Ministry of Health and Social Welfare
The Gambia

MRC The Gambia Unit

The Gambian Survey of Tuberculosis Prevalence (GAMSTEP)

Medical Research Council Unit-The Gambia

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Foreword- Minister of Health and Social Welfare

The Ministry of Health and Social Welfare (MoH&SW) recognises that Tuberculosis (TB) is a disease of great public health importance in The Gambia. Over the years, the National Leprosy/Tuberculosis Control Programme (NLTP) has intensified TB case finding and detection and achieved higher favourable treatment outcomes – 87% and 89% cure and treatment success rates respectively in the 2011 cohort of TB patients. The financial support from the Global Fund to fight AIDS, TB and Malaria (GFATM) Round 9 TB grant significantly contributed to the success registered by the NLTP in the control of TB in The Gambia.

In the past, The Gambia relied on estimates of the burden of TB. However, the Gambia Survey of Tuberculosis Prevalence (GAMSTEP), a population based TB prevalence survey, has enabled us to achieve a significant milestone in the history of the Ministry. The survey made it possible for us to measure directly the burden of TB for the first time throughout the country. The results of the survey revealed that the prevalence of TB in The Gambia is four times less than the 2010 estimates made by the World Health Organisation (WHO).

GAMSTEP has provided us with a baseline on the actual burden of tuberculosis in the Gambia. I hope that we will, in line with our National TB Strategic Plan (2013 – 2017) and our international commitments to the MDGs and the Global Plan to Stop TB, conduct a second GAMSTEP in five years to measure how well we are doing to control this disease.

I wish to thank the Medical Research Council (MRC), The Gambia for successfully accomplishing GAMSTEP, a challenging but important undertaking. The process of identifying pulmonary TB cases in this prevalence survey posed a challenge as diagnostic methods were labour-intensive and large numbers of survey participants needed to be screened because of the low prevalence of TB in The Gambia. The MRC has been collaborating with the Ministry in the area of research. The GAMSTEP is one of the most important research outcomes for TB control in The Gambia. We are also proud that in the African region, the GAMSTEP is an important achievement.

I also thank the GFATM and the MRC Unit-The Gambia for funding GAMSTEP. The key findings in this survey are important and the MoH&SW will use them to improve TB control efforts in the Gambia as part of our continuing commitment to the control of this disease in The Gambia.

Honourable Omar Sey

Minister of Health & Social Welfare

Message- Director, Medical Research Council Unit, The Gambia

The successfully completed First Nationwide Gambian survey of TB prevalence, called GAMSTEP, is one of the numerous signs of the extremely good collaborative relationship between MRC and the Government of the Gambia, more specifically the MOHSW, the National Leprosy and TB Programme and other partners. Such collaboration is in line with the unit's vision of leading research with potential of direct impact on quality of life and health in the Gambia and beyond.

TB is a global priority covered in the MDGs and the WHO STOP TB strategy with TB prevalence as a key impact measure. This survey funded by the Global Fund to fight AIDS, TB and Malaria (GFATM) with significant investment of financial and human resources by the MRC was a priority for the unit as part of its research activities in the disease control and elimination theme, which I lead.

The MRC shares the vision of the MOHSW in aiming to reduce TB to levels where it ceases to be of public health concern in The Gambia. Specifically, the MRC is committed to quality research to generate evidence for successful interventions that can be deployed to achieve this vision in the Gambia as a case study and the sub region and continent at large.

The survey, the first in West Africa, while highlighting the success of TB control activities has already identified gaps and areas of possible interventions that the MRC is willing to address or help with in collaboration with the NLTP, MOHSW and other stakeholders in the fight against TB. Now that this survey has provided the first description of TB epidemiology in The Gambia based on actual data, efforts must now shift to consolidating previous gains, implementation of new and cost effective interventions to achieve TB control as well as support ongoing surveillance.

The survey and ongoing surveillance suggests there is an emergence albeit sporadic of drug resistant forms of TB. The unit is willing to provide support-laboratory and technical expertise through its researchers as part of efforts to better understand this phenomenon and improve patient management.

On behalf of the MRC, I congratulate the MOHSW and NLTP on this significant achievement, which places The Gambia on the same stage as other African countries with more resources and receiving global attention because their larger population and expected TB burden. The MRC looks forward to an enduring partnership with the MOHSW in the next phase of TB control in The Gambia.

Prof. Umberto d'Alessandro MD PhD
Director,
MRC Unit- The Gambia

Message- Manager, National Leprosy and Tuberculosis Programme, The Gambia

The Tuberculosis prevalence survey conducted by the MRC Unit-The Gambia in collaboration with the Ministry of Health and Social Welfare of the Government of the Gambia is the first of its kind since the establishment of The Gambian National Leprosy and Tuberculosis Control Programme (NLTP). The survey is a major breakthrough in the control of tuberculosis in our country. The results have shown that although TB continues to be a major public health problem in The Gambia, the true burden is approximately four times less than the current 2010 WHO estimates.

It is clear from the survey that TB disproportionately affects the males rather than females and is mainly concentrated in urban settings. The survey findings are consistent with routine TB surveillance data. The NLTP will use the findings, with the support of our partners to improve the national programme. Based on what we now know, we plan to focus more on densely populated urban settlements in the Greater Banjul Area; increase routine contact investigation; and, strengthen our capacity to detect more smear negative culture positive TB cases. In addition, the NLTP will increase its efforts to reach other high risks groups such as people living with HIV/AIDS (PLWHIV), children under the age of 15 years and people within congregate settings such as prisons.

I would like to thank all our partners in the fight against tuberculosis in The Gambia. These include the GFATM, who funded this survey, the MRC –The Gambia under the leadership of Professor Tumani Corrah at the start of the survey and now Professor Umberto d'Alessandro. In addition, our appreciation goes to the WHO for the providing us with valuable technical support, the community leaders for mobilizing people for this essential undertaking and above all, all those household, families and individuals across the length and breadth of this country who participated in the survey.

My message to the public is the same as before: TB is preventable, treatable and curable. If you or anyone around you has symptoms such as cough for two weeks or more, please visit or refer this other person to the nearest clinic for a TB test. If we diagnose and treat TB early, we can prevent TB transmission in our communities. The Government of The Gambia is fully committed to the control of TB and provides TB services free of charge to anyone living in The Gambia.

Mr. Adama Jallow
Manager, National Leprosy and TB Programme

Acknowledgements

The Survey Team is grateful to the Ministry of Health and Social Welfare for giving them the opportunity to conduct this survey.

We would like to thank the GFATM and the MRC Unit-The Gambia for funding the survey. We acknowledge the technical support provided by the WHO TB Impact Measurement Taskforce in particular Dr. Ikushi Onozaki and Dr Babis Sismanidis, who significantly contributed to the successful implementation of the survey.

We appreciate the high-level support and the cooperation of key officers of the Ministry of Health and Social Welfare especially the Minister of Health, the Permanent Secretary, the Director of Health Services and the Director of the National Public Health Laboratories. We would also like to thank the Governors of the Regions, Mayors of Municipalities, Directors and Senior Officers at Regional Health Teams, Regional and District Leprosy and TB Control Officers, Leprosy and TB Inspectors (LTIs), Chiefs, Alkalos, Members of the National Assembly, Counsellors and other community leaders for their support in ensuring the smooth operation of field activities. We appreciate the efforts of community volunteers, community radio and television services, and host communities/survey clusters.

We are grateful to members of the Survey Steering Committee; the Technical Advisory Group especially Dr. Marina Tadolini and Dr. Sian Floyd; and, the WHO Representative Dr. Thomas Sukwa and Country Office for their technical inputs, which contributed to the quality of the survey. We acknowledge Dr. Etienne Leroy-Terquem (France), Dr. Jan van den Hombergh and Dr John Mayanda (PharmAccess, Tanzania), and Dr Bimbo Fasan (Lagos, Nigeria) who provided radiological expertise in training and quality control for x-rays.

The survey team is grateful for the support and commitment of the past and current leadership of the MRC Unit-The Gambia in particular, Professor Tumani Corrah; Professor Umberto d'Alessandro; Professor Richard Adegbola (former Head of the Bacterial Disease Programme); Dembo Kanteh (MRC Research Support Office); Michael Kilpatrick and later, Peter Noble (MRC operations); the MRC Transport Unit, and the Finance and Procurement Unit whose efforts were invaluable in ensuring the successful completion of the survey.

We would like to thank Dr. David Jeffries and Ms. Lindsay Kendall for statistical support, Dr. Adedapo Bashorun, Dr. Christopher Linda and Dr Semeeh Omoleke and team for their excellent work in the field; Dr. Martin Antonio and team for the laboratory support; Simon Donkor, Maimuna Sowe and team for data management; and Ma Ansu Kinteh, Simon Donkor and Elina Cole for their administrative oversight of the components of the survey.

Finally, our sincere thanks go to all those who participated because your participation made this survey possible.

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List of Abbreviations

AFB	Acid-fast bacillus
AIDS	Acquired Immune Deficiency Syndrome
BHS	Basic Health Staff
CCU	Central Coordinating Unit
CI	Confidence Intervals
CXR	Chest X-ray
DEFF	Design Effect
DOTS	Directly Observed Therapy Short course
EPTB	Extra pulmonary Tuberculosis
FPC	Finite population Correction
FNAC	Fine needle aspiration cytology
FM	Fluorescence Microscopy
GDF	Global Drug Facility
GFATM	Global Fund to fight AIDS, TB and Malaria
HIV	Human Immunodeficiency Virus
IPW	Inverse probability weighting
MDG	Millennium Development Goal
MDR-TB	Multidrug-resistant TB
MI-	Missing values imputation
MoH&SW	Ministry of Health and Social Welfare
MOTT	Mycobacterium other than TB
NGO	Non-governmental organization
N/P	Notification/Prevalence
NLTP	National Leprosy and Tuberculosis Programme
NPHL	National Public Health Laboratories
NTM	Non-Tuberculous Mycobacteria
OR	Odds ratio
PAL	Practical Approach to Lung Health
PPS	Probability proportionate to size
PSU	Primary sampling unit
PTB	Pulmonary tuberculosis
SOP	Standard operating procedures
TB	Tuberculosis
WHO	World Health Organization
ZN	Ziehl-Neelsen

Executive summary

The Medical Research Council Unit-The Gambia in collaboration with the National Leprosy and Tuberculosis Programme, Ministry of Health and Social Welfare, conducted the Gambian Survey of Tuberculosis Prevalence (GAMSTEP). Technical partners were the World Health Organization (WHO)-Geneva and the National Public Health Laboratories. The Global Fund to fight AIDS, TB and Malaria and the MRC Unit, the Gambia funded the survey.

The overall aim of this survey was to provide an accurate estimate of TB disease prevalence, estimate the proportion of cases detected and treated by the TB programme and identify factors responsible for the low estimate of case detection in The Gambia.

The target sample size was 55,281 aged ≥15 years in 80 clusters nationwide. Each cluster was an aggregate of ≥2 census enumeration areas and expected to have 550-650 persons. As recommended, all participants were screened for TB symptoms and had a chest radiograph (CXR). Those with positive symptom screen and/or abnormal CXR findings submitted two sputum specimens (spot and spot or spot and morning).

The GAMSTEP team conducted the survey between December 2012 and January 2013. The MRC TB research and diagnostic laboratory processed all survey samples. Out of 55,832 eligible persons, 43,100 (77.3%) participated. Participation was higher in rural (83%) compared to urban areas (71%). The average number of participants per cluster was 540 with a range of 351 to 642. The mean numbers of participants were 502 (ranging from 351-607) in urban and 570 (ranging from 482-642) in rural survey clusters. The survey identified 5,948 of 43,100 (13.8%) as suspects based on the presence of symptoms and/or suggestive abnormalities on chest X-ray. Majority (91.4%, 5436) of identified suspects (5948) submitted at least one sputum specimen and had laboratory results. Most of those who submitted samples, 5309 (97.7%) of 5436 had 2 sputum and 2 culture results.

The survey identified 77 bacteriologically confirmed TB cases consisting of 28 smear and culture positive cases; 43 smear negative but culture positive cases; and 6 smear positive but culture negative cases. The overall prevalence of bacteriologically confirmed Pulmonary TB (PTB) in the survey population aged ≥15 years was 212/100,000 (95%CI: 152-272), smear negative culture PTB was 124/100,000 (95%CI: 75-172) and smear positive PTB was 90/100,000 (95%CI: 53-127).

The prevalence of bacteriologically confirmed, smear negative-culture positive and smear positive PTB were higher in urban populations: (266 [95%CI: 164-368], 174 [95%CI: 83-264] and 96 [95%CI: 43-148] /100,000 population ≥15 years) compared to rural parts of the country (169 [95%CI: 99-238], 83 [95%CI: 36-131] and 86 [32-140] /100,000 population ≥15 years) respectively. In addition,

the prevalence of bacteriologically confirmed PTB was approximately three-times higher in males (333 [95%CI: 233-433] /100,000 population ≥15 years) compared to females (109 [54-164] /100, 000 population ≥15 years). The same pattern was seen with smear negative culture positive TB (186 [100-271]/100, 000 population ≥15 years vs. 70 [34-107]/ 100, 000 population ≥15 years for males and females respectively) and for smear positive TB - males (148 [95%CI: 88-208]/ 100,000 population ≥15 years) and females (41 [95%CI: 0-83] /100, 000 population ≥15 years population).

When the data from the TB prevalence survey is extrapolated taking into consideration type of TB and all age groups covered by the survey, **the overall national prevalence of all forms of TB in The Gambia is 128 (95%CI: 94-162)/100,000 population which is 3.8 times lower than the 490/100,000 estimate in the 2013 Global TB Report**. The prevalence of smear positive TB is 53 /100,000 population.

Based on survey data, the revised TB case notification rate is now 130/100,000 population. With this reliable prevalence estimate, **the revised TB incidence for The Gambia is 175 (95%CI: 135-215) / 100, 000 population**.

Of all the TB cases detected by the survey, 95% were not on treatment or known to the TB care service. Only 57% (43 of 77) were symptomatic at diagnosis, whereas 84% (65 of 77) had CXR abnormalities suggestive of TB during review in the field. About 58% (25 of 43) of survey cases had been to a health care facility-a public health facility in 84% of respondents.

The key findings from this survey are:

1. A directly estimated population prevalence of TB showing prevalence of bacteriologically confirmed TB is almost four times less than the current WHO estimate.
2. In addition, the prevalence of smear positive TB is more than five times less than the estimated value.
3. Smear negative, culture positive TB was more prevalent than smear positive TB as majority of survey cases were smear negative and culture positive.
4. TB in the Gambia disproportionately affects adult males more than females.
5. TB is mainly urban as bacteriologically confirmed TB in urban Gambia is more than 1.5 times higher in urban settlements compared to the rural parts of the country.
6. Diagnosis of TB in just a little over half of the survey cases was based on symptoms alone and most (95%) survey TB cases were unknown to the national TB care services.

In the next strategic planning period for TB control efforts in The Gambia, the following are important

1. The national TB strategic plan should be revised to reflect the current prevalence and incidence of TB and the country TB control targets should now be driven by detection and notification of not just sputum smear positive pulmonary TB but all forms of TB.
2. Efforts need to be re-directed towards reducing the community burden of undetected TB and may include some active or enhanced case finding interventions
3. Training, re-training and introduction of strategies like Practical Approach to Lung Health (PAL) are required to reduce the missed opportunities for TB diagnosis within the public sector
4. Novel targeted TB related interventions need to be planned and implemented to the male population. ,
5. Access to diagnostic options beyond smear microscopy need to be increased to improve diagnosis of smear negative TB including operational research to assess the utility and cost effectiveness of new diagnostic algorithms including CXR and deployment of new technologies such as the Xpert® RIF/MTB and other nucleic acid amplification tests as they become available.
6. Strategies need to be developed to target High-risk TB groups that include for example household TB contacts, urban dwellers, people living with HIV/AIDS, and persons in congregate settings.
7. TB programme activities need to take into account increasing TB heterogeneity across the country.
8. Multidisciplinary research is required to understand why TB notification is increasing/remaining stable despite achievement of the DOTs (Directly Observed Therapy Short course) TB case detection and treatment success targets for almost 5 years
9. A situational assessment will be required following implementation of a post survey TB control action plan in 5 years to assess the cost effectiveness of conducting a repeat survey.

1. Introduction

Tuberculosis is a chronic infectious disease that has been with humanity since antiquity with evidence of the disease documented in Egyptian mummies as far back as 4,000 BC. TB in humans is caused by *Mycobacterium tuberculosis complex* that is made up of *M. tuberculosis, M. africanum, M. canetti, M. microti and M. bovis* (no longer as common since introduction of milk pasteurization)

Tuberculosis is a disease caused by *Mycobacterium tuberculosis*. It is an infection with systemic spread. However, it typically affects the lungs (pulmonary TB-PTB) but can affect other parts of the body as well (extra pulmonary TB-EPTB). TB is transmitted via the airborne route with spread by aerosols suspended in air when people with PTB expel the bacilli as they cough, sneeze, talk, etc.

In The Gambia, majority of TB is caused by *M. tuberculosis* (60%) and 40% TB by M. africanum. The clinical manifestations and diagnostic methods for TB remain the same regardless of the infecting strain. [1] Without treatment, mortality rates are high. Treatment using combinations of anti-TB drugs, developed in the 1940s and 1950s, can dramatically reduce mortality rates. The MRC played a lead role in efforts to combat TB and one of its achievements is the MRC-funded landmark trial in 1948, of the first anti-TB drug, streptomycin following its discovery in 1944.

Tuberculosis (TB) remains a significant public health problem particularly in developing countries. Currently, TB is the leading cause of mortality among infectious diseases worldwide with almost all of the cases and mortality (95% and 98% respectively) occurring in developing countries. It is more common in areas where poverty, malnutrition, poor general health and social disruption are present. The 2015 global targets include a decrease in TB incidence (MDG Target 6.c) and a reduction of 50% of TB prevalence and death rates from the 1990 levels.[2] Although there has been substantial global progress towards achieving the MDG targets, the global burden of TB remains enormous despite the availability of highly efficacious treatment for decades. About 2 billion people, a third of the world's population have latent *M. tuberculosis* (LTBI).[3] In 2011 alone, there were an estimated 8.7 million new cases of TB (13% co-infected with HIV) and 1.4 million associated deaths. Approximately 80% of the world's TB cases can be found in 22 high-burden countries and 9 (41%) of them are in sub-Saharan Africa which also home to >80% of HIV co-infected TB cases. The African Region has 24% of the world's cases, and yet it is only home to 13% of the world's population. Sadly, current projections show the Africa region is not going to achieve 50% reduction in TB prevalence by 2015. [2]

The two targets for TB control that form the cornerstone of the WHO DOTS strategy are 70% case detection rate and an 85% cure rate by the year 2000. The WHO launched these two targets in 1994, and the WHO Stop TB Strategy endorsed them in 2006. [4]

Despite increasing availability of good quality data, current estimates of TB incidence, prevalence and mortality are largely based on estimates from working data of less than desired quality. Therefore, estimates of disease burden have to be improved especially in Africa to track progress in TB control towards 2015 and 2050. Unfortunately, there are well-described issues with reliability of data from Africa. Of the three TB impact outcomes captured by global TB control targets, only TB prevalence (the number of cases of TB in a population at a given point in time) can be directly measured. Nationwide surveys in countries with a high burden of TB can be conducted on a sample of approximately 50, 000 people and at costs ranging from US$ 1–4 million per survey.[5] Before the Ethiopian survey in 2011, no country with high burden of TB in sub-Saharan Africa had conducted a survey according to international recommendations in over 50 years.[6] Most existing surveys had been conducted in Southeast Asia and some of the countries in this region had experience with multiple surveys to measure disease trend.

In many resource limited and high burden TB settings where TB case notification data from routine surveillance is incomplete and correlates poorly with TB incidence, TB prevalence surveys are effective tools for monitoring the impact of TB disease control activities especially if repeated at prescribed intervals to show trend in TB burden. Apart from providing an impact measure of disease control efforts, accurate estimates of the true burden of TB disease help inform evaluation, formulation of strategy and planning of interventions by TB disease control programmes.[5]

1.1. Tuberculosis Epidemiology in The Gambia

1.1.1 The Gambia

The Gambia is the smallest mainland country in Africa bordered in the North, South and East by the Republic of Senegal and the West by the Atlantic Ocean. It has a total land area of about 10,689 square kilometres extending approximately 400 kilometres eastwards. For the 2003 census, the country had six local government administrative areas (LGA) and 2 municipalities made up of 39 districts in total. During the study period, there were 40 districts, 1860 settlements and 2477 Enumeration Areas (EA) with 53.7% (1328) of the EAs defined as urban. A settlement is a population unit/centre with an Alkalo (Village Head). The smallest census reporting unit, the EA has 65 households and a population of about 500-700 persons.

The country now has eight local government administrative areas (LGA) and Banjul and Kanifing Municipalities. Elected mayors head the two municipalities whilst Governors head the remaining five regions. There are 40 districts, 1886 settlements. These districts are headed by Chiefs and settlements headed by “Alkalos”.

The Gambia has had a census every decade since 1973. In 1993, the country's population was 1,038,145 increasing to 1,364,507 in 2003 and the 2012 estimate was 1,791,000 with a growth rate of 2.34% (July 2011 estimates).[7] About 57% of the population reside in urban areas of the country and 50% is ≥15 years old. The 2013 census was recently completed.

1.1.2 TB Epidemiology

The World Health Organization (WHO) estimates for incidence and prevalence of TB in the Gambia rose from 258/100,000 and 350/100,000 respectively in 1990, to 279/100,000 and 455/100,000 in 2011.[8] The NLTP found 1,783 cases of all forms of TB in 1990, with increases to 1904 in 2007. Table 1 displays the pattern of notification from 2008-2012. Since 2009, treatment success rate has exceeded 85%. However, TB case detection based on WHO estimates of disease burden remains unsatisfactory at 47% (39–56).[9] However, the decreasing/stable TB notification rate for new TB and smear positive TB while not indicative of true TB incidence definitely contradicts WHO estimates.

In The Gambia, tuberculosis disproportionately affects the most productive age group of society (15 – 59 years) and the majority of notified patients are males. The TB epidemic is more concentrated in the densely populated area of the Gambia called the Greater Banjul Area (GBA), which is home to about 60% of the national population.[10] About 80% of all cases notified in 2011 were from this part of the country. This suggests there might be issues with access to TB care in the more remote parts of the country or increased effort is required in the urban areas to increase TB notification.

Table 1. Pattern of TB notification in The Gambia from 2008-2012[10]

	2008	2009	2010	2011	2012
Population	**1,636,107**	**1,681,734**	**1,728,394**	**1,776,103**	**1,824,777**
Total new smear positive cases notified	**1,300**	**1,316**	**1,344**	**1,375**	**1,375**
Total new smear negative, extra pulmonary, other and unknown cases notified	**726**	**763**	**686**	**692**	**693**
Total number of new cases (notified and projected)	**2,026**	**2,079**	**2,030**	**2,048**	**2,050**
Number of cases per 100,000 population	**124**	**124**	**117**	**115**	**112**

The WHO conducted the first surveys of TB infection and disease in The Gambia in 1958 and 1960 respectively.[11] In 1984, a tuberculin survey was performed around Farafenni in the North Bank

Region.[12] However, since the NLTP was established, no formal surveys have been conducted to obtain accurate data for the burden of disease in The Gambia. With the success of the country's application to the GFATM, funding became available to accurately quantify the burden of TB in The Gambia. The Gambian NLTP and its parent, the Ministry of Health and Social Welfare were concerned about the possibility that significant numbers of TB cases were not being detected in both rural and urban communities. This concern fuelled the need to obtain reliable estimates of the true burden of TB in the country. To achieve this goal, the NLTP partnered with the MRC Unit-The Gambia, an institution with a long history of competently executing large-scale epidemiologic projects, to strengthen its operational research capacity to design and conduct a nationwide TB survey.

1.1.3 TB-HIV epidemiology and HIV prevalence in the country

The Gambia is classified as a low HIV prevalence African country.[2] The epidemic has remained below the threshold of 5% since diagnosis of the first case of HIV in 1987. The main methodology used by The Gambia to estimate prevalence is the National Sentinel Surveillance (NSS) conducted among antenatal women, aged 15-49 years. The current (2007) surveillance data puts the HIV prevalence in The Gambia at 1.4%. This prevalence does not vary significantly across the country.

In 2011, 74% of all TB cases had known HIV status and 329 of 2333 (15.9%) were co infected with HIV. HIV treatment coverage for TB/HIV co infected patients was poor as only 3% of HIV co infected TB cases received antiretroviral therapy (ART). The NLTP implements collaborative TB/HIV activities with the National AIDS Secretariat (NAS) including provider-initiated HIV counselling and testing (PHCT) for TB patients; provision of Antiretroviral Therapy (ART); and Cotrimoxazole Preventive Treatment (CPT) for co-infected cases. Since 2011, referral procedures between HIV and TB care facilities have been established and captured in the TB/HIV policy guiding the implementation of joint activities. This has resulted in higher ART and CPT uptakes of 46% and 93% respectively.

1.1.4 History of the National TB Programme

The National Leprosy and TB programme (NLTP) was established in 1984 and it adopted the Directly Observed Therapy Short course, (DOTS) strategy in 1985 and again in 1993 following the formal launch by the WHO. Over time, geographical DOTS coverage has steadily increased to 100%.[1, 3]

The Director of Health Services within MOH&SW is responsible for management coordination and implementation of the NLTP. The structure of the NLTP is described below.

1.1.4.1 Central Programme Unit of the NLTP

The staff of the Central Unit of the NLTP comprises of the Programme Manager, Deputy Programme Manager, Programme Officer, Senior Leprosy and TB Control Officer, Leprosy and TB Officer and a Monitoring and Evaluation Officer.

1.1.4.2 Regional Level

At the regional levels, the Regional Leprosy Tuberculosis Control Officer (RLTO) who is part of the Regional Health Team (RHT) is responsible for overall health planning, coordination, management and implementation - including tuberculosis care and control activities. The RHT coordinates all TB activities in a region among the different stakeholders comprising the public health sector, NGOs and the private sector.

1.1.4.3 Facility level

At the facility level, a Leprosy Tuberculosis Inspector (LTI) is responsible for diagnosis, treatment, and follow-up of TB cases.

1.1.4.4 Community level

The Community Health Nurses (CHNs) and Village Health Workers (VHWs) identify TB suspects in the community and either collect and transport sputum samples to the laboratory in their catchments area or refer the suspects to the TB diagnostic and treatment centres for further investigations. The CHNs and VHWs are responsible for DOTs delivery at the community level.

1.1.5 TB Diagnostic capacity in The Gambia

Routine TB diagnosis is by smear microscopy, which is a performed at all major health centres countrywide. TB cultures are only available for re-treatment surveillance at the National TB Reference and the MRC TB Research and Diagnostic laboratories. Since 2011, the urban centres with support from the MRC Unit-The Gambia and funding from the GFATM switched to routine use of fluorescent microscopy for TB diagnosis. The National Public Health Laboratories, a directorate of the MOH&SW has overall responsibilities for all laboratory services in the country. There is limited access to chest radiographs, fine needle aspiration cytology (FNAC) and other diagnostic tools to support diagnosis of smear negative and extra pulmonary forms of TB. The GeneXpert platform is

available at the MRC TB Research and Diagnostic laboratory and from early 2014 at the National Public Health Laboratories.

1.1.6 Multidrug resistant TB (MDR-TB)

The MRC Unit conducted the only resistant TB (MDR-TB) survey to date in 1999. The prevalence of MDR in primary and retreatment TB cases was 0% and <0.5% respectively. [13] There have been occasional cases of MDR and significant challenges with maintaining regular routine surveillance of re-treatment cases for resistant TB forms. Efforts to strengthen the national TB reference laboratory through staff training on the use of the WHO-recommended liquid culture and drug susceptibility tests (DST) techniques are ongoing. Although there are currently no plans for a new national survey, there are plans to introduce line probe assays and GeneXpert and other nucleic acid amplification tests for surveillance.

1.2. Goals of the NLTP and TB control efforts in The Gambia

The NLTP's vision is for a TB-free Gambia. Its declared mission is to develop and implement TB control activities through effective, efficient-and evidence based strategies that contribute to the attainment of national and global TB control targets as well as the Millennium Development Goals.

As captured in the its Strategic Plan, the Programme's main goal is to reduce transmission, morbidity and mortality of tuberculosis so that it is no longer a public health problem in The Gambia. The specific objectives are;

1 To increase case notification of new smear negative and extra-pulmonary TB by 10% annually
2 To maintain the current treatment success rate of 90% in 2010 to 2017
3 To reduce death rate in all forms of TB below 5% by 2017
4 To reduce defaulter rate in all forms of TB below 5% by 2017
5 To maintain the MDR-TB prevalence rate among re-treatment cases at less than 1%
6 To increase the number of TB patients being counselled and tested for HIV from 93% in 2010 to 95% by 2017
7 To increase ART coverage for eligible TB/HIV cases from 46% in 2010 to 80% by 2017
8 To strengthen private sector participation in PPM-DOTS(suspecting and diagnosing) to 10% by 2017
9 To establish a DOT centre in each district by 2014
10 To include Gene Xpert in diagnosis of MDR-TB across the country (20) by 2017

2. TB Prevalence Survey: Background, Rationale and Objectives

2.1. Rationale/Justification

The WHO DOTS strategy, which relies on a process of passive TB case finding, has helped to control TB in many parts of the world but not in countries with generalized epidemics of HIV (prevalence of HIV greater than 1% in the general population) such as The Gambia. Furthermore, the epidemiology of TB in The Gambia is poorly understood and there is significant discordance between WHO estimates of prevalence and incidence when compared to the decreasing/stable TB notification rate for new TB and smear positive TB. Evidence from statistical modelling underpinning WHO estimates suggests there may be a significant burden of undetected TB in the country. Unfortunately, the quality of existing programmatic and surveillance data is insufficient to provide the basis for recalculation of TB burden estimates for the country. The MOH&SW and NLTP because of their commitment to obtaining data on the true burden of TB in The Gambia for planning and other aspects of TB control activities reached the conclusion that the TB burden estimates for the country can only be accurately determined via a TB prevalence survey. In addition, the survey is expected to provide much needed information regarding the likely burden of undetected TB in the community. The expected data would enable better planning and allocation of resources on the part of the TB control programme in addition to other implementation plans tailored better to local circumstances. The data from the prevalence survey would be a useful basis for review of the current national TB strategies and revisions required for future plans.

2.2 Aims and objectives

2.2.1 Primary Aim

The primary aim of the Gambian Survey of TB Prevalence (GAMSTEP) i.e. the national TB prevalence survey was to estimate the prevalence of pulmonary TB in The Gambia in 2011-2012 among adults aged 15 years to establish a baseline measurement for future surveys to allow for assessment of trends, as an evaluation of the current efforts towards TB case detection.

2.2.2 Primary objectives:

1. To determine the prevalence of culture positive (bacteriologically confirmed) pulmonary TB
2. To determine the prevalence of smear positive pulmonary TB
3. To assess the health seeking behaviour of TB patients and other survey participants reporting symptoms suggestive of TB.

4. To identify reasons, location and characteristics of TB cases and/or suspects missed by routine health services.
5. To provide baseline prevalence data for measurement of future trends in TB disease burden
6. To obtain data of TB disease burden that can be utilized to obtain more reliable population estimates of disease burden in conjunction with other surveillance and programmatic data.

2.2.3 Secondary objectives:

1. To assess the knowledge, attitude, and practice of the population concerning TB (this will be covered in a separate report)
2. To determine the prevalence of symptoms suggestive of TB
3. To determine the prevalence of radiological abnormalities suggestive of TB
4. To determine the resistance profile of isolated Mycobacterium tuberculosis through drug susceptibility testing.

3. Survey Organization

3.1. Survey Steering Committee

The survey had a Steering Committee consisting of key stakeholders and government representatives that held ownership of the survey on behalf of the Gambian people. The Committee members were:

1 Programme Manager, NLTP
2 Country Representative, WHO (The Gambia)
3 Deputy Permanent Secretary, Ministry of Health and Social Welfare
4 Director of Health Services, Ministry of Health and Social Welfare
5 Director/Chief Epidemiologist, Ministry of Health (Epidemiology and Disease Control Unit)
6 Director, MRC Unit-The Gambia
7 Head, disease elimination theme, MRC Unit, The Gambia
8 Statistician General, Gambia Bureau of Statistics
9 Director, CIAM-Public Health Research & Development Centre
10 Director, National Public Health Laboratories including Gambian National Reference Laboratory

The key responsibilities of the members of the Steering Committee were

1 To provide conceptual and operational guidance for the survey
2 To help advocate and/or mobilize additional human and financial resources where required.
3 To ensure that survey implementation adhered to the approved protocol including protection of survey participants
4 To troubleshoot and facilitate navigation of obstacles to survey implementation that the principal investigator and lead institution cannot resolve
5 To monitor progress, ensure the quality of survey implementation and dissemination the survey result.

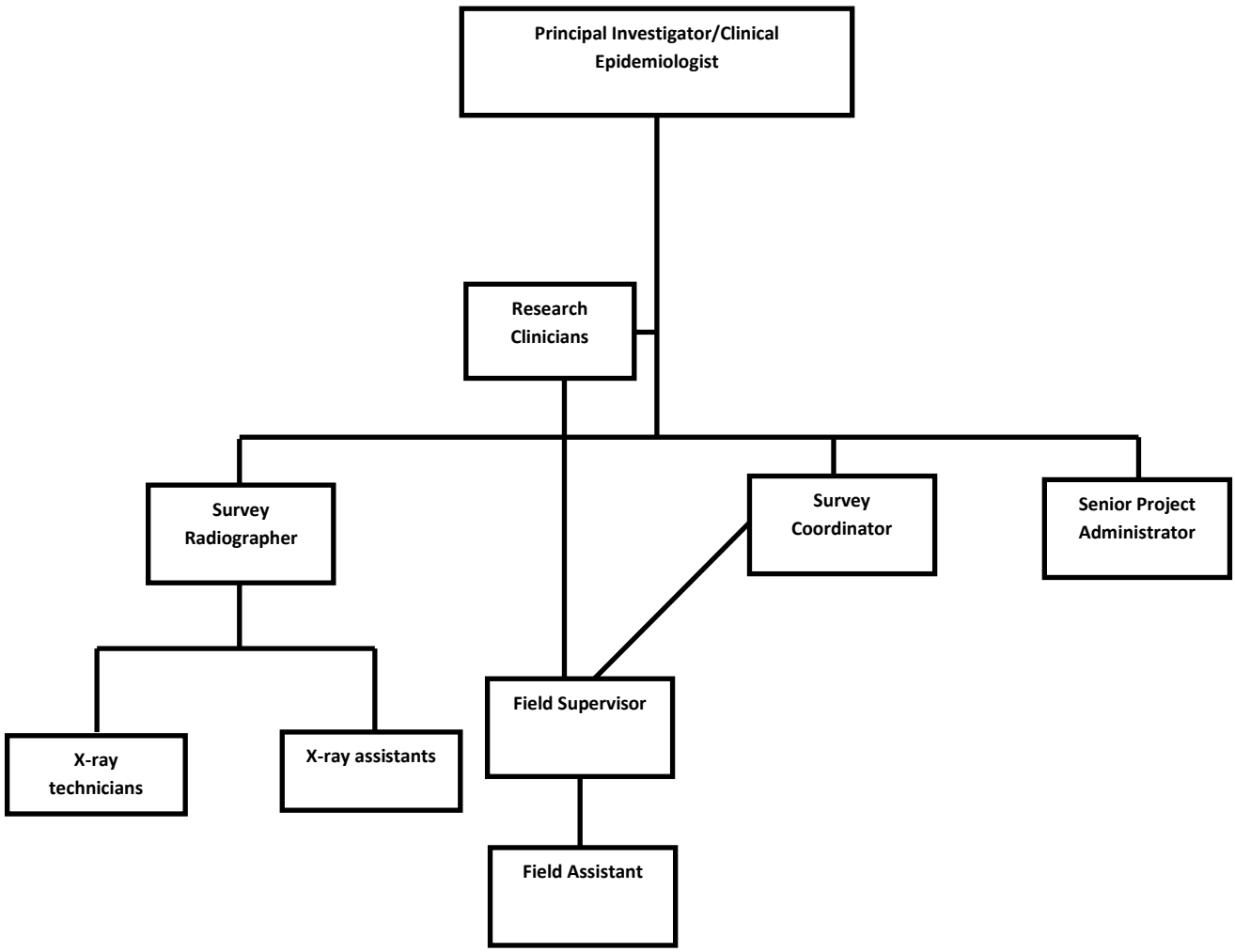
The Deputy Permanent Secretary and Director of Health Services, MoH&SW was the Chairperson of the Committee throughout its deliberations.

3.2. Principal Investigator (PI)

The MRC Unit-The Gambia, the lead institution for the survey, appointed a PI to take responsibility for the planning and execution of the survey. Specifically, the PI's tasks were to design and submit

the survey protocol for scientific and ethical approval and coordinate the meetings and activities of the National Steering Committee and Technical Advisory Group. The PI also coordinated the involvement/contribution of relevant arms of the MRC to the success of the survey. These arms included but were not limited to MRC TB research and diagnostic; and molecular biology laboratories, clinical services and radiology, and operations heads and units. The PI also liaised with the focal person from the NLTP in execution of the survey.

Figure 1. Survey Organogram



3.3 Technical Advisory Group (TAG)

The Technical Advisory Group advised the Steering Committee on technical issues related to the survey and provided reports following assessment visits to the survey operations. The TAG also provided guidance to the PI and host institution as required through review of draft protocols, SOPs study procedures and monitoring of survey progress. The members were:

1. An experienced TB epidemiologist with TB survey experience
2. A statistician from the Tropical Epidemiology Group, LSHTM

3. A social scientist
4. An anthropologist
5. A radiologist

3.4. Field teams and training

Survey operations were carried out by three field teams all led by a research clinician. The team leader coordinated all survey procedures in operations in clusters aided by the field supervisor. Standard operating procedures (SOPs) in the survey field manual described all aspects of survey field activities (leadership of cluster team, census, interviews, X-ray, lab). The tasks and responsibilities of members of the field team were to:

1. lead the second pre-survey visits under the supervision of clinician;
2. organise the activities and logistics and of the field work;
3. coordinate day-to-day field/cluster activities; and,
4. communicate with all relevant authorities at regional, district and settlement level.

Each The MRC survey field team consisted of:

1. a research Clinician/Team leader
2. a radiographer
3. an x-ray technician
4. an x-ray assistant
5. 2 field supervisors
6. 5 field assistants
7. 2 drivers

In addition to the MRC field team, others who joined the MRC team were

1. Village Health Workers.
2. Public Health Officer of the districts.
3. The Focal point for TB in the district or cluster.
4. Community Volunteers identified through the Alkalos and other community leaders.

Three of the field assistants were responsible for taking a census and conducting the interviews while the other two acted as clerks/receptionist. All field activities such as community sensitisation, census, interviews, and how to take a chest X-ray, described in the protocol were guided by appropriate standard operating procedures (SOPs) as laid out in the survey manual. The SOPs also described in detail the tasks and responsibilities of each field team member.

4. Training

Member of the Research Team were trained locally and externally part of activities prior to the start of the survey. Local training sessions, conducted individually or as group sessions, were designed to strengthen capacities to effectively implement the survey protocol.

The PI attended a WHO organised training workshop for Consultants on TB Surveillance and Surveys in Geneva and a study tour of field and central operations of the Ethiopian TB Survey.

The survey coordinator initially received in-house training. This was followed by a three-day training workshop on the study protocol with the members of the team. This was done prior to piloting the data collection tools for the survey.

The field assistants were re-trained using the condensed module of MRC's Field Workers' Levels 1 and 2. This training included role-play, field-testing of instruments and simulations of survey operations.

Data entry clerks and supervisors were introduced to survey data flow and a general introduction to the survey data management plan.

All newly employed scientific officers and laboratory technicians were introduced to the SOPs and instructions for operations in MRC research laboratories, SOPs and the MRC TB diagnostic laboratory.

Staff from Becton Dickinson provided theoretical and practical training sessions for a week as part of the supply contract for the BACTEC MGIT 960 culture analyzer equipment ordered for the survey.

The survey radiographer and principal investigator received a four-day introduction and proficiency training on the digital mobile X-ray at the factory of the vendor. The survey radiographers and manufacturers trained X-ray technicians and assistants on how to use the mobile digital X-rays at delivery of the units. The manufacturers provided a three-day hands-on training to survey radiographers and MRC Biomedical Engineering Staff covering operations, routine maintenance and basic troubleshooting, quality assurance (QA) and radiation safety. The tender for this equipment covered this training.

The PI attended a chest radiograph interpretation course at the University of Cape Town Lung Institute, passed the evaluation to be certified as an independent B' grade reader. The research clinicians serving as CXR readers received training in standardised interpretation of CXRs facilitated by a radiologist and experienced chest physician through PharmAccess, Tanzania for 5 days during which practice sessions on normal and abnormal CXRs using a standardized image set was done followed by an assessment. In addition, they received orientation and end user training on the X-ray technology during installation and commissioning of the X-ray equipment.

Community volunteers received instructions during the preparation visit and on the arrival of the survey team.

5. Methodology

5.1. Study Design

The nationwide cross-sectional multistage cluster survey was executed between December 2011 and January 2013 to obtain a reliable prevalence estimate for the entire population.

5.2. Sample Size Determination

At the time the survey was designed, the estimated population estimate was 1, 780,000, 57% of the population resided in urban areas of the country and about 50% were assumed to be ≥ 15 years old.

The WHO estimate for TB prevalence in the country at the time was 429/100,000 total population (95% CI, 202-698) and 68% (95%CI, 63.4-72.5%) of cases were smear positive i.e. 292 cases/100,000 (95%CI, 270-309/100,000) total population.[14]

Since the proportion of smear positive cases notified in The Gambia for cases <15 years old was less than 4%, we assumed the prevalence of smear-positive pulmonary TB was about 584 per 100,000 in the population of individuals aged 15 or more years old. However, given the uncertainty about the true prevalence of pulmonary TB in the Gambia, expert opinion, as well as findings from several completed TB prevalence surveys in other countries; this estimate appeared too high. After review of already-completed surveys elsewhere, we utilised a "prior guess" of 292 per 100,000 population as the prevalence of smear-positive pulmonary TB among individuals 15 or more years old.

Assuming TB prevalence of 292/100,000 with relative precision set at 0.2 (20%) corresponding to a 95% confidence interval for TB prevalence π between p-0.2π and p+0.2π, the sample size for a simple random sample was calculated as:

$$N = 1.96^2 \frac{(1 - \pi g)}{d^2 \pi \mathrm{g}}$$

Where,

N=Number of people included in the survey

πg= 'prior guess' of true population prevalence of PTB as a proportion

d= relative precision

$$N = (1.96)^2 \frac{(1 - 0.00292)}{0.22 \times 0.00292} = 32,794$$

To allow the clustered survey design, we derived the final sample size from the product of the calculated simple random sample and the design effect (DEFF) The DEFF was calculated as:

$$DEFF = \left[1 + (m-1)\frac{k^2\pi}{(1-\pi)}\right]$$

Where

m =cluster size (700 adults),

k = coefficient of between cluster variation

π = TB prevalence (estimated as 292/100,000 adults).

Assuming = k = 0.5, DEFF= 1.51.

The required sample size adjusted for the design effect was therefore:

$$N' = N \times DEFF = 32{,}794 \times 1.51 = 49{,}557$$

We applied a Finite Population Correction (FPC) since *N'* was a non-negligible proportion of the adult population of The Gambia. The FPC was calculated as:

$$NFPC = \frac{N'}{1 + \frac{(N'-1)}{T}}$$

Where

T = ≥15 year olds in the country (approximately 900,000) and this gives sample size required as:

$$NFPC = \frac{49{,}577}{1 + \frac{(49{,}577-1)}{900{,}000}} = 46{,}989$$

Assuming 85% of eligible adults take part in the survey, each cluster of two EAs was therefore to include approximately 595 participating (consenting) adults bringing the total sample size to;

$$\frac{46{,}989}{0.85} = 55{,}281$$

The total number of clusters required to attain the sample size above is

$$\frac{(46{,}989/0.85)}{700} = 79 \text{ clusters}$$

The total number of clusters was rounded up to 80. Considering a range of alternative values for k, TB prevalence and relative precision, the chosen sample size of 80 clusters was expected to give around 20% precision and better than 25% precision under most plausible scenarios as shown in table 2 below.

Table 2. Number of survey clusters required with varying precision, TB prevalence and coefficients of between cluster variation.

TB Prevalence	relative precision = 20%			relative precision = 25%		
	k			k		
	0.4	0.5	0.6	0.4	0.5	0.6
0.00250	78	87	98	51	57	64
0.00292	70	**79**	90	45	52	59
0.00300	68	78	89	45	51	58
0.00350	61	71	82	40	46	53

Refers to number of clusters required

5.3. Sampling procedure

We randomly selected eighty (80) survey EAs from a complete list of national census EAs and allocated them to each region proportionately to the population as determined in the 2003 census. This procedure was similar in outcome to actual sampling proportional to population size (pps). Proportions and numbers of EAs selected per region are as shown in table 3.

Table 3. Allocation of survey clusters by region in proportion to population size

Region	Population	Proportion	EAs	Reserve EAs
Greater Banjul	357796	0.263	21	4
West Coast	389274	0.287	23	4
Lower River	72184	0.053	4	2
North Bank	172581	0.127	10	2
Central River	185465	0.137	11	2
Upper River	181164	0.133	11	2

The mean population of EAs in the Gambia in 2003 was 549. Assuming a growth rate in population of 2.7% per annum, the population per EA by 2012 was ~700, with about 50%≥ 15 years old. To achieve a reasonable cluster size for the purposes of fieldwork, we paired each selected EA with adjacent EAs (the EA directly to the North and proceeding in a clockwise direction). In cases where the EA directly to the North was difficult to access (e.g. if it was on the other side of a river), fell in another settlement or jurisdiction, the first accessible EA was appended to define the cluster. Where a 2nd or 3rd EA were required to reach the target eligible population, all or blocks of the EA were utilized starting with the block on the border with the 1st or 2nd EA originally paired with the first one. Each set of paired EAs as described above constituted a survey "cluster". See the complete list of survey clusters in annex 1.

5.4. Inclusion and Exclusion Criteria

5.4.1. Exclusion from sampling frame

All parts of the country were included in the sampling frame.

5.4.2. Exclusion criteria in selected settlements/clusters

To ensure survey success, the feasibility of data collection and the likelihood of bias that may result from including special high-risk groups, the following settings or persons were excluded from the survey if they fell into selected clusters

- Military or Police Barracks
- Embassies, Consulates and associated residencies
- Prisons and camps
- Hospitals in-patients
- Boarding Schools/Dormitories
- Orphanages
- Street/homeless people

5.4.1 Individual Eligibility Criteria

- Age ≥ 15 years

- Residents who normally live in the area and spent at least one night in the household in the last 4 weeks before the census day
- Visitors who arrived in the household 4 weeks or more before the census day

5.4.1 The inclusion/exclusion criteria for participation - involvement in screening

This took into account the eligibility criteria described above and the provision of informed consent. Individuals could only included in the survey screening if they had been fully informed of the objectives and procedures of the study and freely gave written informed consent. Individuals who are unable or unwilling to provide informed consent will not be included in the survey screening. The Joint Gambia Government/MRC Joint Ethics Committee approved the consent procedure. Parents or legal guardian or a family member as long as they were 18 years or older provided informed consent for individuals below 18 years. The inclusion/exclusion criteria were:

- Eligible individuals, based on criteria mentioned above
- Individual informed consent provided (or parent/ legal guardian/family member 18 years or older for persons < 18 years or disabled persons who are unable to provide written consent by themselves).

Ill health was not an exclusion criterion; all those who were ill, the elderly and those with mobility problems among the eligible population were transported to central site at no cost as part of mop up procedures on the last day of cluster activities) to have study procedures unless exempted by the team leader/research clinician.

Individuals who were eligible for the study but refused to provide consent were counted as 'absentees.'

5.5. Survey operations

A pilot survey was performed in one urban and one rural cluster, which were not be included in the study sample to consolidate all training and for troubleshooting. Survey SOPs were then finalised or revised based on lessons learnt during the pilot survey. The results from the pilot survey are not part of this report.

5.5.1 Survey period

Field operations for the first Gambian Survey of Tuberculosis Prevalence ran from December 5th 2011 to February 1st 2013. Given the size of The Gambia, all survey clusters could be reached with less than one day of travel

5.5.2 Field survey procedures

There were 80 actual survey clusters. Assuming each survey cluster had an average of 700 eligible persons, the plan was to complete each cluster in a 1-week period. The activities for this 1-week period were

- Day 1 (Saturday/Sunday): Arrival and setting up of survey site alongside briefing of local collaborators
- Day 2 (Sunday/Monday): Census - Confirmation of eligible subjects
- Day 3 (Monday): Screening of eligible subjects and CXR examination
- Day 4 (Tuesday): Screening of eligible subjects and CXR examination
- Day 5 (Wednesday): Screening of eligible subjects and CXR examination & first sputum shipment for culture to the laboratory
- Day 6 (Thursday): Screening of eligible subjects and CXR examination mainly for non-attendees (mop-up operations)
- Day 7 (Friday/Saturday): Final sputum collection and second sputum shipment for culture to the laboratory. Move to next cluster, or back to base.

5.5.3 TB Symptom screening

Members of the survey team screened all consenting participants with a pre-tested questionnaire administered in their own local language. In addition to questions about symptoms, they obtained demographic data, history of previous or current TB and information on some lifestyle factors-alcohol and tobacco use. The symptoms considered suggestive for TB in the guidelines of the National Leprosy and TB control programme are

a. Cough lasting 2 weeks or more
b. Chest pain
c. Night sweats
d. Shortness of breath
e. Loss of appetite
f. Weight loss

For the survey, we obtained sputum samples from participants with symptoms suggestive of TB in the categories below per protocol

a. Any participant with a cough for 2 weeks or more

b. Any participant with a cough lasting <2 weeks and 2 or more symptoms from 1b-f
c. Any participant without a cough AND 3 or more symptoms from 1b-f

All participants with positive history of TB symptoms answered additional questions as part of an in-depth interview to assess health seeking behaviour and reasons of failure of detection by routine health services. Regardless of symptoms, all consenting participants had chest X-rays done except where they met the criteria for exemption.

5.5.4 Radiographic screening

All screened participants had posterior-anterior (PA) view chest X-rays at the survey site using a mobile direct digital X-ray unit.. The research clinician/team leader acting as X-ray reader read by all images taken in the field to classify them as,

a. Normal
b. Abnormal and suggestive of TB for any abnormality in lung field or mediastinum, including cavities, infiltrates, pleural effusion, hilar or mediastinal lymphadenopathy, pulmonary nodules, interstitial abnormalities suggestive or TB or healed TB
c. Abnormal but not suggestive of TB for other abnormalities e.g. cardio vascular diseases, goitre, injury, etc

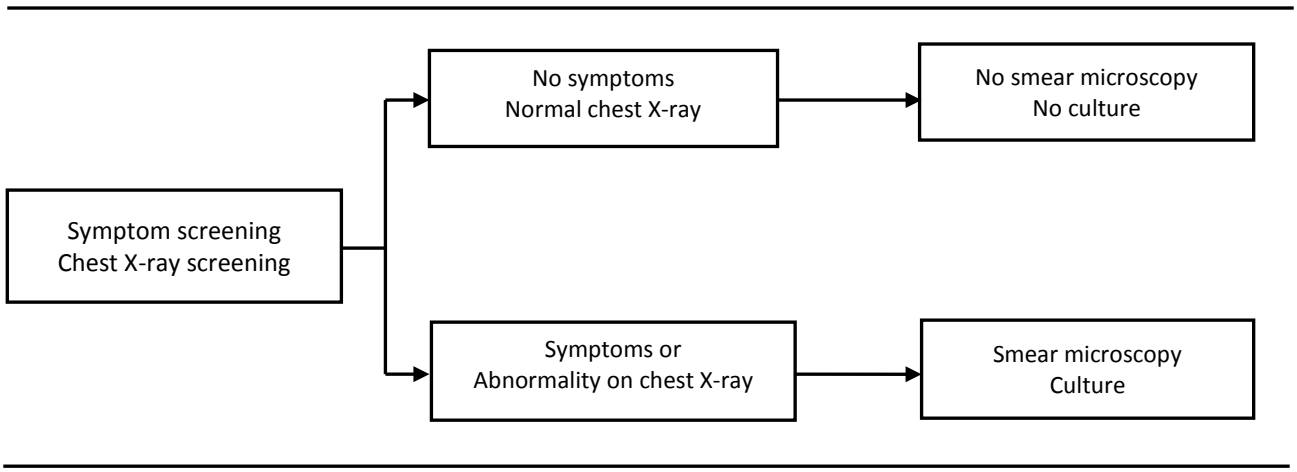
All participants with chest radiographs classified as abnormal and suggestive of TB were asked to produce two sputum specimens regardless of the presence or absence of TB symptoms

Survey participants with an acute illness, symptoms and/or CXR abnormalities and requiring medical care were referred to the nearby health facility (health centre or district hospital) agreed to with the regional health team or as appropriate.

5.5.5 Microbiological Screening

Following instruction and using a poster on production of good quality sputum specimens, all participants with symptoms and/or CXR abnormalities suggestive of TB were instructed to provide two sputum samples (either two spot samples produced 1 hour apart or 1 spot and 1 overnight/early morning). The survey team utilized cold boxes with ice packs and thermometers for sample collection and storage to maintain a cold chain. Survey drivers transported samples daily to the MRC TB Diagnostic and Research Laboratory for processing for urban areas. For upcountry clusters, they transported samples to the laboratory within 48 to a maximum of 72 hours after collection.

Figure 2. Recommended Screening Methodology for Prevalence Surveys



5.6. Laboratory Methods

5.6.1 Sputum microscopy

The MRC TB Diagnostic and Research Laboratory processed all survey samples centrally. Trained laboratory technicians supervised by scientific officers with substantial experience in routine diagnostic and molecular mycobacteriology performed sputum microscopy. Smears were stained with Auramine-O and examined using fluorescence microscopes. The supervising scientific officer re-checked all positive slides and one in ten negative slides as outlined in existing work instructions. The scientific officer in charge of the shift during actual testing or other senior lab staff following verification of the results signed off on all positive results. The MRC TB Laboratory holds Good Clinical Laboratory Practice Accreditation (ISBN 978-1-904610-00-7), serves as reference lab for the Gambia national TB reference laboratory and subscribes to the United Kingdom National External Quality Assessment Service for EQA.

5.6.2 Mycobacterial Culture

All sputum samples obtained from participants eligible to give specimens were cultured at MRC TB laboatory. According to existing laboratory SOPs and work instructions (SOP-TBL-001 and WOI-CLA-401), decontaminated pellets obtained after sample processing for smear microscopy were inoculated into BACTEC MGIT media. Laboratory staff entered inoculated tubes into the instrument via bar code scanning that guides the simple 4-step workflow procedure. The remaining aliquots of

specimen were stored at -20^{o}C. The team performed ZN smear microscopy on all growths within the BACTEC MGIT to confirm the presence of AFB. Following confirmation of growth as AFB positive, we obtained rapid species identification using an immunochromatographic assay (MGIT™ TBc Identification Test, Becton Dickinson, Maryland, USA)**.** Where required, we sub-cultured samples onto a Lowenstein-Jensen slope for speciation purposes. The monitoring schedule prescribed weekly inspections for all cultures for up to 6-12 weeks. In the case of contaminated cultures, allocated laboratory staff retrieved and re-cultured the stored specimen after repeat decontamination. All AFB isolates obtained from cultures were classified as MTB or Not MTB (NMTB) according to prevailing laboratory SOPs.

Quality management systems for all phases of laboratory work (pre-analysis, during analysis and post analysis were maintained as stipulated in laboratory SOPs and work instructions.

5.7 Audited Central X-ray Reading

Radiologists and pulmonologist including those that trained the survey x-ray readers reviewed all abnormal X-ray and about 10% of normal films for quality assurance and for purpose of survey case definitions.

6. Case Definitions

Identification of survey cases was as recommended in WHO guidelines for prevalence surveys. [5]

6.1. Laboratory case definition

- Culture confirmed TB cases: Isolation of Mycobacterium tuberculosis complex from a sputum specimen
- Sputum smear positive TB cases: Acid-fast bacilli positive by sputum smear examination i.e. at least one acid-fast bacilli in an appropriate sample in 100 immersion fields

6.2. Survey case definitions:

6.2.1 Definite survey case

- Bacteriologically-confirmed: A participant with at one positive TB culture and at least one of the following
    - Another sample culture positive
    - Sputum smear positive
    - CXR abnormalities suggestive of TB by central audited reading
- Sputum smear positive: A participant with one AFB positive sample and at least one of the following conditions
    - Culture positive sample

6.2.2 Probable smear positive case: A participant with one AFB positive sample and at least one of the following

- AFB positive in another sample BUT not culture positive AND no isolation of NMTB
- CXR abnormal at central reading BUT not culture positive AND no isolation of NMTB

7. Data Management and Analysis

MRC Data Management Unit carried out survey data management according to standard procedures and work instructions at the unit. The Head of MRC's Data Management Unit provided overall supervision of the entire data team.

The data manager in conjunction with the survey PI developed the data flow plan in advance of starting the survey. The survey data manager coordinated data management for the survey with a team of one data supervisor and five data entry clerks within the MRC data pool. According to protocol, the data management team implemented adjudicated double entry of survey data on a continuous basis to avoid any backlog of unprocessed data including data cleaning and verification as components of this process.

The survey database was a relational SQL database with a Microsoft Access front end, linked to the laboratory, and radiology databases including digital images brought in from the field and stored on servers at the data manager's office. Using this database, the data manager ran queries linking all data sources using the unique ID of all survey participants. All databases were backed up daily and weekly copies kept offsite in a fireproof location according to standard IT SOPs. There was regular feedback from the survey data management to the principal investigator and progress report at fortnightly project meetings. All data collection tools or case record forms were stored in sequentially number binders at the data pool. The numbering was such that it allowed for organization of all forms by cluster, census and household numbers. The consent forms bearing names and other personal identifiers were stored separately in a secure storage area with limited access. All databases required log-on credentials; kept records of all operator activity including changes/amendments to entered data.

All study documents were stored in the data room and archived in the MRC Archival Unit.

7.1 Data analysis

All data analysis was done using Stata 12™ (Stata Corp, College Station, Texas, US) on anonymized data bearing on the unique survey ID numbers. For all eligible study participants, we calculated crude estimates and 95% confidence interval for prevalence of bacteriologically positive (smear-positive and/or culture-positive) and smear negative but culture positive and smear positive PTB.

Finally, an overall point estimate was then calculated using the three approaches described below as recommended.[15] We ran all imputation models using the ICE command for multiple imputations by the MICE system of chained equations in STATA™ 12. We used the MIM command analyzing and manipulating multiply imputed datasets to combine all imputed datasets for the calculation of pooled estimates. We ran chained imputation datasets and obtained trends for the means of the

four imputed variables (CXR, AFB positive, culture positive and bacteriologically confirmed TB) for each iteration. For models 2 and 3 (see 7.2.2 and 7.23 below), we ran 24 and 9 imputations respectively. We derived subject level missing values from the relevant combinations of the imputed variables.

7.1.1 Method 1-Complete case/Individual Level analysis[15]

In this method, analysis using a logistic regression model was restricted to survey participants alone (N_2, see figure 4). This method did not include eligible participants with missing smear and/or culture positive results. Although equal weight is given to each participant, the model accounts for the clustered design of the survey through the calculation of robust standard errors. The model does not adjust for sampling weights since the survey by design is self-weighted i.e. each individual in the population had the same chance of selection into the sample. The results obtained by this model applied to only participants usually underestimate the true TB prevalence because data on PTB are missing only among survey participants eligible for sputum examination.

7.1.2 Method 2- Missing value imputation (MI)[15]

Similar to method 1, this method uses a logistic regression model with robust standard errors, thus allowing for clustering in the sampling design. In addition, there is missing value imputation for the following non-survey participants and participants (i.e. N_1 in figure 4 below) for the survey in the analysis:

- Those without a field chest X-ray result and/or symptom screening – which includes all individuals who did not participate in the survey
- Those with field chest X-ray readings that should have been read at central level as stipulated in the survey protocol, but were missed.
- Those eligible for sputum examination but were not identified as or eliminated as survey TB cases because of missing smear and/or culture results
- Those whose status as survey cases is unknown because they were deemed ineligible for sputum examination, but had a central X-ray reading suggestive of TB

The logistic regression model with robust standard errors used in this method also takes care of the uncertainty introduced by missing values imputation during estimation of the 95% CI for the prevalence of pulmonary TB.

7.1.3 Method 3-Logistic regression model with missing value imputation (MI) and inverse probability weighting (IPW)

This method aims to obtain representation of all of the survey eligible population (i.e. N_1in figure 4), using a logistic regression model with robust standard errors like the earlier mentioned methods. However, missing value imputation is performed only for survey participants eligible for sputum examination (=N_6 in Figure 4), who have missing smear and/or culture results. It is applied also to those individuals who were not eligible for sputum examination but whose CXR at central level reading were classified as suggestive of TB and for those for whom data from one or more of the central CXR reading, symptom questionnaire, and smear and/or culture results are missing. Inverse probability weighting is also applied to all survey participants. Figure 4 shows participants who were screened for symptoms and CXR or exempted as provided for in the survey protocol and submitted sputum samples for TB diagnosis (i.e. N_5). With inverse probability weighting, differentials in participation in the survey by age, sex, and cluster are accounted for. As a result of the foregoing, Method 3 compared to Method 2 is considered the “safer” method because a smaller amount of missing data is imputed meaning the bias in the resulting estimates are smaller even if the imputation model is mis-specified.

8. Monitoring and Evaluation

Internal and external monitoring activities were conducted during the lifespan of the survey

8.1 Laboratory investigations

All laboratory investigations followed standard procedures including quality controls for all assays. We tested all new lots of reagents with known positive and negative control slides. Reference TB strains were inoculated with each new batch of MGIT tubes and LJ slants to assess the medium quality. Finally, a second microscopist for confirmation examined all positive microscopy slides and ten percent of negative slides. Discrepant results noted by both microscopists were read together to reach a consensus.

8.2 Internal monitoring

8.2.1. The team leader had responsibility to monitor and supervise the team members throughout the duration of field activities. As a member of the team , they remained in the field during survey operations, checked the quality data collection-consistency and accuracy of data collected, monitored team work ethic, quality of chest x-rays and sputum collection including the cold chain

8.2.2. A member of the central team (PI, data manager and M&E office, radiographer, survey coordinator periodically visited the field for 3-4 days to participate, review and assess the quality of the field activities.

8.23. The data manager /M& E officer generated performance parameters to monitor study progress, related to the completeness of data the laboratory, CXR and field components of the survey. These performance parameters were discussed during quarterly periodic reviews.

8.3 External monitoring (mid-term review)

8.3.1. Members of the TAG and experts from the WHO conducted external monitoring on two occasions and reported to the survey Steering Committee and MRC leadership Group.

8.3.2. The Steering Committee received reports from the PI and participated in debriefing following mid-term reviews.

9. Results

9.1. Census: eligible survey populations

The census conducted by the survey team yielded 100,678 persons, 55, 832 (55.5%) of whom were eligible to participate in the survey. Just under half 41.3% of the census population were children under the age of 5 years fewer that the 42.6% expected from 2012 population projections. A smaller fraction, 3,285 (3.3%) were not eligible based on survey the residency criteria. As shown in table 4, there were more eligible females than males. Although a higher proportion of those enumerated resided in rural areas, more persons that were eligible lived in urban parts of the country. The population structure of rural compared to urban clusters was clearly different as there was almost twice as many children aged under 15 years in rural areas compared to the urban parts of the country.

Table 4: Survey census population by eligibility for survey, gender, age group and resident type

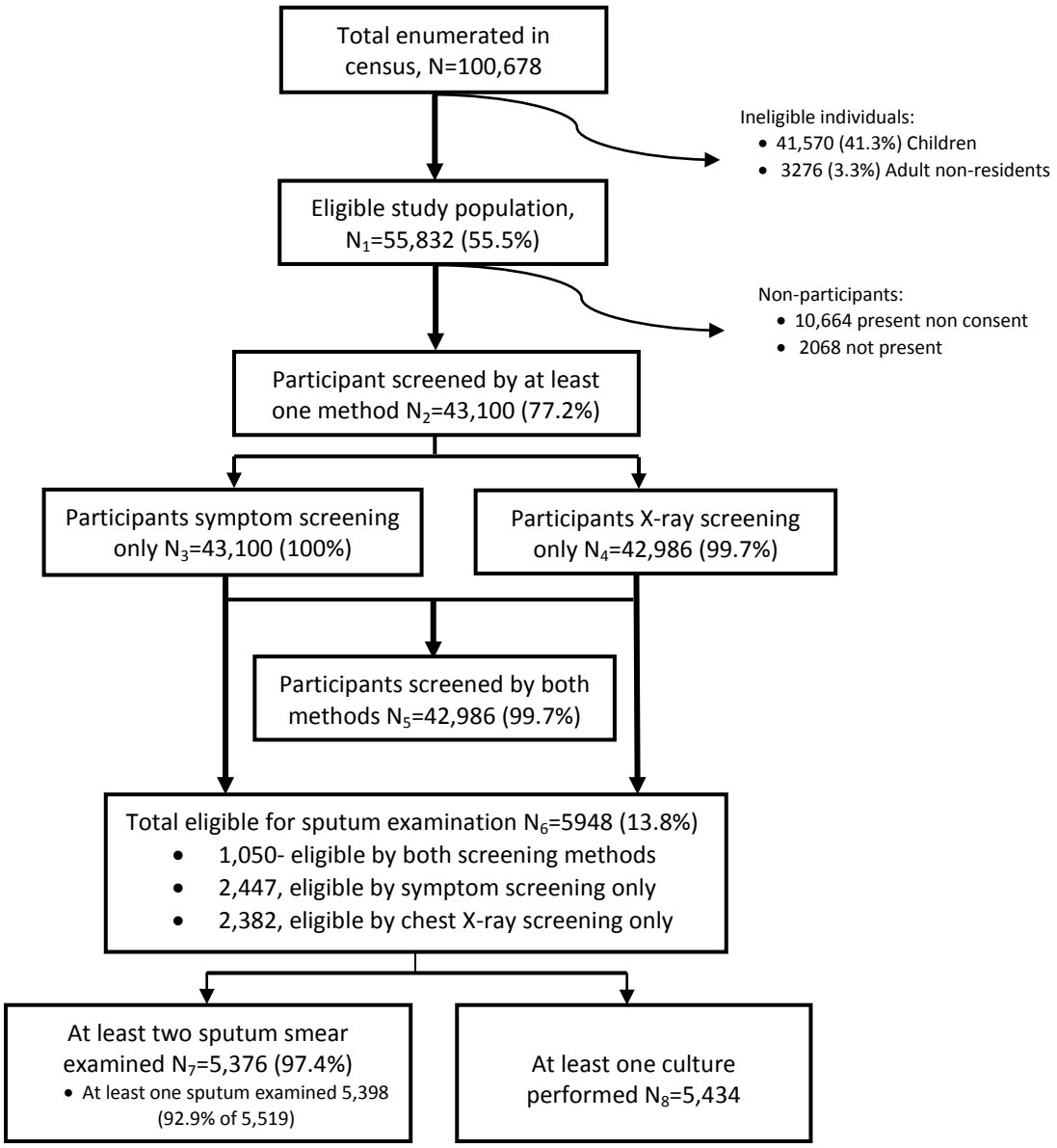
	Eligible		Ineligible ≥15years		Ineligible <15 years		Total enumerated
	number	%	number	%	number	%	
Total	55,832	55.5	3285	3.2	41,561	41.3	100,678
Gender							
Male	25,679	53.1	1,958	4.1	20,701	42.8	48,338
Female	30,153	57.6	1,327	2.5	20,860	39.9	52,340
Age (years)							
0 - 4	0	0.0	0	0.0	16,478	100.0	16478
5 - 9	0	0.0	0	0.0	14,570	100.0	14570
10 - 14	0	0.0	0	0.0	10,513	100.0	10513
15 - 24	21,117	94.0	1,347	6.0	0	0.0	22464
25 - 34	14,027	93.5	968	6.3	0	0.0	14995
35 - 44	8,654	95.2	439	4.8	0	0.0	9093
45 - 54	5,383	95.6	245	4.4	0	0.0	5628
55 - 64	3,181	96.0	132	4.0	0	0.0	3313
65+	3,470	95.8	154	4.2	0	0.0	3624
Resident type							
Urban	24,789	63.0	954	2.4	14,183	34.6	39,926
Rural	31,043	51.1	2,331	3.8	27,378	45.1	60,752

Figure 4 displays the enumerated population and flow of consenting participants through the various stages of the survey.

The age group and gender structure of the enumerated survey population compared to the survey eligible population was the same confirming representativeness of the eligible population (See Figures 3A and B). Similarly, comparison of the population pyramids for the survey eligible population and actual participants showed a similar structure. However, there was a preponderance

of female survey participants, the result of fewer male participants than expected especially in the 25-34 years age group.

Figure 4. Schematic diagram of the numbers of participants screened for tuberculosis in the prevalence survey according to the survey protocol



- Smear positive, culture positive: 28 (77.8% of S+ cases)
- Smear positive, culture negative: 6 (16.7% of S+ cases)
- Smear positive, culture MOTT/contaminated: 2 (5.5% of S+ cases)
- Smear-negative, culture-positive: 43 (55.8% of all cases)
- Smear not done, culture positive: 0 (% of S+ cases)
- Positive bacteriological result: 71

Figure 3A. Comparison of population structure of survey registered population with the eligible population structure

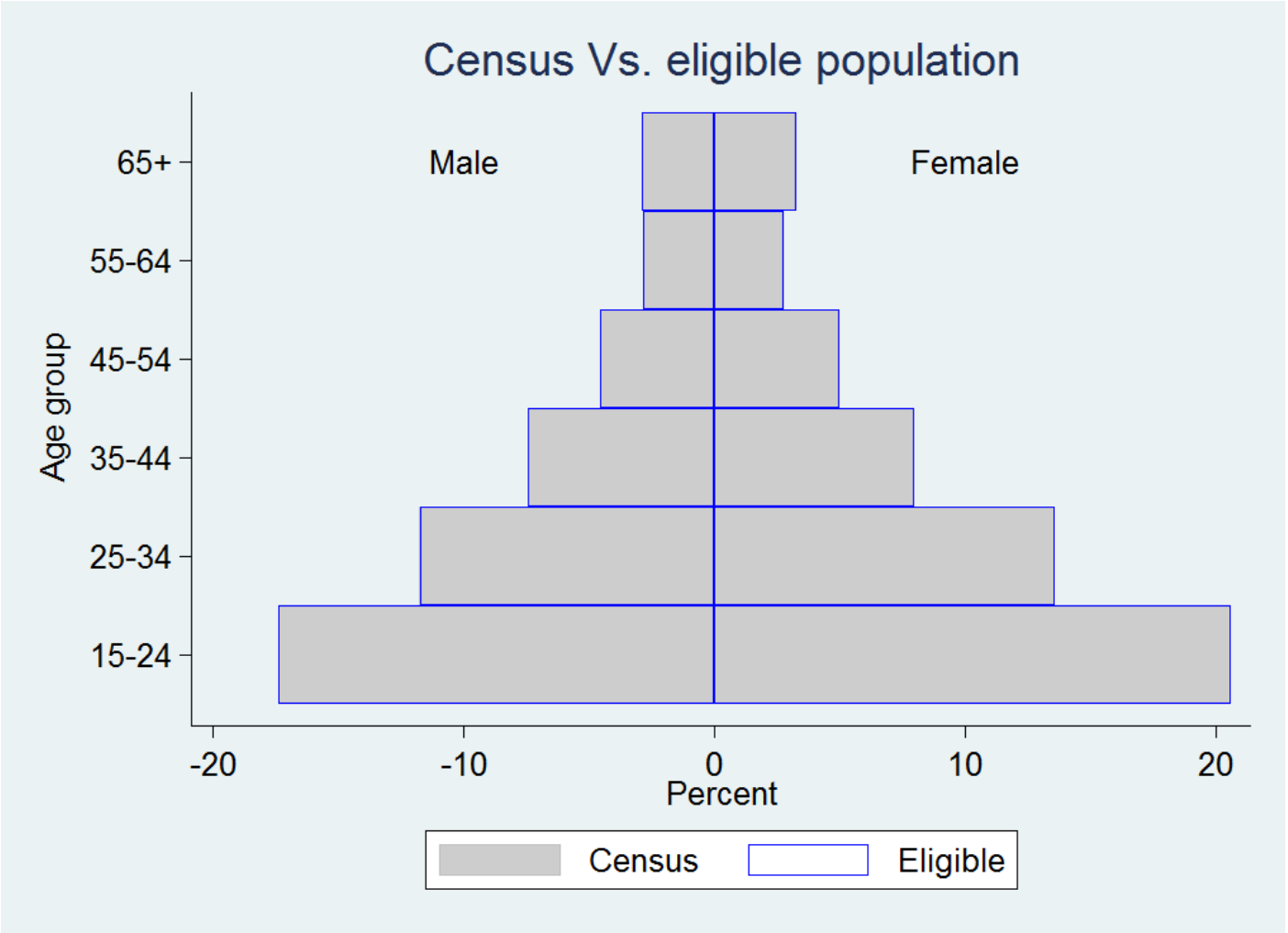
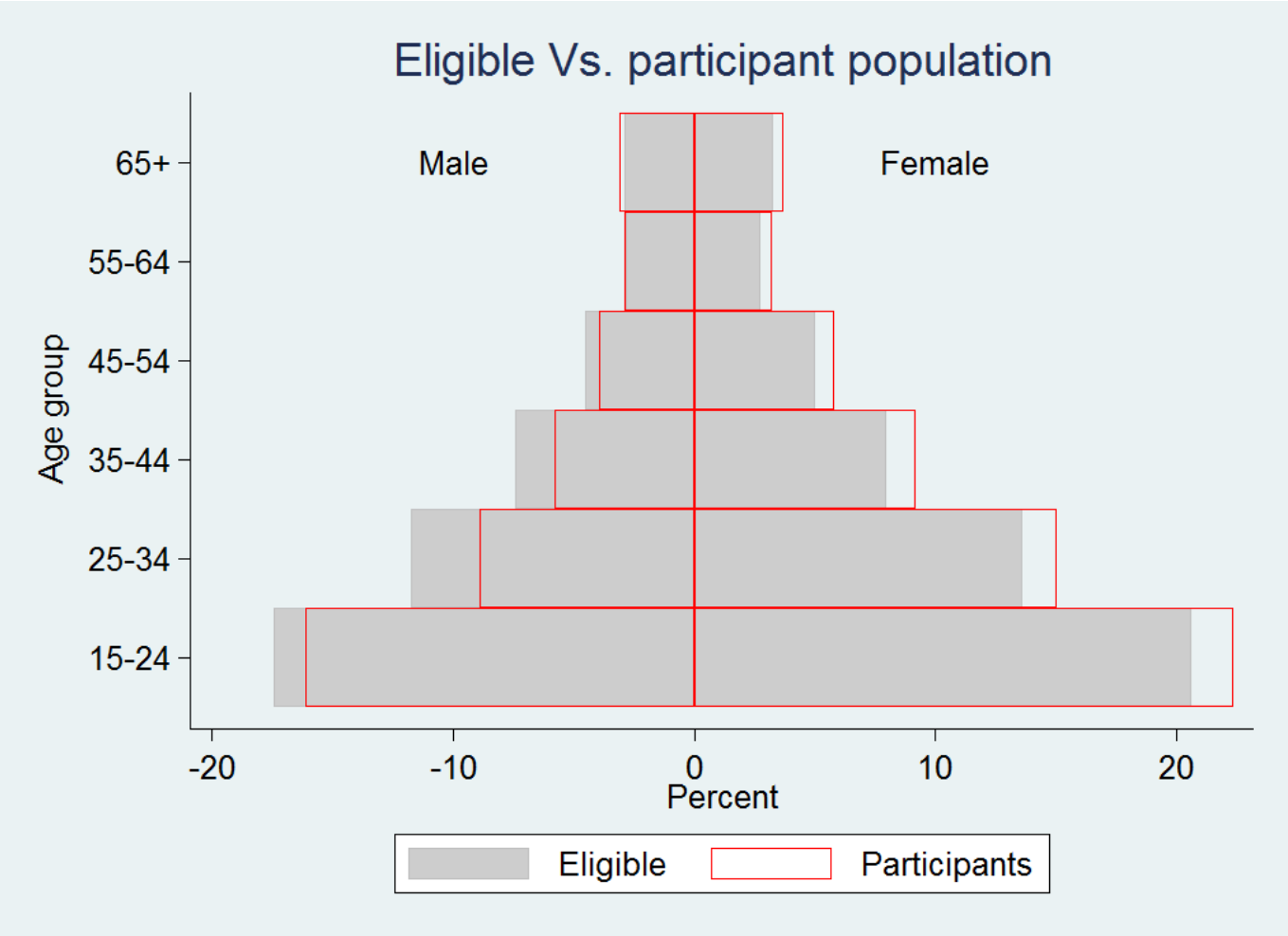


Figure 3B. Comparison of population structure of survey eligible population with participant population



9.2 Participants

9.2.1 Study participation

Of the 55,832 eligible persons invited to participate in the survey, 43,100 (77.2%) gave consent for screening. Participation was less than the 85% target mainly due to lower participation in the urban areas as shown in Table 5. The average number of participants per cluster was approximately 539 (range 363-640), which was less than the 550-650 expected at the planning of the survey. Participation was higher for the older age groups ≥55 years (83.6% [95%CI: 82.7-84.4]) compared to the younger age groups (76.3% [95%CI: 75.9-76.7]) and this was significantly different (p <0.0001). Furthermore, there were significantly more female participants than males (84.9% vs. 68.2%, p <0.0001) and higher participant rates in rural vs. urban clusters (82.3% vs. 70.8%, p <0.0001).

Table 5. Survey Participation and coverage by symptom interview and chest X-ray screening

		Participants		Non-participants		Interviewed		Chest X-ray done	
	Eligible	**number**	**%**	**number**	**%**	**number**	**%**	**Number**	**%**
Total	55,832	43,100	77.2	12,732	22.8	43,100	77.2	42,947	76.9
Gender									
Male	25,679	17,504	68.2	8,175	31.8	17,504	68.2	17,443	67.9
Female	30,153	25,596	84.9	4,557	15.1	25,596	84.9	25,499	84.6
Age (years)									
15 - 24	21,117	16,577	78.5	4,540	21.5	16,577	78.5	16,562	78.4
25 - 34	14,027	10,304	73.5	3,723	26.5	10,304	73.5	10,287	73.3
35 - 44	8,654	6,452	74.6	2,202	25.4	6,452	74.6	6,438	74.4
45 - 54	5,383	4,210	78.2	1,173	21.8	4,210	78.2	4,200	78.0
55 - 64	3,181	2,641	83.0	540	17.0	2,641	83.0	2,624	82.5
65+	3,470	2,916	84.0	554	16.0	2,916	84.0	2,831	81.6
Resident type									
Urban	24,789	17,546	70.8	7,243	29.2	17,546	70.8	17,486	70.5
Rural	31,043	25,554	82.3	5,489	17.7	25,554	82.3	25,456	82.0

9.2.2 Occupational Status

Table 6 shows the occupation categories among participants. Male participants worked predominantly in agricultural sector jobs (21%) or were students (20%) but in contrast, females were mainly homemakers (38%) and about 19% engaged in agricultural sector activities.

Table 6. Occupation of survey participants by gender

Occupation	Male		Female		Total	
	Number	%	Number	%	Number	%
Professional, technical and worker	3113	18	432	2	3545	8
Own Business	1781	10	1848	7	3629	8
Merchant	16	0	19	0	35	0
Service worker (including Government servant)	1459	8	794	3	2253	5
Trader	54	0	438	2	492	1
Agricultural, animal husbandry and forestry worker, fisherman and hunter	3733	21	4759	19	8492	20
Production and related worker, transport, equipment operator and labourers	1962	11	839	3	2801	6
House wife	0	0	9851	38	9851	23
student	3862	22	3495	14	7357	17
Dependent	1320	8	3045	12	4365	10
Clergy	31	0	7	0	38	0
Others	173	1	69	0	242	1
Total	17504	100	25596	100	43100	100

9.3. Screening

9.3.1 TB related symptoms

Survey staff interviewed all 43,100 consenting participants for symptoms suggestive of TB according to the survey protocol. Out of these numbers, 4,802 (11.1%) reported a cough, majority (2,972 [62%]) had a cough that had lasted for <1 week. Only 962 (20.1%) had been coughing for ≥2 weeks while 16.7% (799) had been coughing for 1-2 weeks. Table 7 displays the characteristics of survey participants with chronic cough i.e. duration ≥2 weeks. Significantly more females than males ($p < 0.001$) reported this symptom and more among those aged ≥45 years. The prevalence of this complaint was highest in the 65 years and above category that had 3 times higher prevalence compared to the 15-44 years age group. However, there was no difference between rural and urban habitation with respect to this symptom. For other symptoms listed in the national TB guidelines, 15.2% complained of chest pain, 3.7% had night sweats, 6.2% shortness of breath, 8.4% were anorexic and 19.6% noticed weight loss.

The characteristics of participants with cough of shorter duration and two or more non-cough symptoms are shown in Table 8. Unlike for chronic cough where there was a significant preponderance of males reporting this symptom compared to females, there were significantly more females with cough <2 weeks duration and 2 or more other symptoms compared to males (table 8). The same age group pattern as seen for chronic cough was observed for this combination of symptoms as well. In addition, there was no difference according to urban or rural dwelling.

Table 7. Characteristic of respondents with cough for 14 days or more

	Cough>14	%	Total
Sex			
Male	455	2.6	17,504
Female	507	2.0	25,596
Age			
15 - 24	245	1.5	16,577
25 - 34	142	1.4	10,304
35 - 44	123	1.9	6,452
45 - 54	115	2.7	4,210
55 - 64	122	4.6	2,641
65+	215	7.4	2,916
Resident type			
Urban	386	2.2	17,546
Rural	576	2.3	25,554
Total	962	2.2	43,100

Table 8. Characteristic of respondents with cough <2 weeks and 2 or more symptoms

	Cough +2 or more symptoms*	%	Total
Sex			
Male	498	2.8	17504
Female	874	3.4	25596
Age			
15 - 24	445	2.7	16577
25 - 34	264	2.6	10304
35 - 44	187	2.9	6452
45 - 54	153	3.6	4210
55 - 64	114	4.3	2641
65+	209	7.2	2916
Resident type			
Urban	582	3.3	17546
Rural	790	3.1	25554
Total	1372	3.2	43100

*Symptoms are weight loss; fever; night sweats; chest pain; shortness of breath; anorexia and haemoptysis

In the third symptom category, the same female preponderance as seen for those with cough <2 weeks and two or more symptoms was seen. In this case, there were almost twice as many females without cough but three or more symptoms (see Table 9). The same pattern across age groups and resident type was seen here as for the first two symptom categories.

Table 9. Characteristic of respondents without cough but with three or more other symptoms

	3 or more symptoms* without cough	%	Total
Sex			
Male	318	1.8	17,504
Female	810	3.2	25,596
Age			
15 - 24	242	1.5	16,577
25 - 34	233	2.3	10,304
35 - 44	203	3.1	6,452
45 - 54	153	3.6	4,210
55 - 64	104	3.9	2,641
65+	193	6.6	2,916
Resident type			
Urban	429	2.4	17,546
Rural	699	2.7	25,554
Total	1,128	2.6	43,100

*Symptoms are weight loss; fever; night sweats; chest pain; shortness of breath; anorexia and haemoptysis

9.3.2 Chest X-ray

The majority, 99.6% of the 43,100 interviewed participants had a chest X-ray done. Similar proportions of male and female participants had X-rays done. There were significantly more females than males, elderly than young and rural than urban participants that did not have X-rays done.

Apart from 9 participants who did not have X-rays done on account of technical problems in the field, most participants without X-rays done were exempted on account of mobility issues, mental incapacity to follow instructions, and ill health precluding movement out of the house. In addition, some women and men still refused to have X-rays done because of fears regarding radiation or unexplained anxiety. Based on field X-ray screening, 3,407 (7.9%) had abnormalities suggestive of TB and were eligible to give sputum (see table 10). More males than females had these lung abnormalities but proportions were similar for rural and urban participants. Again, CXR abnormalities suggestive of TB were more prevalent in those over he age of 35 years old with two to four fold increase with increasing age from over 45 years to those 65 years and older.

As Table 11 shows, all abnormal X-rays and a minimum of 10% of the normal X-rays giving a total of 5656 X-rays were reviewed by a central panel. Of the 5656 x rays that were reviewed, the central panel

found 57.4% x-rays to be normal; 10.9% abnormal and suggestive of TB; 27.7% abnormal and suggestive of healed TB; and 4.0% abnormal for other pathology. There was agreement between the central panel and field readings for 2710 normal X-rays and 1286 abnormal X-rays giving a concordance rate of 71%. There was discordance for 1660 X-rays. The central panel noted that 1125 of the discordant X-rays were read as normal by the field team of which 80 (7.1%), 947 (84.2%) and 98 (8.7%) were abnormal for TB, abnormal for healed TB and abnormal for other pathology respectively. Of the 1660, the central panel reclassified 535 reported as abnormal during field readings as normal.

9.3.3 Result of symptom and CXR screening and eligible participants for sputum examination

The survey identified 5948 (13.8%) participants eligible to give sputum for examination because they screened positive for symptoms and/or CXR abnormalities suggestive of TB. As shown in Figure 4, about the same proportion of participants were found eligible by CXR (2382, 40.1%) and by symptom screening (2447, 41.2%) while 1050 (17.7%) were positive for both CXR abnormalities and symptoms.

Furthermore, 6% of ineligible by symptom or CXR criteria were eligible for sputum examination by the other. Of those that did not have a CXR, 56 (36%) were eligible for sputum exam and majority of them had symptoms other than chronic cough.

Table 10. Results of Chest X-ray screening in the field.

	Field CXR Performance				Field X-ray result						
		Taken		Not Taken	Total	Normal		Other Abnormal		Abnormal	
						Not eligible for sputum		Not eligible for sputum		Eligible for Sputum	
		num	%	num		num	%	num	%	num	%
Sex											
Male	17,504	17,443	99.7	61	17,443	15,383	88.2	319	1.8	1,741	10.0
Female	25,596	25,499	99.6	97	25,499	23,001	90.2	832	3.3	1,666	6.5
Age											
15 - 24	16,577	16,562	99.9	15	16,562	16,132	97.4	61	0.4	369	2.2
25 - 34	10,304	10,287	99.8	17	10,287	9,814	95.4	71	0.7	402	3.9
35 - 44	6,452	6,438	99.8	14	6,438	5,793	90.0	123	1.9	522	8.1
45 - 54	4,210	4,200	99.8	10	4,200	3,389	80.7	225	5.4	586	14.0
55 - 64	2,641	2,624	99.4	17	2,624	1,779	67.8	252	9.6	593	22.6
65+	2,916	2,831	97.1	85	2,831	1,477	52.2	419	14.8	935	33.0
Resident type											
Urban	17,546	17,486	99.7	60	17,486	15,595	89.2	402	2.3	1,489	8.5
Rural	25,554	25,456	99.6	98	25,456	22,789	89.5	749	2.9	1,918	7.5
Total	43,100	42,942	99.6	158	42,942	38,384	89.4	1,151	2.7	3,407	7.9

Table 11. Comparison of Field and Central Reading

Central Reading	Field Reading					
	A		B	%	(C)	%
	Total Number	%	Eligible for exam/Re-read	B/5656	Non-eligible/Not read by central team	C/37286
Normal	38,384	89.4	3,837	67.8	34,547	92.7
Abnormal for TB	3,407	7.9	1,817	32.1	1,590	4.3
Other Abnormalities (not TB)	1,151	2.7	2	0.04	1,149	3.0
Total	42,942	100	5,656	100	37,286	100

9.4 Laboratory examination

9.4.1 Sputum sample results

More than a tenth, 5,948 (13.8%) of 43,100 survey participants were eligible for sputum examination and 5,398 (91.4%) of 5,519 had at least one sputum sample tested. The laboratory received 10,742 samples in total from 80 clusters i.e. a mean of approximately 134 samples per cluster. Results were available for 5,434 (91.4%) eligible suspects and 5,376 (97.4%) had results for two sputum and two culture results. Table 12 shows outcome of screening linked to sputum samples obtained for laboratory investigations and central CXR results.

9.4.2 Smear and culture examination results

There were 36 sputum smear positive results (0.6%) by fluorescent microscopy. For 30 participants, both sputum samples provided were positive. As seen in table 13, both spot specimens had the same number of positive results (33 each). Majority of the positive results were smear grade 1^{+} (54.5% for the spot 1 and 51.5% for the spot 2 sample) while only 9.1% and 12.1% of samples had the maximum smear grade for spot 1 and spot 2 samples respectively. Among the smear positive samples, 26 (78.8%) spot 1 and 28 (84.8%) of spot 2 samples respectively were culture positive for *M. tuberculosis complex* (MTBC). Only 0.77% and 0.68% of smear negative spot 1 and spot 2 sputum samples were culture positive for MTBC.

Overall, we found MTBC in 71 participants- 43 from smear negative samples and 28 from smear positive samples.

Table 12. Screening and CXR results and sputum examinations

Outcome of screening	Eligible	2S1C	%	2SOC	%	1S1C	%	1SOC	%	OS1C	%	No Exam	%
Eligible by symptoms Only	2380	2048	86.05	0	0.00	29	1.22	0	0.00	0	0.00	303	12.73
Eligible by CXR abnormality only	2384	2177	91.32	0	0.00	62	2.60	0	0.00	0	0.00	145	6.08
Eligible by both symptoms & CXR	1026	961	93.66	0	0.00	25	2.44	0	0.00	0	0.00	40	3.90
CXR exempted or Refused without Symptoms	102	78	76.47	0	0.00	4	3.92	0	0.00	0	0.00	20	19.61
CXR exempted or Refused with Symptoms	56	50	89.29	0	0.00	2	3.57	0	0.00	0	0.00	4	7.14
Total	5948	5314	89.34	0	0.00	122	2.05	0	0.00	0	0.00	512	8.61
CXR Central reading													
Normal	1621	1414	87.23	0	0.00	19	1.17	0	0.00	0	0.00	188	11.60
Active TB suggestive	559	501	89.62	0	0.00	20	3.58	0	0.00	0	0.00	38	6.80
Healed TB	702	645	91.88	0	0.00	17	2.42	0	0.00	0	0.00	40	5.70
Other lung disease	164	151	92.07	0	0.00	1	0.61	0	0.00	0	0.00	12	7.32
Total	3046	2711	89.00	0	0.00	57	1.87	0	0.00	0	0.00	278	9.13

2S1C- two smear and one culture, 2S0C- two smear and no culture, 1S1C- one smear and one culture, 1S0C- one smear and no culture,0S0C- no smear

Table 13. Relationship between sputum smears and culture results

	Culture Results					
	Total	Positive MTBC	Positive NMTB	Negative	Contaminated	NA
Spot1 Grade						
Total	5435	68	653	4067	647	0
Negative	5401	42	651	4064	645	0
Scanty	5	3	0	1	1	0
1+	18	15	2	0	1	0
2+	7	5	0	2	0	0
3+	3	3	0	0	0	0
NA	0	0	0	0	0	0
Spot2 Grade						
Total	5310	64	628	3945	673	0
Negative	5277	36	626	3942	673	0
Scanty	6	4	0	2	0	0
1+	17	15	1	1	0	0
2+	6	5	1	0	0	0
3+	4	4	0	0	0	0
NA	0	0	0	0	0	0

9.5Prevalent Tuberculosis Cases

In table 14, the characteristics of prevalent cases identified during the survey are shown in relationship to screening status i.e. interview and CXR outcomes; age, gender and urban/rural residence. Using prevalent guidelines for TB diagnosis based on sputum smear microscopy, only 34 (44.2%) of all 77 TB cases would have been diagnosed because 43 (55.8%) were sputum smear negative but culture positive. In addition, 2 cases of NMTB (5.6% of all smear positives) were treated as PTB based on positive smear results. If only those with symptoms had smear microscopy done, just 18 of 34 (52.9%) of prevalent sputum smear positive cases would have been diagnosed compared to 32 of 34 (94.1%) for CXR abnormalities. For all bacteriologically confirmed TB cases, only 43 (60.6%) of 71 would have been detected based on symptoms alone compared to 58 (84.1%) of 69 who had CXR abnormalities suggestive of TB in field readings. This difference in proportions was significant ($p < 0.01$).

Table 14. Number of prevalent TB cases by screening (interview and CXR) results, age, gender and location

	S+C+	S+C-	S-C+	Smear Positive	Bacteriologically Confirmed	Non Study cases/(NMTB)		Total all cases
	TB Case	Probable TB case	TB Case	Survey case	Survey case	S+C-	S+ NMTB	
Total	28	6	43	36	71	0	2	77
Symptoms only								
Eligible	18	0	25	20	44	0	1	44
Non-eligible	9	6	18	16	27	0	1	33
CXR Only								
Eligible	26	6	33	34	58	0	2	64
Non-eligible	1	0	10	1	11	0	0	11
Both (symptoms & CXR)								
Eligible	17	0	15	18	32	0	1	32
Non-eligible	10	6	0	0	0	0	0	6
No CXR	1	0	0	1	1	0	0	1
Central CXR								
Normal	0	0	5	0	5	0	0	5
Active TB	25	6	35	32	60	0	1	66
Healed TB	1	0	3	1	4	0	0	4
Other lung Disease	1	0	0	2	1	0	1	1
Total/Gender								
Male	22	2	27	25	49	0	1	51
Female	6	4	16	11	22	0	1	26
Age Group								
15 - 24	4	0	11	2	15	0	0	15
25 - 34	8	0	6	8	14	0	0	14
35 - 44	8	0	11	9	19	0	1	19
45 - 54	4	1	6	6	10	0	1	11
55 - 64	3	1	4	4	7	0	0	8
65+	1	4	5	5	6	0	0	10
Resident Type								
Urban	13	1	19	16	37	0	2	38
Rural	15	5	24	20	34	0	0	39

As shown in table 15, just about a third of all symptomatic eligible participants had a cough that had lasted 2 weeks or more. There was added benefit of asking for sputum samples based on the presence of a cough less than 2 weeks and associated with 2 or more of following weight loss; fever; night sweats; chest pain; shortness of breath; anorexia and haemoptysis. Furthermore, the additional symptoms criteria identified additional female cases.

Table 15 shows survey prevalent TB cases by symptom category.

	Screening-symptom category						CXR only		Total
	Cough≥14 days	%	Cough <14 days and ≥2 other symptoms	%	No cough and ≥3 other symptoms	%	CXR	%	
Total	25	32.5	14	18.2	5	6.5	33	42.9	77
Total/Gender									
Male	18	35.3	9	17.6	2	3.9	22	43.1	51
Female	7	26.9	5	19.2	3	11.5	11	42.3	26
Age Group									
15 - 24	6	40	4	26.7	2	13.3	3	20.0	15
25 - 34	4	28.6	3	21.4	0	0.0	7	50.0	14
35 - 44	6	31.6	4	21.1	1	5.3	8	42.1	19
45 - 54	6	54.5	0	0.0	0	0.0	5	45.5	11
55 - 64	1	12.5	2	25.0	1	12.5	4	50.0	8
65+	2	20	1	10.0	1	10.0	6	60.0	10
Resident Type									
Urban	15	38.5	8	20.5	1	2.6	11	28.2	39
Rural	10	26.3	6	15.8	4	10.5	18	47.4	38

9.6 Estimating TB prevalence

Below we provide estimates for smear positive, smear negative and culture positive and bacteriologically confirmed TB as crude estimates obtained without taking into account the clustered design.

9.6.1 Crude prevalence of Smear Positive TB

Thirty-six participants were sputum smear positive TB cases but as seen in table 14, 2 were due to NMTB. Majority were males (24, 70.5%) and in the 15-44-year age group (22, 64.7%) as shown in table 16. Of all smear positive cases, only 4 reported being on TB treatment meaning 88.2% (30) were newly diagnosed. In addition, 8 (23.5%) of these 34 smear positive cases reported a history of previous TB. Slightly less than two-thirds, 22 (64.7%) of 34 had cough as a symptom and more than half (13 of 22, 59.1%) of them had been coughing for 2 weeks or more. However, 40.9% had cough less than 2 weeks in duration. Smear-positive TB was 3.5 times more prevalent in males compared to females.

9.6.2 Crude prevalence of Smear-negative/culture-positive TB

The survey found 43 smear negative but culture positive TB cases giving a crude prevalence estimate of as shown in table 16. There were 55.8% (24 of 43) with a cough with equal numbers coughing for

≥2 weeks and for less than 2 weeks. Although lower than seen with smear positive TB, the males had more than twice (2.4) the prevalence of smear negative TB compared to females. The crude prevalence of smear negative/culture positive TB in urban areas was almost twice that seen in settings. However, the stratification by age and location revealed increasing prevalence with age and peaking at with the 35-54 years age group.

9.6.3 Crude prevalence of Bacteriologically positive TB (smear-positive and/or culture-positive)

There were 77 TB cases in total detected during the survey corresponding to a crude prevalence of 179/100,000 (95% CI: 149-231) population aged 15 or older. The male/female ratio was ~3, and prevalence in urban areas was 1.4 times higher than observed for rural areas. This urban-rural divide when stratified by age group is mainly due to the significantly higher prevalence of bacteriologically positive TB in the urban dwelling males in the 15-34 and 35-54 years age groups.

Table 16. Crude Tuberculosis prevalence among survey participants aged ≥15 years

			Smear+ cases				Smear negative/culture positive cases				Bacteriologically positive cases			
	n	**%**	**n**	**/100,000**	**95%CI**		**n**	**/100,000**	**95%CI**		**n**	**/100,000**	**95%CI**	
Total	43,100	100%	34	79	55	110	43	100	72	134	77	179	141	223
Urban/Rural														
Rural	25,554	59.3	20	78	48	128	19	74	45	116	39	153	109	209
Urban	17,546	40.7	14	80	44	134	24	137	88	203	38	217	153	297
Sex and Age														
Male	17,504	40.6	24	137	88	204	27	154	102	224	51	291	217	383
15-34	10,759	61.5	10	109	52	200	9	98	45	186	19	207	125	323
35-54	4,187	23.9	12	295	153	515	12	295	153	515	24	590	378	877
≥55	2,558	14.6	2	47	6	170	6	141	52	307	8	188	81	370
Female	25,596	59.4	10	39	19	72	16	63	36	101	26	102	66	149
15-34	16,122	63.0	2	15	2	54	8	60	26	119	10	75	36	139
35-54	6,475	25.3	1	15	3	82	5	73	24	171	6	88	32	191
≥55	2,999	11.7	7	127	51	261	3	54	11	159	10	181	87	333

9.7 Methods for estimation of Point Estimates of TB prevalence

We obtained point estimates for TB prevalence using the recommended statistical models described in section 7.2 above. [15] The three models already described were used to obtain point estimates for the recommended outcomes i.e. smear positive and bacteriologically confirmed TB.

We applied the three models to the survey participant categories shown in table 17. There were missing data for smear , culture and TB identification for 512 sputum exam-eligible participants and 24 of these had missing CXR as well. Bacterial identification was a conditional imputation, conditioned on a positive culture. In addition, 134 subjects had a missing x-ray only.

Table 17. Participant coding derived from Figure 4 indicating numbers included in different analyses

Category	Code	Total Number
Total enumerated at census	**N**	**100,678**
Eligible survey population	**N_1**	**55,832**
Participants	**N_2**	**43,100**
Symptom screening done	**N_3**	**43,100**
Chest radiograph done	**N_4**	**42,986**
Screen and Chest radiograph done	**N_5**	**42, 986**
Eligible based on symptoms and/or CXR	**N_6**	**5,948**
At least on smear examined	**N_7**	**5,376**
At least one culture done	**N_8**	**5,434**

Therefore, 646 was the total number requiring imputation. Table 18 displays the pattern of missingness for the survey data that was the basis for missing values imputation.

Table 18. Missing combinations for participants eligible for sputum examination

CXR	Smear p	Culture positive	Culture Identification	Count
0				294
1				194
				24
	0	0		108
	0	1	NMTB	25
	1	0		1

9.7.1 Smear Positive PTB

Survey smear positive PTB as defined in section 6 above consists of definite and probable cases with positive sputum smear and a positive culture for *Mycobacterium tuberculosis* complex and/or negative culture fulfilling the other listed criteria respectively.

9.7.1.1 Model 1- Complete case/individual level analysis

The estimates here as shown in table 19A are from a logistic regression model with robust standard errors with no missing value imputation, and analysis was restricted to N_2 in table 17.

9.7.1.2 Model 2- Missing value imputation (MI)

This model also uses a logistic regression model with robust standard errors. However, there is missing value imputation for survey non-participants as well as participants, and this includes all individuals who were eligible for the survey in the analysis i.e. N_1 in table 17. The estimates for smear positive TB using this model is as displayed in table 19A.

9.7.1.3 Model 3- Logistic regression model with missing value imputation (MI) and inverse probability weighting (IPW)

In addition to logistic regression model with robust standard errors, missing value imputation was done only among the subset of survey participants who were eligible for sputum examination but for whom smear and/or culture results were missing (N_6, table 17), and inverse probability weighting applied to all survey participants (N_2, table 17). Table 19A displays the estimates derived from this model.

The findings for smear positive TB are as seen for the crude estimates table 16. Smear positive TB is as prevalent in urban as in rural areas, it is almost 4 times lower than females compared to males and most prevalent in the 25-34 age group. There were very few cases in the 55+ years age group resulting in a relatively imprecise estimate that suggests sputum smear positive TB may highly prevalent in the middle aged and elderly.

In addition, table 20 provides insights into TB prevalence in The Gambia in relation to age and gender. Here it is clear that the overall male preponderance of prevalent smear positive TB is almost exclusively contributed by males 35-54 years old who have > 10-fold higher burden compared to their female counterparts.

Table 19. Prevalence of Smear positive Pulmonary TB per 100,000 population ≥15 years

	Model 1[1]	Model 2[2]	Model 3[3]
Overall point estimate/95%CI	80 [44-116]	92 [55-128]	90 [53-127]
Prevalence by stratum			
Rural	79 [27-132]	90 [38-141]	86 [32-140]
Urban	81 [35-127]	93 [44-142]	96 [43-148]
Prevalence by gender			
Male	139 [82-195]	151 [88-213]	148 [88-208]
Female	40 [0-81]	40 [1-80]	41 [0-83]
Prevalence by age group			
15-34	45 [19-71]	53 [23-82]	56 [24-88]
35-54	102 [57-190]	141 [59-224]	144 [65-223]
55+	146 [55-387]	187 [0-385]	159 [0-367]

[1] Robust standard errors; [2] Robust standard errors with missing value imputation; [3] Robust standard errors with missing value imputation and inverse probability weighting; Confidence interval for this estimate is calculated with exact binomial probability theory

Table 20. Table showing prevalence[1] for categories of Tuberculosis by gender and age per 100,000 population ≥15 years

Gender/Age categories	15-34 years	35-54 years	≥55 years
Smear Positive PTB			
Male	104 [42-166]	282 [118-445]	83 [0-203]
Female	33 [0-78]	26 [0-80]	227 [0-557]
Bacteriologically confirmed PTB			
Male	209 [113-305]	634 [384-885]	325 [108-543]
Female	71 [20-191]	105 [19-191]	330 [0-677]
Smear negative culture positive PTB			
Male	105 [24-186]	349 [157-541]	248 [53-442]
Female	58 [14-101]	88 [9-167]	100 [0-214]

[1] Estimate derived with Model 3- Robust standard errors with missing value imputation and inverse probability weighting; Confidence interval for this estimate is calculated with exact binomial probability theory

9.7.2 Bacteriologically confirmed PTB

Bacteriologically confirmed cases include those with smear positive or negative sputum samples as long as there is a positive TB culture and the case meets other criteria outlined in section 6. The estimates of prevalent bacteriologically confirmed PTB derived from all 3 models below are displayed in table 21.

9.7.2.1 Model 1-Complete case/individual level analysis

Compared to the crude estimates in table 16, this model obtains the estimates for bacteriologically confirmed PTB using logistic regression with robust standard errors to account for the clustered design.

9.7.2.2 Model 2- Missing value imputation (MI)

In addition to a logistic regression model with robust standard errors, model 2 includes missing value imputation for survey non-participants as well as participants. All individuals who were eligible for the survey in the analysis i.e. N_1 in table 17 are included in this analysis as well.

9.7.2.3 Model 3- Logistic regression model with missing value imputation (MI) and inverse probability weighting (IPW)

Compared to model 2, this model applies inverse probability weighting to all survey participants (i.e. N_2, table 17) in addition to the missing value imputation that was done only among the subset of survey participants who were eligible for sputum examination but for whom smear and/or culture results were missing (N_6, table 17).

Overall bacteriologically confirmed PTB was 2.4 times more prevalent than just smear positive PTB. In contrast to smear positive TB above but similar to the pattern seen with the crude prevalence estimates, bacteriologically confirmed PTB was more than twice as prevalent in urban compared to rural areas. In addition, males were 3 times more likely to be prevalent cases of bacteriologically confirmed TB compared to females. The 35-54 years age group was the most affected and this age group had more than 2.5 times the TB seen in their 15-34 years counterparts. Table 20 confirms most of this age-group associated burden is from the higher prevalence of bacteriologically confirmed TB in males rising from 3- to 6-fold more in the youngest and middle age groups respectively.

Table 21. Prevalence of bacteriologically confirmed Pulmonary TB per 100,000 population ≥15 years

	Model 1[1]	Model 2[2]	Model 3[3]
Overall point estimate/95%CI	181 [129-232]	199 [147-250]	212 [152-272]
Prevalence by stratum			
Rural	154 [90-219]	165 [102-228]	109 [54-164]
Urban	219 [138-301]	239 [152-327]	266 [164-368]
Prevalence by gender			
Male	295 [208-381]	309 [221-396]	333 [233-433]
Female	103 [50-155]	104 [53-156]	109 [54-164]
Prevalence by age group			
15-34	109 [63-155]	117 [70-163]	133 [76-190]
35-54	285 [178-392]	323 [199-447]	355 [219-490]
55+	331 [92-570]	364 [140-588]	329 [99-558]

[1] Robust standard errors; [2] Robust standard errors with missing value imputation; [3] Robust standard errors with missing value imputation and inverse probability weighting; Confidence interval for this estimate is calculated with exact binomial probability theory

9.7.3 Smear negative but culture positive PTB

The three models described for smear positive and bacteriologically confirmed PTB were applied to obtain prevalence figures for smear negative culture positive PTB as shown in table 22. Using estimates from model 3 as the most reliable, this form of TB was 1.4 times more prevalent overall than smear positive TB. Unlike smear positive but similar to bacteriologically confirmed PTB, it was also more prevalent in urban compared to rural settings. It also had the male preponderance (male-female ratio is 2.7:1) noticed with smear positive and bacteriologically confirmed PTB. The burden was highest in the 35-54-year age group who had >2.5 times more disease compared to the younger age group (see table 22). Similar to bacteriologically confirmed TB, there was a 2- to 4-fold difference in prevalence of this form of TB between males and females in the youngest and middle age groups respectively.

Table 22. Prevalence of smear negative culture positive Pulmonary TB per 100,000 population ≥15 years

	Model 1[1]	Model 2[2]	Model 3[3]
Overall point estimate/95%CI	100 [62-137]	115 [76-153]	124 [75-172]
Prevalence by stratum			
Rural	74 [32-116]	83 [40-125]	83 [36-131]
Urban	137 [71-203]	154 [83-224]	174 [83-264]
Prevalence by gender			
Male	154 [86-222]	170 [104-237]	186 [100-271]
Female	63 [31-94]	67 [33-100]	70 [34-107]
Prevalence by age group			
15-34	63 [28-99]	70 [32-108]	79 [32-126]
35-54	159 [77-242]	186 [88-283]	211 [101-321]
55+	162 [52-272]	193 [66-320]	172 [53-290]

[1] Robust standard errors; [2] Robust standard errors with missing value imputation; [3] Robust standard errors with missing value imputation and inverse probability weighting; Confidence interval for this estimate is calculated with exact binomial probability theory

9.8 Drug resistance profile of survey cases

Following complete accrual of survey TB cases, we tested samples from confirmed and probable cases for TB drug resistance using the Xpert® MTB/RIF on the GeneXpert platform developed by Cepheid, Inc. (Sunnyvale, CA). All 6-probable survey cases tested negative by liquid culture and Xpert MTB/RIF. Table 21 displays the profile of survey cases by Xpert MTB/RIF results.

There was some discordance with about a third (32.4%) of definite cases (culture positive) negative by Xpert MTB/RIF. There was concordance for the probable survey cases as all culture negative results were also Xpert negative. However, 3 (6.3%) of all positive Xpert results reported Rifampicin resistance, an important marker for multi-drug resistant (MRC) TB while another 3 (6.3%) gave indeterminate resistance results. We will re-culture these isolates for phenotypic/conventional drug susceptibility tests to confirm these results. None of these Rifampicin resistance cases had a history or current or previous TB treatment.

Table 21. Results of drug resistance testing of survey cases using the Xpert® MTB/RIF

	*Xpert/RIF Results				
Survey case	Negative	Positive no **Rif resistance	Positive with Rif resistance	Positive with indeterminate resistance	Total
Definite	23	42	3	3	71
Probable	6	0	0	0	6
Total	**29**	**42**	**3**	**3**	**77**

**GeneXpert, Xpert/RIF©
*Rif, Rifampicin

9.9 Deriving general population TB prevalence estimates from survey population results

The prevalence estimates drawn from the survey population are among adults and based on bacteriological confirmation of TB. Derivation of TB prevalence values applicable to all ages/age groups and all TB presentations required statistical manipulation of the estimates for TB derived from the survey age-eligible participants. We followed the following steps to achieve this;

a) Step I. We calculated pulmonary TB (all ages) as a weighted average of TB in adults (from the prevalence survey) and TB in children. The prevalence of TB in children was calculated from routine TB notification data.

b) Step II. In this step, we inflated upwards PTB by the same percentage as extra-pulmonary over total (all forms) TB notifications.

Using the formula below, we calculated the adjusted TB prevalence for all ages and all forms

$$pr = (c*pr.c + (100-c)*pr.ad) / (100-ep)$$

Following the first nationwide TB prevalence survey, the revised **national TB prevalence in all forms of TB and all age group for The Gambia is 128 (95%CI: 94-162) per 100,000 population**. The updated estimated incidence is **175 (95%CI: 135-215) per 100,000 population** and TB case notification is **130 per 100,000 population**. This TB prevalence is almost 4 (3.8) times less than previously held estimates reported in the Global TB report. Although there is now less interest reporting on smear positive TB, the revised prevalence of smear positive TB assuming prevalence in the population <15 years is 3.1 per 100,000 based on country notification data, is 53 per 100,000.

Table 20. Table showing assumptions underlying derivation of overall prevalence for all forms of Tuberculosis (TB) for all ages

pr.ad	**TB prevalence among adults from survey**	**212**
pr.ad.se	Standard deviation of **pr.ad**	30
c	Percentage of children over total country population	45.9%
pr.c	TB prevalence among children	10.5%
pr.c.se	Standard deviation of **pr.c**	1.6%
source.c	Source of information for TB prevalence in children	Notifications
ep	Percentage of extra-pulmonary over total notifications	6.7%
ep.se	Standard deviation of **ep**	0.7%
source.ep	Source of information for extra-pulmonary TB	Notifications
pr	Updated estimate of prevalence, all ages	127.9
pr.se	Standard deviation of pr	17.4
inc	Updated estimate of incidence	175
inc.se	Standard deviation of incidence	39.8
old.inc	Old incidence (global TB report 2013)	283.6
old.pr	Old prevalence (global TB report 2013)	490.0
newrel	TB case notification rate per 100,000	129.8
tbhiv	Percentage of HIV among incident TB	0.15%

10. Health Seeking Behaviour

Of all the TB cases detected by the survey, 95% were not on treatment or known to routine TB care service. Only 57% (43 of 77) were symptomatic at diagnosis, whereas 84% (65 of 77) had CXR abnormalities suggestive of TB during review in the field.

About 50.7% (38 of 75) of survey cases had sought care because of their symptoms and all of them visited a health care facility. In majority, 82% (31 of 38) who sought care had visited a public health facility. Of survey cases who had not sought care, most (57% of 37) said it was not clear to them at the time that the symptoms they had were serious while the next large group of 37.8% (14 of 37) said they did not feel sick. Interestingly, almost all 12 (92.3%) of the 14 cases who did not seek care because they did not feel sick had chest X-rays abnormal for TB at central reading. Only one TB case in this group did not seek care on because of the cost of doing so and the one other case had decided in favour of alternative (traditional) treatment options.

11. Discussion

The results here show TB prevalence in The Gambia is significantly lower than previously thought. The estimates for prevalence of all forms of TB and sputum smear positive TB when the survey was designed have been described in section 5.2. The results from this survey suggest the prevalence of smear positive pulmonary TB is almost 6 times lower than the 292/100,000 used in calculating the sample size.

In addition, the prevalence of all forms of TB at 128/100,000 is 3.4 times lower than the 429/100,000 assumed for all forms of TB in section 5.2.

These preliminary results are similar to data obtained from the TB prevalence survey in Ethiopia where the overall burden of TB was significantly lower than previously thought. However, now that a few surveys have now been completed in Western (Nigeria) and Eastern (Rwanda and Tanzania) Africa it would be necessary to compare their findings with results from The Gambia.

The total number of TB case notified by the Gambia National TB Programme in 2013 was 2,340 [unpublished, National Leprosy and TB Programme, The Gambia]. The preliminary result of the 2013 Gambian census puts the total population at 1,882,450.[16] Considering the updated TB incidence (175 per 100,000), the revised case detection for the country should be 71% (95%CI: 69.5-72.6) instead of the current estimate, 47% (95%CI: 39–56)[9].

Applying the updated incidence estimate the population and TB case notification from 2009-2013 suggests the Gambia achieved the minimum of 70% case detection 5 years ago except for a drop in 2010. This coupled with the >85% treatment success achieved for more than 5 years as well means Gambia has achieved the 2 DOTS programme targets related to case detection and treatment success.

Table 21. Tuberculosis case detection rates from 2009-2013 based on revised TB incidence estimates

	2009	2010	2011	2012	2013
Estimated/Actual Population*	**1,681,734**	**1,728,394**	**1,776,103**	**1,824,777**	**1,882,450**
Total all forms of TB notified**	**2,065**	**1,962**	**2,249**	**2,333**	**2,340**
Total number of new/incident cases (estimated)	**2,943**	**3,024**	**3,108**	**3,193**	**3,294**
Number of notified cases per 100,000 population	**123**	**114**	**127**	**128**	**124**
Proportion of incident cases notified (%) 95% Confidence Intervals	**70.2** **68.5-71.8**	**64.9** **63.1-66.6**	**72.4** **70.7-73.9**	**73.1** **71.5-74.6**	**71.0** **69.5-72.6**

*2013 figure is actual census data **Obtained from routine National TB Programme Reports

12. Implications of survey results for the National Leprosy and TB programme in The Gambia

The magnitude of sputum smear positive TB and all forms of TB is much lower than estimated. However, the following are important issues for consideration;

1. Tuberculosis in The Gambia is predominantly urban as these have high population densities
2. There is still significant undetected TB in The Gambia as only a few of the prevalent TB cases were known to the NLTP
3. The burden of survey defined TB was significantly higher in males compared to females and particularly those aged 35-54 years. Male targeted interventions are required
4. The burden of smear negative and bacteriologically confirmed TB is significantly more than that for sputum smear positive TB. The current TB diagnostic strategy (symptom screen and smear microscopy) will identify a little more than half of all cases.
5. Improved diagnostic algorithms including increased access to good chest X-ray (including its interpretation) and bacteriologic confirmation-culture/GeneXpert should be part of the response to survey data.
6. The NLTP needs to increase efforts aimed at key target groups- children, HIV infected persons, persons in congregate settings, etc
7. The Gambia appears to have reached DOTS targets for case detection and treatment success of the last 5 years, but TB notification is increasing/stable suggesting that current TB control efforts are not sufficient to achieve a significant decline in TB burden and incidence. This is most likely related to limited impact of current TB control efforts on TB transmission
8. There is a trend towards a significant burden of TB among the elderly especially males although the numbers are small. However, active screening may be required for this age group especially in the context of case contact investigations and the cultural acceptance of chronic cough in the elderly.
9. An evidence based approach is required for the new phase of TB control efforts in The Gambia starting with the use of results from this prevalence survey for revision of the national strategy
10. Surveillance for drug resistant forms of TB needs to be strengthened in primary and re-treatment TB cases.
11. Despite the achievement of DOTS targets and the much lower TB burden compared to earlier estimates, the efforts and resources invested to achieve these need to be

maintained. Added resources are now required to increase case notification and interrupt TB community TB transmission.

12. The results of this survey highlights several research questions ;
    a. Where does TB transmission occur in The Gambia?
    b. What are the responsible networks for transmission?
    c. What new diagnostic tools and algorithms are appropriate for this setting to improve TB diagnosis?
    d. What are the appropriate evidence-based approached for scaling up activities aimed at the high risk groups- men, household and community TB contacts, children, persons living with HIV/AIDS and other less well described at risk groups in The Gambia such as person with type 2 diabetes?

13. Limitations of survey data

The survey had the following limitations;

1. Survey design

a. The screening strategy for this survey will miss the very small number of asymptomatic TB patients with normal chest X-rays.

b. We could not directly measure the prevalence of TB in children and extrapulmonary TB

c. Because of (b), the extrapolation of survey obtained prevalence to the population prevalence of all forms of TB was based on assumptions for the prevalence of childhood and extrapulmonary TB. If these are very low from underreporting, there is the risk that the population prevalence presented here underestimates the true burden.

d. Voluntary counselling and testing for HIV examinations was not included in survey procedures. Therefore, this survey could not investigate the relationship between a TB prevalence and HIV infection by age, gender or locality.

2. Operational aspects

a. Overall participation did not reach the desired target although this was mainly an urban phenomenon as the rural clusters did much better.

b. Logistical challenges led to delays in starting and the extension during implementation such that the survey lasted for 13 months.

c. Contamination rates (11%) were higher in the laboratory for this survey using liquid cultures despite efforts to assure the best quality for sputum samples and the integrity of the decontamination procedure. The contamination rate in the same laboratory for routine samples was within prescribed ranges for both solid and liquid media cultures. As a result, there is a risk that the survey might have underestimated the prevalence of culture positive TB and the overall estimates especially for smear negative cases.

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Annex 1

List of survey clusters

ClusterNO	EA TYPE	Region	Settlement	ORDER
001	URBAN	GREATER BANJUL REGION	BANJUL SOUTH	51
002	URBAN	GREATER BANJUL REGION	BANJUL CENTRAL	80
003	URBAN	GREATER BANJUL REGION	BANJUL NORTH	29
004	URBAN	GREATER BANJUL REGION	BAKAU NEWTOWN	77
005	URBAN	GREATER BANJUL REGION	BAKAU SANCHABA (NEW TOWN)	44
008	URBAN	GREATER BANJUL REGION	KOLOLI	79
009	URBAN	GREATER BANJUL REGION	MANJAI KUNDA	61
010	URBAN	GREATER BANJUL REGION	BAKOTEH	40
011	URBAN	GREATER BANJUL REGION	BAKOTEH	23
012	URBAN	GREATER BANJUL REGION	EBO TOWN	20
013	URBAN	GREATER BANJUL REGION	EBO TOWN	30
014	URBAN	GREATER BANJUL REGION	EBO TOWN	34
015	URBAN	GREATER BANJUL REGION	EBO TOWN	37
017	URBAN	GREATER BANJUL REGION	BUNDUNGKA KUNDA	4
018	URBAN	GREATER BANJUL REGION	BUNDUNGKA KUNDA	5
019	URBAN	GREATER BANJUL REGION	BUNDUNGKA KUNDA	3
020	URBAN	GREATER BANJUL REGION	BUNDUNGKA KUNDA	1
021	URBAN	GREATER BANJUL REGION	FAGIKUNDA	2
022	URBAN	WEST COAST REGION	SUKUTA	76

ClusterNO	EA TYPE	Region	Settlement	ORDER
023	RURAL	WEST COAST REGION	BUSUMBALA	71
024	RURAL	WEST COAST REGION	BUSUMBALA	70
025	RURAL	WEST COAST REGION	NEW YUNDUM	75
026	URBAN	WEST COAST REGION	WELLINGARA	73
027	URBAN	WEST COAST REGION	KUNKUJANG KEITA	72
028	URBAN	WEST COAST REGION	GUNJUR	59
029	RURAL	WEST COAST REGION	SIFOE	60
030	RURAL	WEST COAST REGION	JAMBAJELLY	68
031	RURAL	WEST COAST REGION	JAMBUR	74
033	RURAL	WEST COAST REGION	DARSILAMEH	67
034	URBAN	WEST COAST REGION	BRIKAMA WELLINGARA	64
035	URBAN	WEST COAST REGION	BRIKAMA SANTOSU	66
036	URBAN	WEST COAST REGION	BRIKAMA SUM KUNDA	53
037	URBAN	WEST COAST REGION	BRIKAMA SUMA KUNDA	56
038	RURAL	WEST COAST REGION	GIBOROH	54
039	RURAL	WEST COAST REGION	TANENE	65
040	RURAL	WEST COAST REGION	FARABA-BANTA	62
041	URBAN	WEST COAST REGION	SIBANOR	57
042	URBAN	WEST COAST REGION	SIBANOR	58
044	RURAL	WEST COAST REGION	KANFENDA	52
045	RURAL	CENTRAL RIVER REGION	KAYAI	32
046	RURAL	CENTRAL RIVER REGION	BAKADAGIE	33
047	RURAL	CENTRAL RIVER REGION	TANKONG KUNDA AND KUNTING	22

ClusterNO	EA TYPE	Region	Settlement	ORDER
048	RURAL	CENTRAL RIVER REGION	MISERA	24
049	RURAL	CENTRAL RIVER REGION	KUMBANEY	21
050	RURAL	CENTRAL RIVER REGION	JAHALLY MADINA	27
051	URBAN	CENTRAL RIVER REGION	BRIKAMA BA	26
052	RURAL	CENTRAL RIVER REGION	BORABA	25
053	RURAL	CENTRAL RIVER REGION	NJOBEN	28
054	RURAL	CENTRAL RIVER REGION	DARU	18
055	RURAL	CENTRAL RIVER REGION	SANTATO	19
056	RURAL	NORTH BANK REGION	FASS NJAGA CHOI	50
057	RURAL	NORTH BANK REGION	BAKINDIK	49
058	RURAL	NORTH BANK REGION	NDUNGU KEBBEH	48
059	RURAL	NORTH BANK REGION	PAKAU NJOGU	47
060	RURAL	NORTH BANK REGION	MUNYAGEN	45
061	RURAL	NORTH BANK REGION	SUWAREH KUNDA	42
062	RURAL	NORTH BANK REGION	SALIKENE	46
063	RURAL	NORTH BANK REGION	DOBO	36
064	RURAL	NORTH BANK REGION	DIBBA KUNDA	41
066	RURAL	LOWER RIVER REGION	KENEBA	39
068	RURAL	LOWER RIVER REGION	SIBITO	35
069	RURAL	LOWER RIVER REGION	SITAHUMA	31
071	RURAL	UPPER RIVER REGION	KOSEMAR TENDA	17
072	RURAL	UPPER RIVER REGION	KULKULEH	12
073	RURAL	UPPER RIVER REGION	GARAWOL	7

ClusterNO	EA TYPE	Region	Settlement	ORDER
074	RURAL	UPPER RIVER REGION	GARAWOL	8
075	RURAL	UPPER RIVER REGION	NYAMANARR	9
076	RURAL	UPPER RIVER REGION	KOINA	10
077	RURAL	UPPER RIVER REGION	WELLINGARA	11
078	RURAL	UPPER RIVER REGION	BARROW KUNDA	16
079	RURAL	UPPER RIVER REGION	BAJA KUNDA	14
080	RURAL	UPPER RIVER REGION	BAJA KUNDA	15
083	URBAN	GREATER BANJUL REGION	TALLINDING	6
084	URBAN	GREATER BANJUL REGION	NEW JESHWANG	63
085	URBAN	GREATER BANJUL REGION	BUNDUNG	78
086	URBAN	WEST COAST REGION	BRIKAMA SANCHABA	55
087	RURAL	WEST COAST REGION	NEW NEW YUNDUM	69
092	URBAN	NORTH BANK REGION	ESSAU	43
095	URBAN	LOWER RIVER REGION	SOMA	38
098	RURAL	UPPER RIVER REGION	LIMBAMBULU	13