TB without treatment, 'pDdATB', 0.23 (157).

Contact infection



- A 'logical node' is used to allow contacts infections also be captured in the model.
- For every single primary active TB case, some contacts are assumed to have been infected (Probability of contact infection,' pContactTB' assumed to be 1.0). The cost of contact tracing coded 'cContactTB' was estimated at £482 (143).
- The probability of contacts to develop active 'pCATBa' or latent TB 'pCATBl'

following exposure to a primary active TB case is assumed to be 0.20 or 0.18 (143) respectively.

APPENDIX 20: COST AND EFFECTIVENESS OUTCOMES OF ALL THE CYCLES IN THE MONTE CARLO SIMULATION

Monte Carlo CE Strategy Values

Iteration	Strategy	Cost	Eff	NMB
1				
	Investment in Nigeria TB control	259.776	17.072	85101.374
	Present practice (Chest x ray screening at the airport)	208.605	17.086	85219.395
	IGRA	561.639	17.126	85067.111
	NOTHING	55.324	17.017	85027.426
2				
	Investment in Nigeria TB control	241.390	17.357	86543.560
	Present practice (Chest x ray screening at the airport)	206.779	17.214	85865.571
	IGRA	575.058	17.405	86448.442
	NOTHING	73.322	17.229	86070.078
3				
	Investment in Nigeria TB control	238.192	17.454	87030.208
	Present practice (Chest x ray screening at the airport)	211.811	17.186	85717.139
	IGRA	659.594	17.136	85018.206
	NOTHING	55.646	17.429	87088.454
4				

Iteration	Strategy	Cost	Eff	NMB
	Investment in Nigeria TB control	263.958	17.351	86492.142
	Present practice (Chest x ray screening at the airport)	496.769	17.450	86752.431
	IGRA	567.042	17.303	85947.358
	NOTHING	91.886	17.218	85996.464
5				
	Investment in Nigeria TB control	268.055	17.365	86555.895
	Present practice (Chest x ray screening at the airport)	339.655	17.142	85368.745
	IGRA	722.273	17.224	85399.427
	NOTHING	110.696	17.256	86171.004
6				
	Investment in Nigeria TB control	251.356	17.377	86632.544
	Present practice (Chest x ray screening at the airport)	279.362	17.452	86980.088
	IGRA	652.759	17.434	86518.191
	NOTHING	62.604	17.284	86358.096
7				
	Investment in Nigeria TB control	254.022	17.384	86664.828
	Present practice (Chest x ray screening at the airport)	235.388	17.438	86955.812
	IGRA	602.733	17.536	87076.917
	NOTHING	61.670	17.296	86420.780

Iteration	Strategy	Cost	Eff	NMB
8				
	Investment in Nigeria TB control	388.828	17.672	87969.822
	Present practice (Chest x ray screening at the airport)	187.367	17.493	87278.833
	IGRA	623.339	17.391	86331.961
	NOTHING	211.792	17.577	87671.908
9				
	Investment in Nigeria TB control	248.378	17.204	85770.372
	Present practice (Chest x ray screening at the airport)	338.938	17.048	84899.262
	IGRA	669.200	17.149	85077.300
	NOTHING	70.426	17.232	86089.424
10				
	Investment in Nigeria TB control	271.549	17.122	85337.651
	Present practice (Chest x ray screening at the airport)	181.629	17.143	85531.271
	IGRA	812.968	17.247	85423.382
	NOTHING	93.137	17.033	85072.413

11				
	Investment in Nigeria TB control	261.554	17.088	85176.246
	Present practice (Chest x ray screening at the airport)	246.387	17.181	85658.963
	IGRA	661.238	17.345	86063.962
	NOTHING	68.590	16.981	84835.760
12				
	Investment in Nigeria TB control	240.818	17.491	87214.932
	Present practice (Chest x ray screening at the airport)	425.647	17.468	86913.003
	IGRA	625.129	17.494	86844.921
	NOTHING	40.398	17.421	87066.952
13				
	Investment in Nigeria TB control	268.794	17.293	86194.906
	Present practice (Chest x ray screening at the airport)	572.183	17.342	86136.717
	IGRA	634.009	17.466	86696.191
	NOTHING	89.724	17.218	85999.876
14				
	Investment in Nigeria TB control	233.838	17.669	88109.312
	Present practice (Chest x ray screening at the airport)	502.315	17.540	87197.135
	IGRA	664.232	17.459	86630.018

	NOTHING	39.522	17.569	87806.028
15				
	Investment in Nigeria TB control	251.312	17.496	87226.688
	Present practice (Chest x ray screening at the airport)	197.609	17.384	86723.241
	IGRA	693.991	17.444	86524.659
	NOTHING	60.374	17.458	87231.476
16				
	Investment in Nigeria TB control	241.700	17.441	86962.650
	Present practice (Chest x ray screening at the airport)	204.640	17.415	86872.760
	IGRA	620.095	17.441	86585.055
	NOTHING	56.390	17.390	86892.960
17				
	Investment in Nigeria TB control	234.670	17.202	85774.930
	Present practice (Chest x ray screening at the airport)	226.381	17.326	86405.769
	IGRA	661.516	17.255	85614.534
	NOTHING	29.934	17.151	85726.766

18				
	Investment in Nigeria TB control	273.052	17.061	85030.398
	Present practice (Chest x ray screening at the airport)	194.831	17.087	85240.769
	IGRA	658.450	17.011	84399.000
	NOTHING	128.723	16.954	84640.227
19				
	Investment in Nigeria TB control	261.506	17.041	84943.144
	Present practice (Chest x ray screening at the airport)	452.181	17.245	85771.769
	IGRA	710.383	17.073	84653.517
	NOTHING	79.600	16.986	84850.100
20				
	Investment in Nigeria TB control	250.188	17.148	85488.912
	Present practice (Chest x ray screening at the airport)	172.140	17.091	85280.910
	IGRA	501.483	17.038	84688.517
	NOTHING	55.560	17.139	85636.990

21				
	Investment in Nigeria TB control	240.428	17.253	86025.072
	Present practice (Chest x ray screening at the airport)	392.568	17.079	85002.682
	IGRA	673.980	17.192	85286.020
	NOTHING	69.335	17.115	85506.665
22				
	Investment in Nigeria TB control	233.110	17.467	87100.940
	Present practice (Chest x ray screening at the airport)	215.886	17.535	87460.164
	IGRA	562.548	17.493	86902.802
	NOTHING	39.392	17.459	87254.808
23				
	Investment in Nigeria TB control	380.714	17.377	86502.486
	Present practice (Chest x ray screening at the airport)	264.796	17.513	87299.854
	IGRA	565.553	17.651	87689.247
	NOTHING	182.488	17.422	86926.612
24				
	Investment in Nigeria TB control	236.402	17.299	86256.748
	Present practice (Chest x ray screening at the airport)	317.563	17.196	85662.137
	IGRA	598.252	17.391	86354.948

	NOTHING	53.024	17.272	86308.576
25				
	Investment in Nigeria TB control	234.436	16.972	84627.364
	Present practice (Chest x ray screening at the airport)	265.625	17.258	86023.075
	IGRA	920.500	17.330	85728.800
	NOTHING	45.762	16.864	84272.788
26				
	Investment in Nigeria TB control	234.474	17.423	86879.076
	Present practice (Chest x ray screening at the airport)	407.824	17.491	87049.226
	IGRA	765.673	17.558	87023.777
	NOTHING	37.964	17.323	86575.536
27				
	Investment in Nigeria TB control	252.772	17.428	86887.128
	Present practice (Chest x ray screening at the airport)	243.026	17.401	86763.224
	IGRA	809.147	17.447	86425.353
	NOTHING	56.090	17.362	86751.510

28				
	Investment in Nigeria TB control	276.407	17.474	87091.643
	Present practice (Chest x ray screening at the airport)	210.691	17.406	86817.909
	IGRA	846.598	17.360	85951.852
	NOTHING	79.949	17.425	87045.251
29				
	Investment in Nigeria TB control	277.653	17.117	85305.997
	Present practice (Chest x ray screening at the airport)	155.399	17.081	85249.251
	IGRA	731.505	17.132	84928.545
	NOTHING	73.087	17.125	85549.663
30				
	Investment in Nigeria TB control	240.762	17.457	87044.888
	Present practice (Chest x ray screening at the airport)	229.189	17.311	86328.161
	IGRA	704.765	17.516	86877.085
	NOTHING	43.378	17.401	86961.572

31				
	Investment in Nigeria TB control	225.692	16.941	84481.008
	Present practice (Chest x ray screening at the airport)	271.719	16.739	83423.481
	IGRA	670.805	17.161	85134.245
	NOTHING	27.310	16.901	84477.190
32				
	Investment in Nigeria TB control	246.330	17.092	85214.970
	Present practice (Chest x ray screening at the airport)	231.079	17.110	85317.921
	IGRA	737.605	17.210	85314.095
	NOTHING	59.616	17.015	85016.334
33				
	Investment in Nigeria TB control	249.216	17.539	87446.384
	Present practice (Chest x ray screening at the airport)	254.503	17.458	87033.697
	IGRA	643.840	17.245	85581.560
	NOTHING	110.991	17.388	86831.009
34				
	Investment in Nigeria TB control	297.141	17.353	86469.259
	Present practice (Chest x ray screening at the airport)	201.622	17.254	86070.328
	IGRA	793.083	17.392	86167.617
	NOTHING	98.671	17.276	86279.479

35				
	Investment in Nigeria TB control	243.222	17.453	87022.728
	Present practice (Chest x ray screening at the airport)	166.461	17.210	85885.289
	IGRA	755.271	17.155	85021.729
	NOTHING	38.486	17.373	86828.564
36				
	Investment in Nigeria TB control	254.626	17.520	87344.624
	Present practice (Chest x ray screening at the airport)	240.444	17.484	87177.956
	IGRA	745.354	17.607	87292.096
	NOTHING	73.398	17.475	87302.302
37				
	Investment in Nigeria TB control	276.198	17.273	86089.652
	Present practice (Chest x ray screening at the airport)	175.063	17.169	85671.837
	IGRA	511.650	17.256	85769.850
	NOTHING	98.749	17.178	85790.101
38				
	Investment in Nigeria TB control	238.504	17.358	86550.196
	Present practice (Chest x ray screening at the airport)	267.633	17.400	86730.217
	IGRA	610.316	17.420	86490.334
	NOTHING	52.076	17.331	86602.124

39				
	Investment in Nigeria TB control	238.972	17.405	86785.828
	Present practice (Chest x ray screening at the airport)	311.780	17.591	87643.070
	IGRA	685.718	17.598	87302.632
	NOTHING	58.660	17.321	86543.990
40				
	Investment in Nigeria TB control	246.144	17.106	85281.856
	Present practice (Chest x ray screening at the airport)	315.961	16.950	84432.389
	IGRA	619.555	16.999	84376.395
	NOTHING	47.684	16.945	84675.766
41				

Iteration	Strategy	Cost	Eff	NMB
41				
	Investment in Nigeria TB control	228.406	17.395	86745.394
	Present practice (Chest x ray screening at the airport)	262.096	17.275	86111.254
	IGRA	677.912	17.522	86931.088
	NOTHING	27.698	17.367	86806.252
42				
	Investment in Nigeria TB control	249.756	17.444	86969.044
	Present practice (Chest x ray screening at the airport)	258.063	17.426	86873.437
	IGRA	696.841	17.587	87240.309
	NOTHING	77.802	17.348	86663.598
43				
	Investment in Nigeria TB control	257.460	17.173	85608.990
	Present practice (Chest x ray screening at the airport)	231.856	17.081	85172.394
	IGRA	541.548	17.142	85170.802
	NOTHING	105.975	17.152	85652.825
44				
	Investment in Nigeria TB control	269.672	17.635	87907.578
	Present practice (Chest x ray screening at the airport)	191.702	17.690	88259.248

Iteration	Strategy	Cost	Eff	NMB
	IGRA	693.297	17.661	87613.603
	NOTHING	76.446	17.582	87831.154
45				
	Investment in Nigeria TB control	237.982	17.311	86316.268
	Present practice (Chest x ray screening at the airport)	226.418	17.245	85999.882
	IGRA	733.369	17.249	85511.381
	NOTHING	45.382	17.206	85984.968
46				
	Investment in Nigeria TB control	231.410	17.222	85878.240
	Present practice (Chest x ray screening at the airport)	441.625	16.986	84490.625
	IGRA	680.220	16.871	83676.780
	NOTHING	26.960	17.157	85757.640
47				
	Investment in Nigeria TB control	257.280	17.258	86032.320
	Present practice (Chest x ray screening at the airport)	421.919	17.135	85250.581
	IGRA	822.713	17.107	84712.237
	NOTHING	74.892	17.073	85291.758
48				

Iteration	Strategy	Cost	Eff	NMB
	Investment in Nigeria TB control	258.860	17.679	88138.540
	Present practice (Chest x ray screening at the airport)	503.367	17.621	87600.783
	IGRA	876.581	17.653	87386.869
	NOTHING	82.152	17.567	87753.598
49				
	Investment in Nigeria TB control	257.332	17.255	86018.568
	Present practice (Chest x ray screening at the airport)	355.509	17.212	85706.891
	IGRA	703.369	17.061	84601.531
	NOTHING	66.734	17.242	86143.216
50				
	Investment in Nigeria TB control	235.062	17.190	85714.338
	Present practice (Chest x ray screening at the airport)	484.848	17.262	85823.052
	IGRA	536.106	17.296	85944.744
	NOTHING	50.766	17.118	85539.084
51				

	Investment in Nigeria TB control	237.224	17.499	87258.576
	Present practice (Chest x ray screening at the airport)	381.571	17.350	86368.829
	IGRA	504.138	17.320	86098.162
	NOTHING	36.880	17.452	87224.870
52				
	Investment in Nigeria TB control	281.058	16.877	84101.792
	Present practice (Chest x ray screening at the airport)	345.447	16.906	84187.003
	IGRA	527.711	16.849	83716.239
	NOTHING	114.339	16.774	83753.311
53				
	Investment in Nigeria TB control	263.732	17.302	86247.618
	Present practice (Chest x ray screening at the airport)	248.407	17.085	85178.143

	IGRA	684.705	17.109	84859.545
	NOTHING	69.236	17.305	86454.014
54				
	Investment in Nigeria TB control	241.208	17.314	86330.492
	Present practice (Chest x ray screening at the airport)	249.752	17.251	86003.148
	IGRA	676.926	17.269	85669.524
	NOTHING	35.874	17.227	86098.226
55				
	Investment in Nigeria TB control	263.608	17.374	86605.242
	Present practice (Chest x ray screening at the airport)	491.552	17.153	85271.248
	IGRA	614.301	17.242	85594.199

	NOTHING	63.684	17.288	86377.066
56				
	Investment in Nigeria TB control	258.438	17.184	85662.112
	Present practice (Chest x ray screening at the airport)	233.071	17.102	85274.879
	IGRA	997.388	17.260	85304.012
	NOTHING	72.320	17.100	85429.080
57				
	Investment in Nigeria TB control	237.540	17.356	86540.110
	Present practice (Chest x ray screening at the airport)	469.972	17.152	85290.428
	IGRA	634.141	17.077	84752.259
	NOTHING	34.102	17.303	86479.448

58				
	Investment in Nigeria TB control	228.552	17.377	86658.848
	Present practice (Chest x ray screening at the airport)	263.993	17.358	86525.657
	IGRA	858.439	17.348	85882.611
	NOTHING	48.294	17.364	86772.656
59				
	Investment in Nigeria TB control	257.096	17.367	86576.354
	Present practice (Chest x ray screening at the airport)	326.042	17.367	86509.658
	IGRA	1011.760	17.257	85270.840
	NOTHING	83.429	17.392	86876.071

60				
	Investment in Nigeria TB control	239.320	17.277	86144.780
	Present practice (Chest x ray screening at the airport)	318.826	17.316	86259.324
	IGRA	698.572	17.414	86371.478
	NOTHING	69.474	17.216	86008.926

61				
	Investment in Nigeria TB control	239.230	17.332	86420.320
	Present practice (Chest x ray screening at the airport)	264.334	17.282	86147.316
	IGRA	743.131	17.427	86391.819
	NOTHING	118.514	17.293	86348.536
62				

	Investment in Nigeria TB control	241.936	17.384	86679.114
	Present practice (Chest x ray screening at the airport)	539.092	17.496	86941.158
	IGRA	576.772	17.500	86923.278
	NOTHING	45.800	17.247	86186.700
63				
	Investment in Nigeria TB control	256.326	17.395	86717.274
	Present practice (Chest x ray screening at the airport)	193.040	17.274	86174.810
	IGRA	917.426	17.344	85802.324
	NOTHING	99.327	17.328	86538.973
64				
	Investment in Nigeria TB control	305.692	17.618	87785.358
	Present practice (Chest x ray screening at the airport)	270.186	17.426	86860.464
	IGRA	707.461	17.389	86236.789
	NOTHING	145.118	17.539	87548.132

65				
	Investment in Nigeria TB control	246.626	17.251	86009.724
	Present practice (Chest x ray screening at the airport)	301.966	17.181	85604.234
	IGRA	732.308	17.205	85294.142
	NOTHING	73.604	17.170	85775.046
66				
	Investment in Nigeria TB control	232.406	17.230	85917.394
	Present practice (Chest x ray screening at the airport)	351.207	17.115	85222.843
	IGRA	652.678	17.259	85643.322
	NOTHING	34.646	17.163	85778.004
67				
	Investment in Nigeria TB control	229.654	17.476	87152.746
	Present practice (Chest x ray screening at the airport)	330.427	17.314	86237.773

	IGRA	599.656	17.469	86747.144
	NOTHING	40.486	17.409	87006.964
68				
	Investment in Nigeria TB control	242.412	17.540	87455.788
	Present practice (Chest x ray screening at the airport)	307.439	17.322	86300.911
	IGRA	575.866	17.272	85785.034
	NOTHING	73.122	17.465	87251.928
69				
	Investment in Nigeria TB control	303.994	17.123	85309.606
	Present practice (Chest x ray screening at the airport)	467.880	17.188	85470.120
	IGRA	1019.473	17.368	85820.527
	NOTHING	112.840	16.972	84746.860
70				

	Investment in Nigeria TB control	228.422	17.404	86790.178
	Present practice (Chest x ray screening at the airport)	199.515	17.369	86643.835
	IGRA	742.334	17.485	86683.366
	NOTHING	48.518	17.302	86459.832
71				
	Investment in Nigeria TB control	277.067	17.487	87155.833
	Present practice (Chest x ray screening at the airport)	378.562	17.490	87072.338
	IGRA	933.497	17.384	85984.753
	NOTHING	147.153	17.433	87019.797
72				
	Investment in Nigeria TB control	245.454	17.287	86190.296
	Present practice (Chest x ray screening at the airport)	230.785	17.024	84888.665
	IGRA	719.365	17.034	84451.485
	NOTHING	55.062	17.272	86306.888
73				
	Investment in Nigeria TB control	235.088	17.303	86278.212

	Present practice (Chest x ray screening at the airport)	289.038	17.388	86649.662
	IGRA	850.792	17.498	86641.108
	NOTHING	53.102	17.232	86109.098
74				
	Investment in Nigeria TB control	246.472	17.301	86258.228
	Present practice (Chest x ray screening at the airport)	256.426	17.443	86960.424
	IGRA	566.209	17.707	87967.391
	NOTHING	82.316	17.337	86601.684
75				
	Investment in Nigeria TB control	248.886	17.416	86831.164
	Present practice (Chest x ray screening at the airport)	265.160	17.365	86560.340
	IGRA	533.439	17.269	85811.111
	NOTHING	65.432	17.393	86899.668
76				
	Investment in Nigeria TB control	239.466	17.267	86096.584
	Present practice (Chest x ray screening at the airport)	185.646	17.201	85818.154
	IGRA	579.233	17.178	85310.317
	NOTHING	48.712	17.185	85873.788

77				
	Investment in Nigeria TB control	292.120	17.167	85543.080
	Present practice (Chest x ray screening at the airport)	238.469	17.043	84978.331
	IGRA	680.568	16.943	84032.582
	NOTHING	124.557	17.156	85653.293
78				
	Investment in Nigeria TB control	241.494	17.611	87811.506
	Present practice (Chest x ray screening at the airport)	239.049	17.505	87283.501
	IGRA	921.845	17.604	87100.205
	NOTHING	67.448	17.519	87528.452
79				
	Investment in Nigeria TB control	247.900	17.312	86313.200
	Present practice (Chest x ray screening at the airport)	153.473	17.224	85966.377
	IGRA	792.412	17.333	85873.638
	NOTHING	55.324	17.251	86198.226
80				
	Investment in Nigeria TB control	245.768	17.375	86628.632
	Present practice (Chest x ray screening at the airport)	209.475	17.113	85353.525
	IGRA	613.773	17.061	84689.127

	NOTHING	44.916	17.268	86292.784
81				
	Investment in Nigeria TB control	250.170	17.408	86789.580
	Present practice (Chest x ray screening at the airport)	474.755	17.343	86240.045
	IGRA	752.172	17.432	86408.028
	NOTHING	47.670	17.284	86374.130
82				
	Investment in Nigeria TB control	228.422	17.781	88678.778
	Present practice (Chest x ray screening at the airport)	236.379	17.699	88256.771
	IGRA	613.103	17.744	88104.897
	NOTHING	51.078	17.691	88402.372
83				
	Investment in Nigeria TB control	238.684	17.060	85059.966
	Present practice (Chest x ray screening at the airport)	381.939	17.141	85324.711
	IGRA	738.518	17.225	85386.232
	NOTHING	48.918	16.983	84866.282
84				

	Investment in Nigeria TB control	242.064	17.452	87019.486
	Present practice (Chest x ray screening at the airport)	292.360	17.559	87501.840
	IGRA	777.961	17.494	86694.139
	NOTHING	80.168	17.435	87092.382
85				
	Investment in Nigeria TB control	236.154	17.098	85254.696
	Present practice (Chest x ray screening at the airport)	233.500	17.042	84976.700
	IGRA	570.622	17.339	86124.078
	NOTHING	59.976	17.122	85551.874
86				
	Investment in Nigeria TB control	244.830	17.639	87948.620
	Present practice (Chest x ray screening at the airport)	302.831	17.633	87860.819
	IGRA	646.911	17.592	87312.439
	NOTHING	75.944	17.663	88240.206
87				
	Investment in Nigeria TB control	225.042	17.192	85736.758
	Present practice (Chest x ray screening at the airport)	187.461	17.088	85252.689
	IGRA	726.697	17.090	84724.553
	NOTHING	39.974	17.147	85697.376

88				
	Investment in Nigeria TB control	313.010	17.400	86688.490
	Present practice (Chest x ray screening at the airport)	194.311	17.432	86965.189
	IGRA	604.027	17.346	86125.273
	NOTHING	120.306	17.380	86781.344
89				
	Investment in Nigeria TB control	249.418	17.236	85930.232
	Present practice (Chest x ray screening at the airport)	223.690	17.304	86294.110
	IGRA	597.617	17.424	86521.783
	NOTHING	67.210	17.229	86075.740
90				
	Investment in Nigeria TB control	275.289	17.197	85707.811
	Present practice (Chest x ray screening at the airport)	329.534	16.886	84101.916
	IGRA	608.793	17.051	84644.157
	NOTHING	70.187	17.147	85665.213
91				
	Investment in Nigeria TB control	265.584	17.353	86497.166
	Present practice (Chest x ray screening at the airport)	232.497	17.389	86714.803

	IGRA	684.323	17.334	85984.777
	NOTHING	78.860	17.310	86473.440
92				
	Investment in Nigeria TB control	237.116	17.196	85743.984
	Present practice (Chest x ray screening at the airport)	332.493	17.239	85862.857
	IGRA	741.312	17.135	84934.488
	NOTHING	42.918	17.156	85737.732
93				
	Investment in Nigeria TB control	259.316	17.391	86696.934
	Present practice (Chest x ray screening at the airport)	170.573	17.385	86752.927
	IGRA	694.106	17.456	86584.894
	NOTHING	60.750	17.314	86507.900
94				
	Investment in Nigeria TB control	251.654	17.546	87479.546
	Present practice (Chest x ray screening at the airport)	520.601	17.667	87816.699
	IGRA	733.776	17.546	86995.974
	NOTHING	95.059	17.499	87398.041
95				
	Investment in Nigeria TB control	232.904	17.281	86173.196

	Present practice (Chest x ray screening at the airport)	237.680	17.157	85547.220
	IGRA	682.032	17.261	85621.068
	NOTHING	57.328	17.241	86146.022
96				
	Investment in Nigeria TB control	234.122	17.133	85433.028
	Present practice (Chest x ray screening at the airport)	454.978	17.139	85241.522
	IGRA	652.165	17.231	85504.885
	NOTHING	65.908	17.156	85712.642
97				
	Investment in Nigeria TB control	262.166	17.402	86748.434
	Present practice (Chest x ray screening at the airport)	188.463	17.323	86424.437
	IGRA	534.965	17.387	86401.335
	NOTHING	67.320	17.341	86635.430
98				
	Investment in Nigeria TB control	247.234	17.091	85207.116
	Present practice (Chest x ray screening at the airport)	191.378	16.960	84609.872
	IGRA	733.587	17.126	84896.163
	NOTHING	56.388	16.956	84725.712

99				
	Investment in Nigeria TB control	255.978	17.166	85576.172
	Present practice (Chest x ray screening at the airport)	479.675	17.194	85491.275
	IGRA	913.816	17.307	85622.384
	NOTHING	73.294	17.149	85673.256
100				
	Investment in Nigeria TB control	265.660	17.280	86132.090
	Present practice (Chest x ray screening at the airport)	279.283	17.208	85758.317
	IGRA	629.676	17.259	85667.624
	NOTHING	89.836	17.297	86394.964

APPENDIX 21: QUESTIONNAIRES

Principal Investigator:
Dr Nisser Ali Umar
School of Medicine, Health Policy and Practice,
Faculty of Health,
University of East Anglia, Norwich NR4 7TJ
England
Tel: +44 7877045785
E-mail: N.Umar@uea.ac.uk
February, 2009

Date of Interview	Clinic Name and Place	Interviewer Name	Patient Chart Number (or Patient Initials)

9. COST OF A DAY IN HOSPITAL (EXCLUDING DRUGS, LABORATORY TESTS AND X-RAYS)

A: NURSING STAFF COSTS

TYPE OF NURSING STAFF WORKING IN TB WARD	**NUMBER WHO WORK IN TB WARD (a)**	**ANNUAL COSTS (b)**	**AV. PROPORT- ION OF TIME SPENT ON TB WARDS (c)**	**TOTAL ANNUAL COSTS = (a) x (b) x (c)**

TOTAL ANNUAL COST OF NURSING STAFF = _____

SECTION 1 – CLINICAL INFORMATION

B: MEDICAL STAFF COSTS

TYPE OF MED. STAFF WORKING IN TB WARD	NUMBER WHO WORK IN TB WARD (a)	ANNUAL COSTS (b)	AV. PROPORT- ION OF TIME SPENT ON TB WARDS (c)	TOTAL ANNUAL COSTS = (a) x (b) x (c)

TOTAL ANNUAL COST OF MEDICAL STAFF = _____

C: SUPPORT STAFF COSTS

TYPE OF SUPPORT STAFF IN TB WARD	NUMBER WHO WORK IN TB WARD (a)	ANNUAL COSTS (b)	AV. PROPORT- ION OF TIME SPENT ON TB WARDS (c)	TOTAL ANNUAL COSTS (a) x (b) x (c)

TOTAL ANNUAL COST OF SUPPORT STAFF = _____

D. BUILDING COST

REPLACEMENT COST OF THE TB WARD INCLUDING THE NEGATIVE PRESURE ROOM (a)	ANNUALIZED COST OF TB WARD = (a) x 25.73

E. STAFF OVERHEAD COST, EXCLUDING KITCHEN, LAUNDRY LABORATORY AND X-RAY STAFF

TYPE OF STAFF NOT INVOLVED IN DIRECT PATIENT CARE EXCLUDING KITCHEN/LAUDRY/LAB/ANY SUPPORT STAFF AS ABOVE	ANNUAL COST (a)	NUMBER EMPLOYED (b)	TOTAL ANNUAL COST= (a) x (b)

TOTAL ANNUAL STAFF OVERHEAD COST : _____

TOTAL ANNUAL NUMBER OF HOSPITAL INPATIENT DAYS ACCOUNTED FOR BY TUBERCULOSIS PATIENTS:

_____

TOTAL ANNUAL STAFF OVERHEAD COST ACCOUNTED FOR BY TUBERCULOSIS INPATIENT CARE:

_____

F: KITCHEN AND LAUDRY SERVICE COST

TYPE OF STAFF EMPLOYED IN THE KITCHEN AND LAUDRY	ANNUAL COST (a)	NUMBER EMPLOYED (b)	TOTAL ANNUAL COST= (a) x (b)

TOTAL ANNUAL KITCHEN/LAUDRY STAFF COST: _____

TOTAL ANNUAL NON-STAFF RECURRENT EXPENDITURE OF KITCHEN AND LAUDRY SERVICES:

_____

REPLACEMENT COST OF THE KITCHEN AND LAUDRY BUILDING (a)	ANNUALIZED = (a) x 25.73

TOTAL ANNUAL COSTS OF STAFF, BUILDINGS AND NON-STAFF RECURRENT EXPENDITURE ASSOCIATED WITH KITCHEN AND LAUNDRY FACILITIES:

_____

TOTAL ANNUAL COSTS OF KITCHEN AND LAUNDRY SERVICES TO BE ALLOCATED TO TUBERCULOSIS PATIENTS:

_____

G: GENERAL HOSPITAL RECURRENT OVERHEAD COSTS, EXCULUDING STAFF, ITEMS ASSOCIATED WITH DRUGS, LABORATORY TESTS, X-RAYS, KITCHEN, LAUNDRY FACILITIES, AND ANY OTHER ITEMS CLEARLY IRRELEVANT TO TUBERCULOSIS PATIENTS: _____

TOTAL ANNUAL COST OF GENERAL NON-PERSONNEL RECURRENT HOSPITAL EXPENDITURE OF ALL ITEMS EXCEPT THOSE ASSOCIATED WITH DRUGS, LABORATORY TESTS, X-RAYS, KITCHEN, LAUNDRY FACILITIES, AND ANY OTHER ITEMS CLEARLY IRRELEVANT TO TUBERCULOSIS PATIENTS: _____

PROPORTION OF TOTAL COSTS CALCULATED ABOVE (i) TO BE ALLOCATED TO INPATIENT SERVICES:

_____

TOTAL NON-PERSONNEL OVERHEAD RECURRENT COST ASSOCIATED WITH INPATIENT SERVICES:

_____

PROPORTION OF INPATIENT DAYS FOR WHICH TUBERCULOSIS PATIENTS ACCOUNT:

_____

TOTAL ANNUAL OVERHEAD NON-PERSONNEL RECURRENT COSTS TO BE ALLOCATED TO TUBERCULOSIS INPATIENT CARE:

_____

H: GENERAL BUILDING AND EQUIPMENT COSTS:

REPLACEMENT COST OF THE BUILDING USED FOR GENERAL SUPPORT SERVICES (a)	**ANNUALIZED COST** **= (a) x 25.73**

REPLACEMENT COST OF THE FOR GENERAL EQUIPMENT USED FOR GENERAL SUPPORT SERVICES (a)	**ANNUALIZED COST** **= (a) x 25.73**

TOTAL ANNUALIZED COST OF BUILDING AND EQUIPMENT:

_____

PROPORTION OF GENERAL BUILDING AND EQUIPMENT COSTS TO BE ALLOCATED TO INPATIENT SERVICES:

_____

ANNUAL GENERAL BUILDING AND EQUIPMENT COSTS TO BE ALLOCATED TO INPATIENT SERVICES:

_____

PROPORTION OF TOTAL INPATIENT DAYS FOR WHICH TUBERCULOSIS PATIENTS ACCOUNT:

_____

TOTAL GENERAL BUILDING AND EQUIPMENT COSTS TO BE ALLOCATED TO TUBERCULOSIS PATIENTS:

_____

THEREFORE, INPATIENTS CARE OF TUBERCULOSIS PATIENTS:

AVERAGE COST PER DAY : _____

ESTIMATED AVERAGE INCREMENTAL COST PER DAY: _____

ESTIMATED MARGINAL COST PER DAY: _____

AVERAGE NUMBER OF INPATIENT DAYS SPENT BY PATIENT WITH DRUG SENSITIVE TB: _____

AVERAGE NUMBER OF INPATIENT DAYS SPENT BY A PATIENT WITH MDR-TB: _____

AVERAGE NUMBER OF INPATIENT DAYS SPENT BY A PATIENT WITH XDR- TB: _____

10. COST OF AN OUTPATIENT DAY (EXCLUDING DRUGS, LABORATORY TESTS AND X-RAYS)

A: NURSING STAFF COSTS

TYPE OF NURSING STAFF WORKING IN TB CLINIC	NUMBER WHO WORK IN TB CLINIC (a)	ANNUAL COSTS (b)	AV. PROPORT- ION OF TIME SPENT ON TB CLINIC (c)	TOTAL ANNUAL COSTS = (a) x (b) x (c)

TOTAL ANNUAL COST OF NURSING STAFF = _____

B: MEDICAL STAFF COSTS

TYPE OF MED. STAFF WORKING IN TB CLINIC	NUMBER WHO WORK IN TB CLINIC (a)	ANNUAL COSTS (b)	AV. PROPORT- ION OF TIME SPENT ON TB CLINIC (c)	TOTAL ANNUAL COSTS = (a) x (b) x (c)

TOTAL ANNUAL COST OF MEDICAL STAFF = _____

C: SUPPORT STAFF COSTS

TYPE OF SUPPORT STAFF IN TB CLINIC	NUMBER WHO WORK IN TB CLINIC (a)	ANNUAL COSTS (b)	AV. PROPORT- ION OF TIME SPENT ON TB CLINIC (c)	TOTAL ANNUAL COSTS (a) x (b) x (c)

TOTAL ANNUAL COST OF SUPPORT STAFF = _____

D. BUILDING COST

REPLACEMENT COST OF THE TB CLINIC (a)	ANNUALIZED COST OF TB CLINIC = (a) x 25.73

E. STAFF OVERHEAD COST, EXCLUDING KITCHEN, LAUNDRY, LABORATORY AND X-RAY STAFF

TYPE OF STAFF NOT INVOLVED IN DI-RECT PATIENT CARE EXCLUDING KITCHEN/LAUDRY/LAB/ANY SUPPORT STAFF AS ABOVE	ANNUAL COST (a)	NUMBER EMPLOYED (b)	TOTAL ANNUAL COST= (a) x (b)

TOTAL ANNUAL STAFF OVERHEAD COST : _____

TOTAL ANNUAL NUMBER OF OUTPATIENT DAYS ACCOUNTED FOR BY TUBERCULOSIS PATIENTS:
_____

PROPORTION OF ALL OUTPATIENT DAYS ACCOUNTED FOR BY TUBERCULOSIS PATIENTS:
_____

TOTAL ANNUAL STAFF OVERHEAD COST ACCOUNTED FOR BY TUBERCULOSIS INPATIENT CARE:
_____

G: GENERAL HOSPITAL RECURRENT OVERHEAD COSTS, EXCULUDING STAFF, ITEMS ASSOCIATED WITH DRUGS, LABORATORY TESTS, X-RAYS, KITCHEN, LAUNDRY FACILITIES, AND ANY OTHER ITEMS CLEARLY IRRELEVANT TO TUBERCULOSIS PATIENTS:_____

TOTAL ANNUAL COST OF GENERAL NON-PERSONNEL RECURRENT HOSPITAL EXPENDITURE OF ALL ITEMS EXCEPT THOSE ASSOCIATED WITH DRUGS, LABORATORY TESTS, X-RAYS, KITCHEN, LAUNDRY FACILITIES, AND ANY OTHER ITEMS CLEARLY IRRELEVANT TO TUBERCULOSIS PATIENTS: _____

PROPORTION OF TOTAL COSTS CALCULATED ABOVE (i) TO BE ALLOCATED TO OUTPATIENT SERVICES:_____

TOTAL NON-PERSONNEL OVERHEAD RECURRENT COST ASSOCIATED WITH OUTPATIENT SERVICES:
_____

PROPORTION OF OUTPATIENT DAYS FOR WHICH TUBERCULOSIS PATIENTS ACCOUNT:
_____

TOTAL ANNUAL OVERHEAD NON-PERSONNEL RECURRENT COSTS TO BE ALLOCATED TO TUBERCULOSIS OUTPATIENT CARE: _____

H: GENERAL BUILDING AND EQUIPMENT COSTS:

REPLACEMENT COST OF THE GENERAL BUILDING USED FOR GENERAL SUPPORT SERVICES (a)	**ANNUALIZED COST** **= (a) x 25.73**

REPLACEMENT COST OF THE FOR GENERAL EQUIPMENT USED FOR GENERAL SUPPORT SERVICES (a)	**ANNUALIZED COST** **= (a) x 25.73**

TOTAL ANNUALIZED COST OF BUILDING AND EQUIPMENT:
_____

PROPORTION OF GENERAL BUILDING AND EQUIPMENT COSTS TO BE ALLOCATED TO OUTPATIENT SERVICES:
_____

ANNUAL GENERAL BUILDING AND EQUIPMENT COSTS TO BE ALLOCATED TO OUTPATIENT SERVICES:
_____

PROPORTION OF TOTAL OUTPATIENT DAYS FOR WHICH TUBERCULOSIS PATIENTS ACCOUNT:_____

TOTAL GENERAL BUILDING AND EQUIPMENT COSTS TO BE ALLOCATED TO TUBERCULOSIS PATIENTS:_____

THEREFORE, OUTPATIENTS CARE OF TUBERCULOSIS PATIENTS:

AVERAGE COST PER VISIT:_____

ESTIMATED AVERAGE INCREMENTAL COST PER DAY: _____

ESTIMATED MARGINAL COST PER DAY: _____

11: COST OF DRUGS

COST OF DRUGS FOR THE INTENSIVE PHASE (1-2MTHS) TUBERCULOSIS PATIENT:
_____

COST OF DRUGS FOR THE MAINTAINANCE PHASE (2-9 MTHS) TUBERCULOSIS PATIENT:_____

COST OF DRUGS FOR MULTI DRUG RESISTANT TUBERCULOSIS (MDR-TB) PATIENT TREATMENT:
_____

COST OF DRUGS FOR EXTENSIVELY DRUG RESISTANT TUBERCULOSIS (XDR-TB) PATIENT TREATMENT:_____

COST OF DRUGS FOR RE-TREATMENT OF TUBERCULOSIS PATIENT:_____

12: COST OF A SPUTUM SMEAR:

QUOTED AVERAGE COST OF SPUTUM SMEAR: _____

SOURCE OF QUOTATION: _____

AVERAGE NUMBER OF SPUTUM SMEAR TESTS REQUIRED BY A PATIENT WITH DRUG SENSITIVE TB:
_____

AVERAGE NUMBER OF SPUTUM SMEAR TESTS REQUIRED BY A PATIENT WITH MDR-TB:
_____

AVERAGE NUMBER OF SPUTUM SMEAR TESTS REQUIRED BY A PATIENT WITH XDR- TB:
_____

13: COST OF A SPUTUM CULTURE:

QUOTED AVERAGE COST OF SPUTUM CULTURE (OR ESTIMATED AVERAGE COST OF SPUTUM CULTURE = AVERAGE COST OF A SPUTUM SMEAR x 1.6) :_____

SOURCE OF QUOTATION_____

AVERAGE NUMBER OF SPUTUM CULTURE TESTS REQUIRED BY A PATIENT WITH DRUG SENSITIVE TB:_____

AVERAGE NUMBER OF SPUTUM CULTURE TESTS REQUIRED BY A PATIENT WITH MDR-TB:
_____

AVERAGE NUMBER OF SPUTUM CULTURE TESTS REQUIRED BY A PATIENT WITH XDR-TB:_____

14: COST OF AN X-RAY:

QUOTED AVERAGE OF AN X-RAY: _____

SOURCE OF QUOTATION: _____

AVERAGE NUMBER OF X RAY REQUIRED BY A PATIENT WITH DRUG SENSITIVE TB:
_____

AVERAGE NUMBER OF X RAY REQUIRED BY A PATIENT WITH MDR-TB:
_____

AVERAGE NUMBER OF X RAY REQUIRED BY A PATIENT WITH XDR-TB:_____

15: COST OF OUTPATIENT SUPERVISIONS/VISITS OF PATIENTS BY HEALTH WORKERS/SUPPORT WORKERS:

STAFF COSTS:

TYPES OF STAFF INVOLVE/PARTICIPATE IN SUPERVISION	**ANNUAL COST (a)**	**PROPORTION OF TIME SPENT (b)**	**TOTAL ANNUAL COST (c)**

TOTAL ANNUAL COST OF STAFF INVOLVED/PARTICIPATE IN SUPERVISION:
_____

ESTIMATED TOTAL ANNUAL COST (MILES*RATE) OF TRANSPORTATION FOR THE SUPERVISION OF PATIENTS AND THEIR SURPERVISORS:_____

AVERAGE COST FOR SUPERVISIONS/VISITS TO PATIENT BY HEALTH WORKERS/SUPPORT WORKERS:

Ii Assessing Patient Costs due to Tuberculosis (TB)

Date of Interview	Clinic Name and Place	Interviewer Name	Patient Chart Number (or Patient Initials)

SECTION 1 : Clinical Information

1. Date of Birth	2. Sex	3.Ethnicity/ Country of Origin	3a. Legal Status	4. What was the date and location of diagnosis for this episode of TB?	5. Classification

SECTION 1 – CLINICAL INFORMATION

Write date:	Circle:	Country of Origin:	Circle:	Write date:	Circle:
____/ /_____ day / month / year (write month in full ex. 17/August/2004)	Male Female	Born in _____ Country of current residence: _____ AND (if applicable) Year arrived_____	Accepted refugee Citizen Immigrant applicant Landed immigrant Refugee claimant Student Visitor Work visa Other _____	____/_____/_____ day / month / year (write month in full) Name of Facility where diagnosed _____ Type of Health Facility: Public Hospital (as inpatient) Private Hospital (as inpatient) Clinic at Public Hospital (as outpatient) Clinic at Private Hospital (as outpatient) Public Clinic Private Clinic Other	New Case (if new case go to Q7) OR Retreatment Failure Relapse Default

SECTION 1 – CLINICAL INFORMATION

				(Specify)_____	

6. If re-treatment case, what was the date of the patients prior TB?	7. Was this patient referred to this clinic, from immigration, a hospital or another clinic?	8. Has the patient been admitted into hospital?	9. Form/Site of TB	10. Smear	11. Culture	12. Culture sensitivity?
Write date: ____/_____/_____ day / month / year (write month in full) OR Don't know	Circle: Yes No If Yes: Circle source: Hospital Clinic at Hospital Clinic Immigration	Circle: Yes No If Yes: Name of Hospital: _____ Type of Hospital: (i.e. public/private) _____	Circle: Pulmonary Extra-Pulmonary Both * If not pulmonary or both, do not proceed.	Circle: Any Positive All Negative	Circle: Any Positive All Negative Not Done	Circle: Not done Sensitive All OR Resistant to: INH (H) RIF (R) PZA (Z) EMB (E) STREP (S)
				* At least one of the above must be positive in order for the patient to be eligible for this study		

SECTION 1 – CLINICAL INFORMATION

13. What treatment is the patient on?	14. When did the patient start treatment?	15. Treatment Supervision (current)	16. Does the patient have private insurance?	17. Co morbidity? (Circle all that apply)	
Circle : INH (H) RIF (R) PZA (Z) EMB (E) STREP (S)	Write Date: ____/ /_____ day / month / year (write month in full)	Circle: Directly Observed Therapy (DOT) OR Self Administered Treat-ment (SAT) If DOT OR If SAT	Circle: Yes No	Circle: Asthma/COPD Cancer Diabetes Diarrhea Fracture Gonorrhea Heart Disease HIV/AIDS Intestinal Parasites	Syphilis Typhoid Urinary Infection Other STD (Specify) _____ Other Illness (Specify) _____ Other Injury (Specify) _____

SECTION 1 – CLINICAL INFORMATION

OR WHO Scheme 1 WHO Scheme 2		Location: Health Post Home Clinic Hospital Clinic in hospital Other (Specify)	Frequency of Med. Pick up: Weekly Bi Weekly Monthly		Kidney (renal) disease Malaria Malnutrition Measles Meningitis Poisoning	Don't Know OR None

SECTION 2: General Questions

Explain to the patient that you will now ask them a few general questions about their household, education and employment history.

18. How many people live in your household? (i.e. family or persons with whom you share costs)	19. What is the highest level of education that you have completed?	20. What type (s) of work do you do?	21. If NOT WORKING, Please provide a reason
Circle: One Two Three Four Five or more (Specify number) _____ OR Lives Alone	Circle: None Primary school Some high school Finished high school Above high school	Write Main Type of work: Additional Work: OR Student OR Not Working	Circle: Unemployed Fired Contract Ended Retired Other: Is the reason for Not Working related to the patient's TB illness? (please check one) Yes □ No □

SECTION 3 – PRE DIAGNOSTIC PERIOD

22. What is YOUR average total MONTHLY take home earnings (after tax) &/or the TOTAL amount of financial support you receive NOW? (includes welfare, disability, or other social support, but not loans due to illness)	23. What was YOUR average total MONTHLY take home earnings (after tax) &/or the TOTAL amount of financial support you received PRIOR TO YOUR DIAGNOSIS? (includes welfare, disability, or other social support)	24. What is your HOUSEHOLD average total MONTHLY take home earnings (after tax) &/or the total amount of financial support your household receives NOW? (including government assistance and money sent from overseas) * Skip this question if the patient lives alone	25. What was your HOUSEHOLD average total MONTHLY take home earnings (after tax) &/or the total amount of financial support your household received PRIOR TO YOUR DIAGNOSIS WITH TB? (including government assistance and money sent from overseas) * Skip this question if the patient lives alone
Circle Amount: Under 100$/month 100-500$/month 500-1000$/month More than 1000$/month	Circle Amount: Under 100$/month 100-500$/month 500-1000$/month More than 1000$/month	Circle Amount: Under 100$/month 100-500$/month 500-1000$/month More than 1000$/month	Circle Amount: Under 100$/month 100-500$/month 500-1000$/month More than 1000$/month
* Is the change in earnings related to the patient's TB illness (please check one) Yes □ No □		* Is the change in earnings related to the patient's TB illness (please check one) Yes □ No □	

SECTION 3 – PRE DIAGNOSTIC PERIOD

SECTION 3A: Pre-Diagnostic Period – History of Pre-Diagnostic Medical Visits

Explain to the patient that you will now ask them some questions about their health and experiences PRIOR to their TB diagnosis.

26. Which of the following symptoms did you have preceding your TB diagnosis?	27. If symptomatic: How long did you have these symptoms before seeking help? (health facility or other doctor/expert)	28. Where did you first go to seek help because of these symptoms?	29. When did you first visit this facility/person to seek help for your symptoms? (month/year)

Circle: Cough Wheezing or asthma like symptoms Sputum/phlegm production Blood in sputum Fatigue Fever/sweats Loss of appetite Weight loss OR None/ Asymptomatic	Write amount of time between first symptoms and first consultation: _____ weeks months	Name of first location (person) visited Type of facility Public Clinic Private Clinic Public Hospital Private Hospital Clinic at Public Hospital Clinic at Private Hospital Private Doctor Health Post Spiritual Healer Pharmacy Other _____	Date of first visit: (month/year)

SECTION 3 – PRE DIAGNOSTIC PERIOD

* Begin by reciting to the patient the dates of their TB diagnosis and treatment start date that you have obtained from their chart. Check with the patient that they agree with their diagnosis and start dates, and record this information in question 27a before beginning.

30. Starting with the first location, please list ALL the locations visited PRIOR to the TB diagnosis (for any respiratory or TB related symptoms)

(Please include all hospitals, clinics, pharmacies, spiritual healers, and other sites visited because of TB related symptoms)

* Only include visits made up to one year ago

Name of facility/person	Type of facility/person (select from list in Q25)	How many months BEFORE TB DIAGNOSIS did the patient visit this facility/person?	Was the patient hospitalized at this facility? If YES, fill in Section 5 – Hospitalization If NO, fill in Section 3 – Pre-Diagnosis
1)		months	Yes □ No □
2)		months	Yes □ No □
3)		months	Yes □ No □
4)		months	Yes □ No □
5)		months	Yes □ No □
6)		months	Yes □ No □
7)		months	Yes □ No □
8)		months	Yes □ No □

SECTION 3 – PRE DIAGNOSTIC PERIOD

31. Where were you officially diagnosed with TB? Write name of location:	When were you officially diagnosed with TB? (month/year)	Were you hospitalized during diagnosis? Yes □ No □ If NO fill in the details in Section 4 – Diagnosis If YES fill in the details in Section 5 – Hospital.

SECTION 3 – PRE DIAGNOSTIC PERIOD

32. Did you visit anywhere else because of these symptoms or because you were instructed to do so?
Circle: Yes If YES return to the previous questions and complete the missing information No

SECTION 3B: Pre Diagnostic Period – Establishments visited (excluding hospitalizations)

3.1 First Location Visited Prior to Diagnosis (if hospitalized, fill in details in SECTION 5 – Hospitalization Period)

33. Name of First Location visited pre-diagnosis, listed in Q30, excluding hospitalizations.	34. Type of Facility	35. Were you diagnosed at this location?	36. How many times did you visit this place?
Name of first location/facility:	Circle: Public Clinic Private Clinic Clinic at Public Hospital Clinic at Private Hospital Private Doctor Health Post Spiritual Healer Pharmacy Other (Specify)_____	Circle: Yes If YES, skip this section and go to Section 4 (DIAGNOSIS) No	Circle: One Two Three Four Five or more (Specify number) _____

37. How long on average did you spend traveling to and from the facility?	38. How long on average did one of these visits take? (include waiting time, consultation and tests)	39. Did any family or friend accompany you on these visits?	40. How many visits did your family member/friend accompany you for?
Write total travel time: _____ Hours Minutes	Write total consultation time: _____ Hours Minutes	Circle: Yes No	Circle: None Almost none Some Most All

41. What did you or your accompanier have to pay for at this establishment or following your appointments?

WRITE ZERO here if patient had no expenditures:_____

WRITE TOTAL if patient only knows total amount:_____$

	Amount	Per Visit	Total
Parking			
Travel			
Registration fee			
Paperwork fee			
Consultation			
Blood Tests			
Medication (TB or Non-TB)			
X-ray			
Food			
Other (Specify _____			

3.2 Second Location Visited Prior to Diagnosis (if hospitalized, fill in details in SECTION 5 – Hospitalization Period)

42. Name of Second Location visited pre-diagnosis listed in Q30, excluding hospitalizations	43. Type of Facility	44. Were you diagnosed at this location?	45. How many times did you visit this place?
Name of second location/facility:	Circle: Public Clinic Private Clinic Clinic at Public Hospital Clinic at Private Hospital Private Doctor Health Post Spiritual Healer Pharmacy Other (Specify)_____	Circle: Yes If YES, skip this section and go to Section 4 (DIAGNOSIS) No	Circle: One Two Three Four Five or more (Specify number) _____

46. How long on average did you spend traveling to and from the facility?	47. How long on average did one of these visits take? (include waiting time, consultation and tests)	48. Did any family or friend accompany you on these visits?	49. How many visits did your family member/friend accompany you for?
Write total travel time: _____ Hours Minutes	Write total consultation time: _____ Hours Minutes	Circle: Yes No	Circle: None Almost none Some Most All

50. What did you or your accompanier have to pay for at this establishment or following your appointments?

WRITE ZERO here if patient had no expenditures:_____

WRITE TOTAL if patient only knows total amount:_____$

	Amount	Per Visit	Total
Parking			
Travel			
Registration fee			
Paperwork fee			
Consultation			
Blood Tests			
Medication (TB or Non-TB)			
X-ray			
Food			
Other (Specify) _____			

3.3 Third Location Visited Prior to Diagnosis (if hospitalized, fill in details in SECTION 5 – Hospitalization Period)

51. Name of Third Location visited pre-diagnosis, listed in Q30, excluding hospitalizations	52. Type of Facility	53. Were you diagnosed at this location?	54. How many times did you visit this place?
Name of third location/facility:	Circle: Public Clinic Private Clinic Clinic at Public Hospital Clinic at Private Hospital Private Doctor Health Post Spiritual Healer Pharmacy Other (Specify)_____	Circle: Yes If YES, skip this section and go to Section 4 (DIAGNOSIS) No	Circle: One Two Three Four Five or more (Specify number) _____

55. How long on average did you spend traveling to and from the facility?	56. How long on average did one of these visits take? (include waiting time, consultation and tests)	57. Did any family or friend accompany you on these visits?	58. How many visits did your family member/friend accompany you for?
Write total travel time: _____ Hours Minutes	Write total consultation time: _____ Hours Minutes	Circle: Yes No	Circle: None Almost none Some Most All

59. What did you or your accompanier have to pay for at this establishment or following your appointments?

WRITE ZERO here if patient had no expenditures:_____

WRITE TOTAL if patient only knows total amount:_____$

	Amount	Per Visit	Total
Parking			
Travel			
Registration fee			
Paperwork fee			
Consultation			
Blood Tests			
Medication (TB or Non-TB)			
X-ray			
Food			
Other (Specify) _____			

3.4 Fourth, Fifth, and Sixth Location Visited Prior to Diagnosis (if hospitalized, fill in details in SECTION 5 – Hospitalization Period)

60. How many VISITS did you make to additional health establishments prior to your diagnosis? (Include all visits made to the fourth, fifth and sixth sites listed in Q30, excluding hospitalizations)	61. What did you or your accompanier have to pay for at all of these additional visits? WRITE ZERO here if patient had no expenditures:_____ WRITE TOTAL if patient only knows total amount:_____$			
Circle: One Two Three Four Five or more (Specify number) _____		Amount	Per Visit	Total
	Parking			
	Travel			
	Registration fee			
	Paperwork fee			
	Consultation			
	Blood Tests			
	Medication (TB or Non-TB)			
	X-ray			
	Food			
	Other (Specify) _____			

62. Where were you diagnosed for Tuberculosis (TB)? (If diagnosed while hospitalized, write HOSPITAL below, skip the remainder of this section and collect information about the stay in SECTION 5)	63. How many times did you visit this clinic during your diagnosis period? (including all initial visit(s), sputum inductions and visit where patient was informed of diagnosis)	64. How long on average did you spend traveling to and from the facility?	65. How long on average did one of these visits take? (including waiting time, consultation and tests)	66. Did any family or friend accompany you on these visits?	67. How many visits did your family/friend accompany you for?

Write location:	Circle:	Write total travel time:	Write total consultation time:	Circle:	Circle:
_____	One	_____	_____	Yes	None
	Two	Hours	Hours	No	Almost none
	Three	Minutes	Minutes		Some
	Four				Most
	Five or more				All
	(Specify number)				

SECTION 4: Diagnosis Period

Explain to the patient that the following section collects information on the establishment in which their diagnosis was made.

68. What did you or your accompanier have to pay for at the establishment that you were diagnosed at, or following your appointments?

WRITE ZERO here if patient had no expenditures:_____

WRITE TOTAL if patient only knows total amount:_____$

	Amount	Per Visit	Total
Parking			
Travel			
Registration fee			
Paperwork fee			
Consultation			
Blood Tests			
Medication (TB or Non-TB)			
X-ray			

Other Tests			
Food			
Other (Specify) _____			

SECTION 5 Hospitalization periods:

Explain to the patient that the following section collects information about the period when they were hospitalized. It is only for patients who have been ADMITTED into hospital FOR ANY REASON for at least ONE NIGHT due to their illness (including any hospitalization in the SIX MONTHS leading up to their TB diagnosis). If the patient was not admitted into hospitals then SKIP THIS SECTION.

<table>
<tr><td>69. Were you hospitalized for any illness in the 6 months leading up to your diagnosis of TB?</td><td>70. Were you diagnosed for any of the following conditions?</td><td colspan="2">71. Where were you hospitalized for these conditions?</td></tr>
<tr><td rowspan="4">Circle:

Yes

No

If NO skip to SECTION 6</td><td rowspan="4">Circle:

Pneumonia

Bronchitis

Asthma

Respiratory problems

Lung conditions

Weight loss

Other

Specify_____</td><td>Write hospital name(s):

(please check correct period for each stay)</td><td>Duration of hospital stay:

(please circle units)</td></tr>
<tr><td>1) Name: _____

Pre-diagnosis

During diagnosis

Post-diagnosis</td><td>days weeks months</td></tr>
<tr><td>2) Name: _____

Pre-diagnosis

During diagnosis

Post-diagnosis</td><td>days weeks months</td></tr>
<tr><td>3) Name:_____

Pre-diagnosis

During diagnosis

Post-diagnosis</td><td>days weeks months</td></tr>
</table>

5.1 – Information pertaining to the Most Recent Hospitalization

The following questions relate ONLY to the most recent hospital stay. Make sure the patient is only giving information related to the most recent hospitalization.

72. On your MOST RECENT stay did any family/friends STAY with you while in hospital? (i.e. sleep in the hospital with you)	73. For how many days?	74. On your most recent stay did any family/friends VISIT you while you were in hospital?	75. How long on average did ONE visit last?	76. On how many days did you have friends or family visiting you?
Circle: Yes No If NO skip to Q74	Circle: None Almost none Some Most All	Circle: Yes No If NO, skip to Q77	Write time: Minutes Hours	Circle: None Almost none Some Most All

77. On your MOST RECENT hospital stay, what did you have to pay for?

WRITE ZERO here if patient had no expenditures:_____

WRITE TOTAL if patient only knows total amount:_____$

	Amount	Per Day	Total
Parking			
Travel			
Registration fee			
Paperwork fee			
Consultation			
Blood Tests			
Medication (TB or Non-TB)			
X-ray			
Food			
Sheets			
Other (Specify) _____			

SECTION 6: DOT/DOSSETTE pill collection visits

Carefully explain that the following questions are for pill collection visits. This section is ONLY APPLICABLE TO PATIENTS WHO HAVE CLINIC VISITS THAT ARE EXCLUSIVELY FOR THE COLLECTION OF TB PILLS. This strictly means clinic visits to collect one dose of TB pills, and does NOT INCLUDE VISITS WHERE ANYTHING ELSE IS DONE. If the patient's treatment is SELF ADMINISTERED or if a pill collection visit is combined with follow up/monitoring activities (ex. taking blood, or looking at side effects) by a nurse or doctor, skip this section and record this information the next section, SECTION 7.

78. How often do you go to the clinic for DOT to pick up pills ONLY?	79. How long does it take you to travel to and from the facility to collect your pills?	80. How long does it take to pick up your pills?	81. Do any family members or friends accompany you on these visits?	82. How many visits do your friends or family member accompany you for?
Circle: Daily Once per week Twice per week 3 times per week	Write total time: _____ Hours Minutes	Write total time: _____minutes	Circle: Yes No	Circle: None Almost none Some Most All

83. What did you or your accompanier have to pay for during DOT (pill collection visits)?

WRITE ZERO here if patient had no expenditures:_____

	Amount	Per Visit
Parking		
Travel		
Medication (TB or Non-TB)		
Food		
Other (Specify) _____		

SECTION 7: TB Follow-up visits

Explain to the patient that this section collects information on all visits made to the clinic during TB follow up. This includes monthly TB follow up visits to the doctor, or more frequent visits for combined visits to collect medication and have blood tests etc. This section includes all visits except for strict DOT visits that have already been discussed in SECTION 6.

84. Where do you go for your TB follow up appointments?	85. How regularly do you go to see the doctor who is following you for TB since you were diagnosed? (To see nurse/doctor for any TB related medical evaluation, tests etc.)	86. How long on average does one of these follow up visits take (including travel time, all waiting time and seeing the doctor)?	87. Do any family/friends accompany you on these visits?	88. How many visits have your family member/ friend accompanied you for?
Write Location: _____	Circle: Monthly Twice a month Weekly	Write total time: _____ Hours Minutes	Circle: Yes No	Circle: None Almost none Some Most All

89. With these follow up visits in mind, what did you or your accompanier have to pay for at the Doctors office and EACH VISIT? WRITE ZERO here if patient had no expenditures:_____		
	Amount	Per Visit
Parking		
Travel		
Registration fee		
Paperwork fee		
Consultation		
Blood Tests		
Medication (TB or Non-TB)		
X-ray		
Food		
Other (Specify) _____		

SECTION 8: Events throughout Illness

Explain to the patient that the following questions pertain to events that have occurred throughout their illness, and how they feel their TB has affected their daily activities and their family. The questions at the end of this section are slightly more general than previous questions. The patient may need to be reminded of some of the disruptions that they mentioned earlier in the interview, or that you may have picked up on at any point throughout the interview.

90. Have you missed any additional time from your principal daily activities (work/school) because of your TB illness? (Excluding visits to see the doctor or hospitalization, which have been captured in previous sections)	91. Have you needed to borrow/ been given any extra money because of your TB illness?	92. Has your TB illness affected your ability to complete your household chores and activities?	93. Which of the following has your TB caused you to have problems completing?
Circle: Yes No IF Yes, How long in total TOTAL:_____ Days Weeks Months	Circle: Yes No IF Yes, Write TOTAL: $_____	Circle: Yes No If NO, skip to Q96	Circle: Child care Laundry Cooking or meal preparation Shopping House maintenance Carrying loads Other_____

<table>
<tr><td>94. Have you received any extra help (PAID or UNPAID) because your illness has affected your ability to complete these chores?</td><td colspan="2">95. Please specify the kind(s) and duration of help the patient (or family) has received due to the patient's illness:</td></tr>
<tr><td rowspan="3">Circle:

Yes

No

If NO, skip to Q96</td><td>Type of Help

Circle:</td><td>Time and Cost

(complete the information for the relevant time period)</td></tr>
<tr><td>Paid</td><td>Pre-diagnosis

How much did you pay for this extra help PER WEEK? $_____/week

For how many weeks: _____weeks

Post-diagnosis

How much did you pay for this extra help PER WEEK? $_____/week

For how many weeks: _____weeks</td></tr>
<tr><td>Unpaid - Family</td><td>Pre-diagnosis

Average number of additional hours per week spent with or for the patient _____hours

For how many weeks: _____weeks

Post-diagnosis

Average number of additional hours per week spent with or for the patient _____hours

For how many weeks: _____weeks</td></tr>
</table>

	Unpaid – other Specify _____	Pre-diagnosis Average number of additional hours per week spent with or for the patient _____hours For how many weeks: _____weeks Post-diagnosis Average number of additional hours per week spent with or for the patient _____hours For how many weeks: _____weeks

96. Are you currently buying any supplements (e.g. energy drink, vitamins, medicine…) due to your illness? (not including costs already captured in previous sections)	97. How much do you spend on these items per month?		98. Throughout your illness, how has your household routine changed since you have been diagnosed with TB? (This includes *changing rooms to sleep, using different utensils and dishes)*	99. How has TB affected your family (your children or between you and your partner)?
Circle: Yes No If NO, skip to Q98	Item	Extra cost /month	Please explain: _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	Please explain: _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

SECTION 7 – TB FOLLOW-UP VISITS

100. How does TB affect you physically today?	101. How does TB affect you socially today? *(This includes effects related to stigmatization isolation, rejection and fear)*	102. How do you feel that TB will impact you and your family in the future?
Please explain: _____ _____ _____ _____ _____ _____ _____ _____ _____	Please explain: _____ _____ _____ _____ _____ _____ _____ _____ _____	Please explain: _____ _____ _____ _____ _____ _____ _____ _____ _____

SECTION 7 – TB FOLLOW-UP VISITS

Extra question: Do you have any other concerns about your medical visits, your experiences with TB or the effect that TB has had on you and your family?

_____
_____
_____
_____

Extra Pages for Longer Answers:

_____
_____
_____
_____

Please note that if the patient provides you with information that makes you think that they may be carrying out activities that are affecting their TB treatment or may be damaging their health, or if the patient expresses fears and doubts about their illness, please ask the patient if they would mind if you relayed some of their concerns to the nurse in charge of their care for further follow up.