Research Article

The epidemiology of tuberculosis in Kenya, a high TB/HIV burden country (2000-2013)

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Interest in the epidemiology of TB was triggered by the re-emergence of tuberculosis in the early 1990's with the advent of HIV and falling economic status of many people which subjected them to poverty. The dual lethal combination of HIV and poverty triggered an unprecedented TB epidemic. In this study, we focused on the period 2000-2013 and all the notified data in Kenya was included. Data on estimates of TB incidence, prevalence and mortality was extracted from the WHO global Tuberculosis database. Data was analysed to produce trends for each of the years and descriptive statistics were calculated. The results showed that there was an average decline of 5% over the last 8 years with the highest decline being reported in the year 2012/13. TB continues to disproportionately affect the male gender with 58% being male and 42% being female. Kenya has made significant efforts to address the burden of HIV among TB patients with cotrimoxazole preventive therapy (CPT) uptake reaching 98% and ART at 74% by the end of 2013. Kenya's TB epidemic has evolved over time and it has been characterised by a period where there was increase in the TB cases reaching a peak in the year 2007 after which there was a decline which began to accelerate in the year 2011. The gains in the decline of TB could be attributed in part to the outcomes of integrating TB and HIV services and these gains should be sustained. What is equally notable is the clear epidemiologic shift in age indicating reduced transmission in the younger age groups.

Keywords: Tuberculosis, HIV, ART, Epidemiology, TB/HIV, Kenya

INTRODUCTION

Tuberculosis (TB) continues to be one of the major infectious diseases of public health concern globally WHO (2012). It is caused by *bacillus* bacteria and the most common causative organism is the *Mycobacterium tuberculosis*. Other causative agents that are occasionally implicated are *Mycobacterium bovis* which is transmitted through contaminated milk and *Mycobacterium africanum*, Cadmus *et al.* (2006). The transmission of the bacteria is through infectious aerosolized droplet nuclei generated by coughing, laughing, talking, sneezing and singing. The ability to generate infectious aerosolized droplet nuclei is dependent on the infectivity of the patient with sputum smear positive patients considered most infectious, Dooley *et al.* (1992). Infection with the *mycobacterium* does not always lead to development of disease as the immune system is able to contain the infection and the bacilli remains dormant.

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The risk of infection is dependent on the extent to which exposure happens; longer durations of exposure to infected persons who are not on treatment increases the chance of infection, Dooley *et al.*(1992). The most at risk to develop TB include children under five, the old and those who are immunosuppressed, WHO (2012).

Globally, the World Health Organization (WHO) estimates that 2 billion people, or 1/3 of the world's population, are infected with (*Mycobacterium tuberculosis*) the bacillus that causes tuberculosis (TB). In 2013, there were 9 million incident cases with 1.5 million people dying of TB, making it the leading infectious cause of death worldwide, WHO (2014).

Globally, the African region contributes 26% of the TB burden making the region the second after Asia which contributes 59% of the Global case load, WHO (2012). Kenya is among the twenty two (22) TB high burden countries in the world which contribute 80% of the global TB burden, WHO (2012). The absolute number of TB cases notified has increased more than tenfold since 1990 while the TB incidence has increased from below 50 per 100,000 in 1990 to 329 per 100,000 population for all forms of TB in 2008, DLTLD (2013). The HIV epidemic is the single most contributing factor for this massive increase in the burden of TB in Kenya. From the Kenya AIDS Indicator Survey 2013, the prevalence of HIV in Kenya currently stands at 5.6%, NASCOP (2013), while the TB HIV co-infection rate was at 35% in 2014, NLTLD (2014). To combat the challenges of TB epidemic in Kenya there has been massive scale up of both treatment and diagnostic facilities. In 2013, diagnosis and treatment of TB was carried out by general health care workers in 1,900 TB diagnostic centres and over 4,300 TB treatment centres in Kenya DLTLD (2013). This translates to one diagnostic centre per 37,634 populations and one treatment centre per 18,411 populations DLTLD (2013). Diagnosis of TB is through sputum smear microscopy for new smear positive cases. Smear negative cases are diagnosed via a diagnostic algorithm as per the national TB guidelines DLTLD (2013). The diagnosis of extra pulmonary TB is based on clinical suspicion and the collection of appropriate specimens for TB bacteriology where this is feasible DLTLD (2013). Kenya developed a medium term TB control strategic plan covering the period 2011-2015 which is modelled along the WHO Stop TB Strategy. The global targets of TB control are to achieve at least 70% TB case detection rate and 85% treatment success rate, WHO (2006).

Kenya has made good progress in the fight against TB; TB Case detection rate (CDR) reached 79% in 2013, the treatment success rate was 89% in 2013. By the end of 2014, 95% of TB patients were tested for HIV against a national target of 95%, NTLD (2014). Despite this progress, major problems still remain as close to 21% of all incident TB cases are not detected, the significant delays in TB diagnosis facilitates TB transmission and is associated with a higher frequency of the poor sequel of TB and the emerging problem of drug resistant tuberculosis DLTLD (2013). There are concerns that inadequate infection control measures in health care settings may be facilitating the transmission of TB to health care workers and patients which has significant consequences for vulnerable groups such as HIV infected persons, DLTLD (2013). The emergence of multidrug-resistant *Mycobacterium tuberculosis* (MDR-TB) worldwide poses a serious problem to the treatment of tuberculosis. These MDR strains are at least resistant to two most important primary chemotherapeutic agents rifampicin and isoniazid, WHO (2003) which require treatment with more costly and more toxic second-line drugs.

To understand TB epidemiology, there is need to consider the changes in the trends of the burden of TB disease over a period of time. The main indicators for the burden of TB disease include; incidence, prevalence and mortality, WHO (2013). These estimates have been derived from WHO databases on TB. Data on TB prevalence and mortality are hardly available due to low coverage of the civil registration systems in the country. Kenya is currently (2015) undertaking a TB national prevalence survey (the last TB prevalence survey was conducted in 1956).

There is currently no nationally representative vital registration system with standard ICD-10 coding in place in Kenya. Less than half of deaths are recorded, and approximately 10% of deaths receive any ICD code (CRS, 2014). Results from a prevalence survey and vital registration systems can be used to assess the current levels of TB disease and mortality and could also provide important evidence about the effectiveness of current TB programmatic efforts and actions needed to improve TB care and control.

Sitienei *et al.* (2013) has noted that the evolution of TB epidemiology in Kenya has mainly been guided by a number of factors which include but not limited to economic and environmental factors and the comprehensive TB control strategies that have been implemented by the Government of Kenya.

In this paper we describe the epidemiological evolution of TB in Kenya over the last 14 years with focus of TB burden measures; prevalence, incidence, mortality and notifications over the years.

MATERIALS AND METHODS

This study was carried out through detailed and extensive review of existing TB/HIV data estimates

from the Global TB database (http://who.int/tb/country/data/download/en/). This data was further augmented from the National TB control program databases. The Kenyan National TB control program is well known for maintaining a robust surveillance system which maintains data on notification from the whole country. The Country has consistently reported the surveillance data to the World Health Organization which then facilitates the production of yearly country profiles.

The national TB surveillance system in Kenya (TIBU) is an electronic case based system that enables availability of real time information on all TB patients in the Country. Data is entered into a tablet by sub-County TB coordinators from TB facility registers during routine monthly support supervision visits in the health facilities. The data is then electronically transmitted to the national database. This electronic system commenced in 2012, replacing the previous paper based system where the districts would on a quarterly basis aggregate all data from health facilities before transmission to the regional and national levels.

After retrospectively extracting the data from the Global WHO database on estimates of prevalence, incidence and mortality together with the notification data from the National TB databases for the period (2000-2013), the data was subjected to exploratory data analysis (EDA) to look at the emerging trends that was inherent in the data. The datasets that did not have all the requisite variables were omitted from the analysis. The data was managed using MS access and excel was used to create graphs and tables to depict the changes in TB epidemiology over the years.

The trends in case notification rates were obtained using total TB cases notified and population estimates from the Kenya National Bureau of statistics. The data was stratified by year, child/adult (<14 years and >15 years), gender, HIV test, disease type and age group.

In Kenya, the policy for diagnosis of TB is that, all presumed TB cases with signs and symptoms of TB are sent to the laboratory for collection of sputum specimen and examination in the laboratory for presence or absence of tubercle bacilli. Those whose specimens turn positive for tubercle bacilli are classified as smear positive, while those who are smear negative may be commenced on treatment if they fit the clinical diagnostic criteria or having been diagnosed for TB based on an abnormal chest x-ray. Before the patients are started on TB treatment, patients are provided with information and advantages of HIV testing and those who consent are provided with HIV testing according to the national guidelines. Further treatment and diagnosis for Tuberculosis in Kenya is free and the government bears the costs of both diagnosis and procurement of quality assured anti TB medicines.

RESULTS

Burden of TB Disease

Burden of disease is looked at from 3 contexts; incidence, prevalence and mortality. Analysis of the trends in estimates of TB incidence (Figure 1) suggests a consistent decline in new TB cases over time, with the decline in TB cases starting in 2005 following the decline in TB/HIV cases which started in 2004. After peaking in 2006, there has been a slowing in the rate of decline in estimates of TB prevalence (Figure 2). TB mortality estimates suggest an increase in TB deaths in 2011-2012 (Figure 3). However, the wide confidence intervals indicate considerable uncertainty in the estimates, suggesting the need for other more direct methods to measure prevalence and mortality.

With regards to deaths occurring to HIV positive TB patients there has been a consistent decline in the estimated TB-related deaths among people living with HIV (Figure 4). This could be attributed to interventions in both HIV and TB programs beginning to bear fruits and could need to be further sustained.

TB Case Notifications

In Kenya, the number of notified TB cases (all forms) increased from approximately 95,000 cases in 2003 to a peak of over 116,000 cases in 2007 (Figure 5). After 2007, the number of notified TB cases steadily declined until 2013, when the number of notified TB cases was approximately 89,000 – the lowest it has been in over a decade. Approximately 10,000 fewer cases were reported in 2013 compared with 2012. This trend is consistent with the trend of incidence and prevalence which has been observed in (Figures 1 & 2) above.

The case notification rate for all TB cases (new and retreatment) shows three distinct trends (Figure 6). From 2000 to 2004, the TB case notification rate increased steadily; from 2004 to 2006, rates remained constant; and from 2006 to 2013, rates steadily declined, with rates in 2013 lower than those recorded in 2000 (Figure 6). Based on national data, the case notification rates fell especially quickly between 2011 and 2013, decreasing approximately 8% and 12% each year, respectively (Table 1); for all years, notification rates based on Kenyan data are slightly higher than WHO estimates (Figure 6) and this may be explained by use of different population estimates.

Case notification rates were calculated using population estimates from Kenya's 2009 census (years 2009-2013) and updated population estimates from the 1999 census (years 2003-2008). Changes in population estimates between 2008 and 2009 did not appear to have a large effect on national level case notification rates.
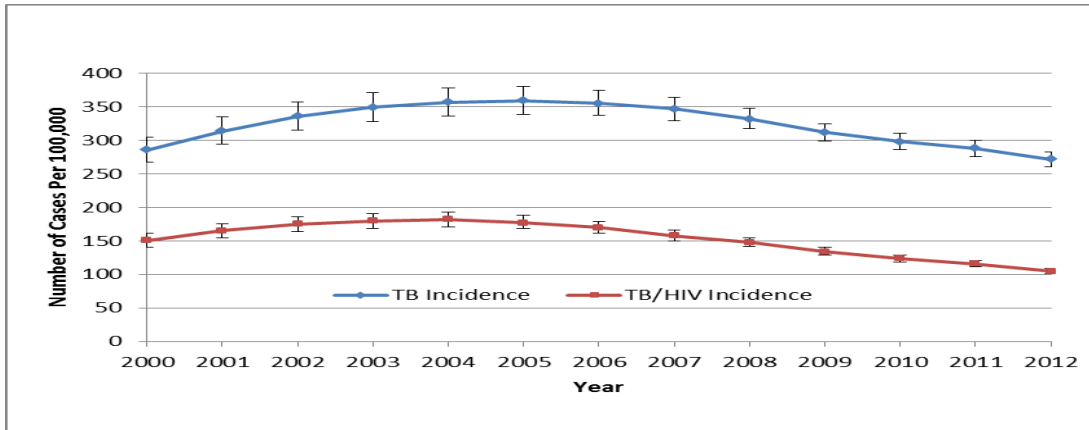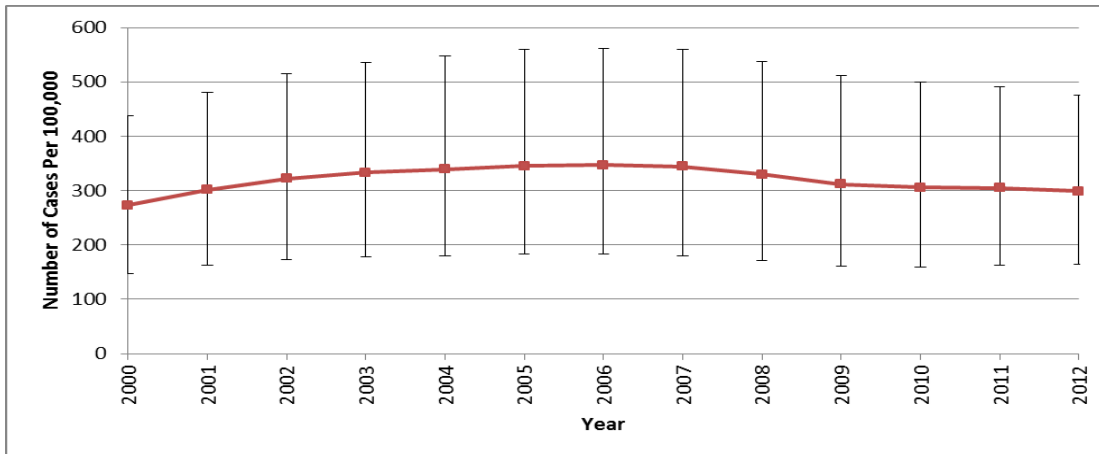
Figure 1. Tuberculosis incidence 2000-2012

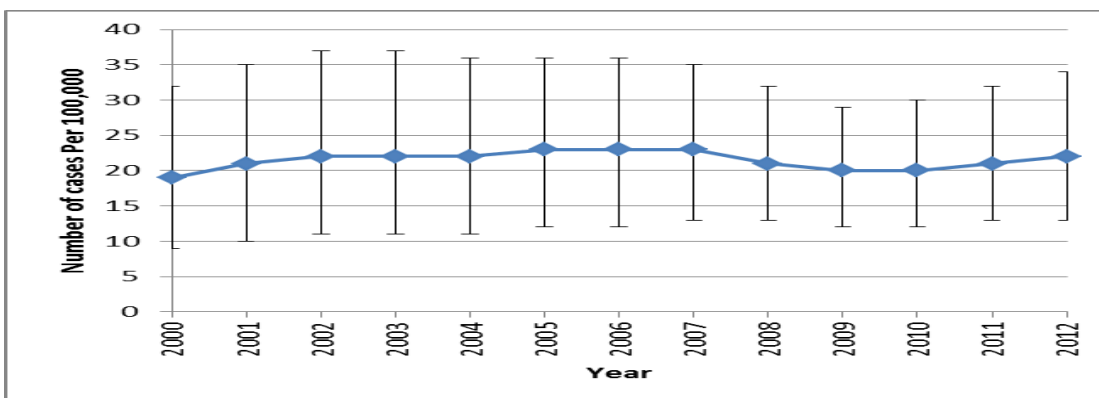**Figure 2.** Tuberculosis prevalence 2000-2012

Figure 3. Tuberculosis mortality 2000-2012

As shown in Figure 7, the percentage of new childhood and adult TB cases has remained consistent between 2008 – 2012.The ratios are fairly consistent with the rates that have been proposed by WHO in their standards and benchmarks tool which suggests that the data collected at the national level have a high level of external consistency if the percentage of children diagnosed with TB ranges between 5-15% in low - and middle-income countries, WHO (2014).

TB Cases by Disease Type

The relative numbers of new bacteriologically confirmed (smear positive) cases and extrapulmonary TB cases
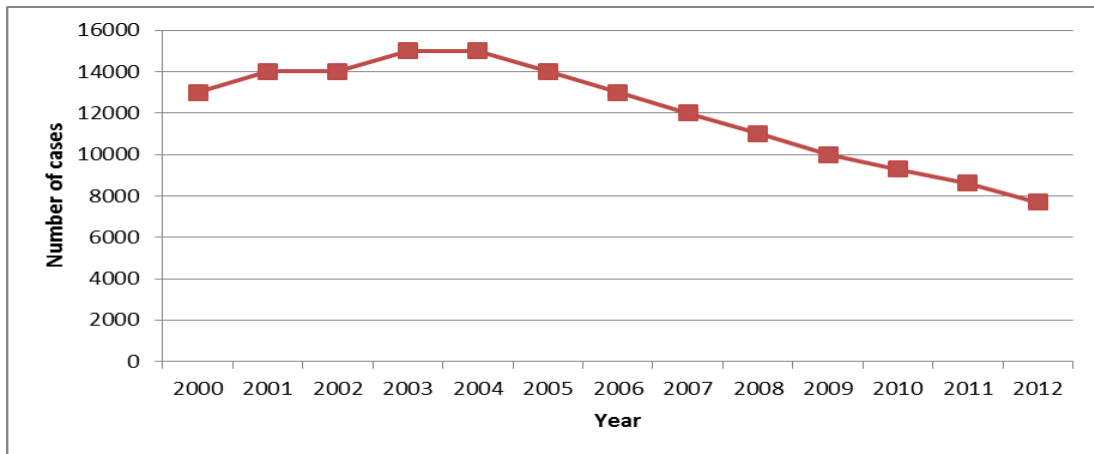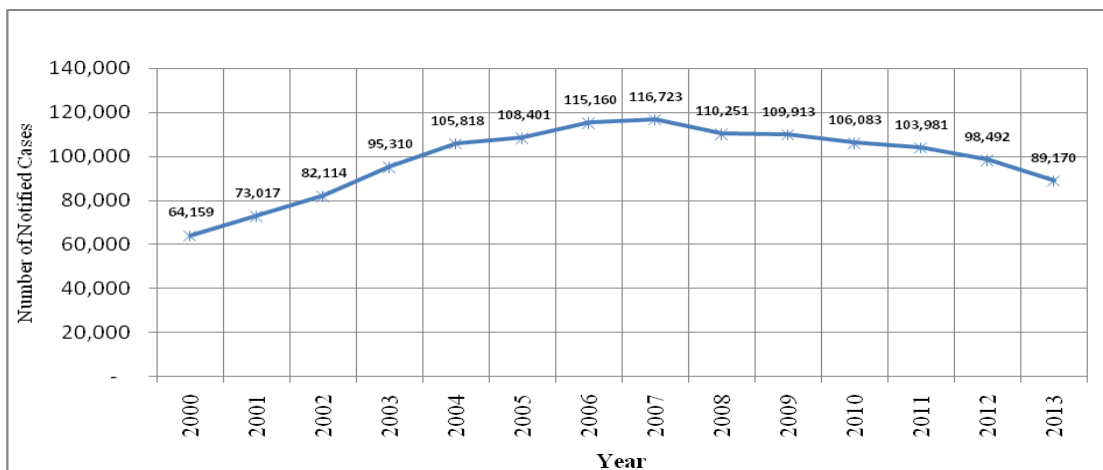
Figure 4. TB deaths among HIV patients 2000-2012

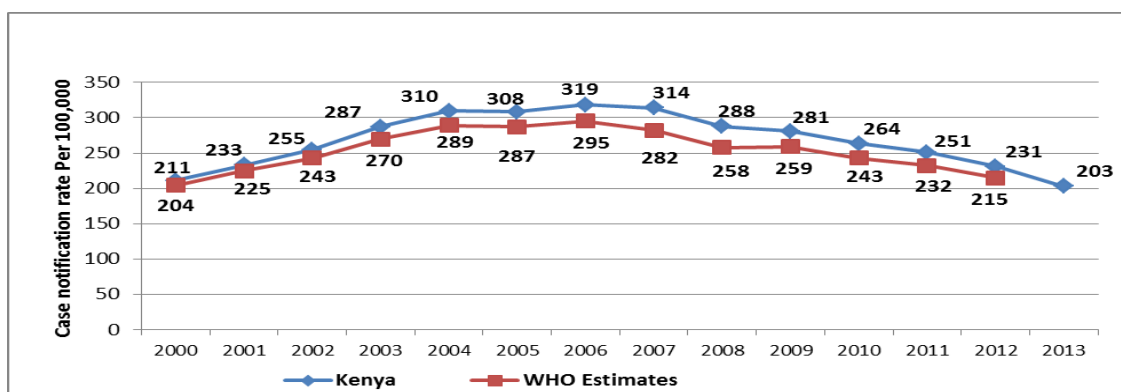**Figure 5**. TB notifications 2003-2013

**Figure 6.** TB notification rates: 2000-2012

have remained fairly consistent over time (Figure 8). The percentage of new cases that are bacteriologically confirmed ranged from 37.3% to 43.0% between 2003 to 2012, fluctuating slightly from year-to-year. The percent of new cases that are extrapulmonary, however, increased gradually since 2003 but maintained a narrower range: 15.1% to 18.2% (Figure 8). This slight increase may result in a reduction in TB transmission because there are fewer pulmonary TB cases in the community. Further, when smear positive new cases are compared to extrapulmonary TB, it shows that the percentage range of extra-pulmonary is between 26% and 31% over the years and has remained stable in this range (Figure 9).

Table 1. Change in Notified TB cases (all forms), Kenya, 2003-2012

Year	National TB case notification rate (per 100,000)	% Δ from previous year
2000	210.8	
2001	233.2	**10.6%**
2002	254.8	**9.3%**
2003	287.3	**12.7%**
2004	309.6	**7.8%**
2005	308.5	**-0.4%**
2006	318.7	**3.3%**
2007	313.9	**-1.5%**
2008	288.0	**-8.2%**
2009	281.2	**-2.4%**
2010	263.6	**-6.2%**
2011	251.0	**-4.8%**
2012	230.9	**-8.0%**
2013	203.1	**-12.1%**

Figure 7. TB cases: Adults versus children
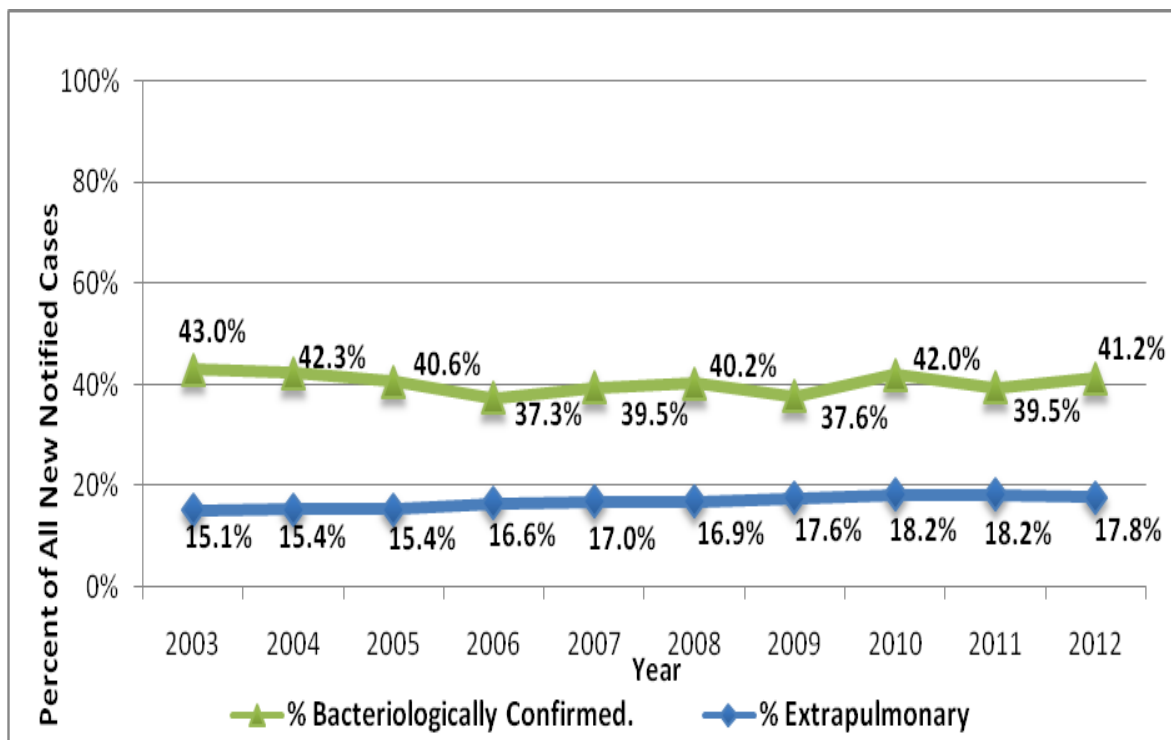
Figure 8. Percent of new bacteriologically confirmed (smear positive) and extrapulmonary TB cases out of all new cases, Kenya, 2003 – 2012.

TB Cases by Age

The largest number of TB cases occurred among young adults (Figure 10), with the most cases reported for adults aged 25-34 years, followed by adults aged 35-44 and 15-24 years; this indicates that HIV continues to be a major driver of the TB epidemic in Kenya. The average age of TB cases in 2012 and 2013
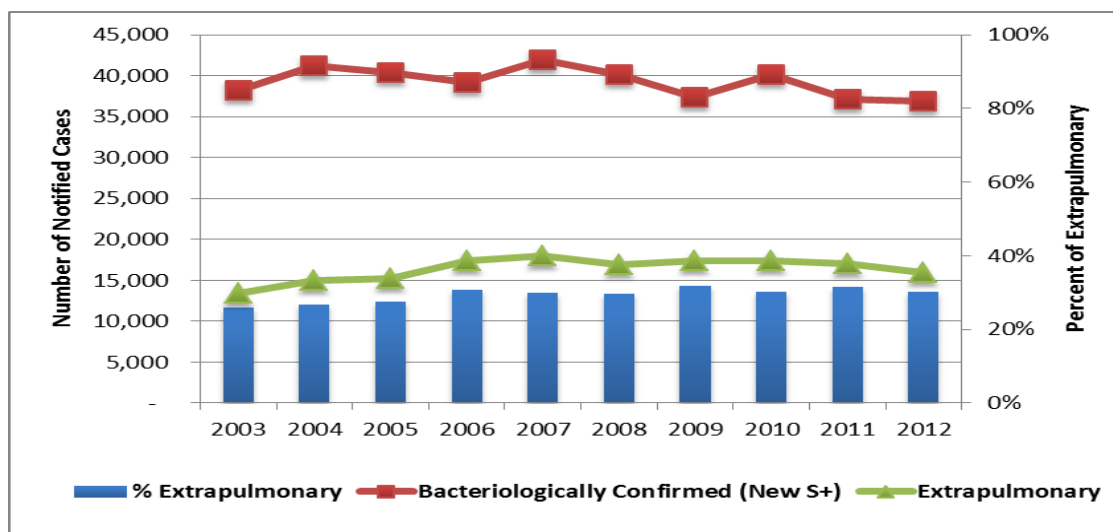
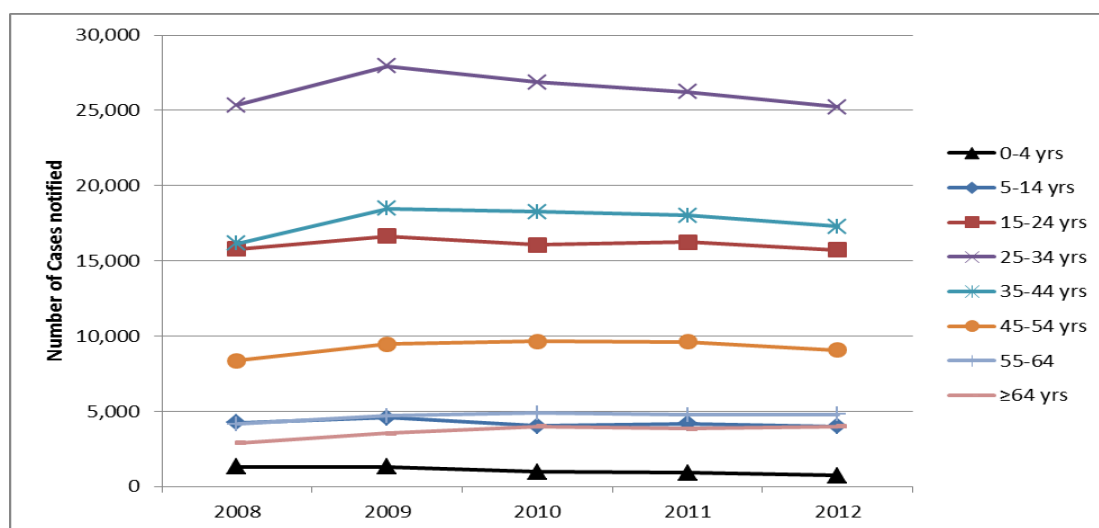**Figure 9.** Pulmonary versus extrapulmonary TB- all new cases

Figure 10. All TB cases by age group- Kenya, 2008-2012

was 33.7 and 37.7 years, respectively; these are the only years for which case-based data are available. The fewest cases were reported in children aged 0-4 years.

Age- and sex-specific case notification rates

Figures 11a and 11b show that among all age groups, except for children (0-15 years) and young adults (15-24 years), males had higher TB case notification rates than females. For children and young adults, rates of new TB disease were equal between males and females. For both males and females, adults aged 35-44 years had the highest rates of new TB disease; however, rates of TB among males in this age group were approximately 30% greater than rates of TB for females in the age group.

Differences between males and females by age group remain, but are less pronounced for new smear positive TB case notification rates (Figures 12a and 12b). In particular, for males, 35-44 and 25-34 year olds have the highest rates for smear positive TB, while 35-44 and 45-54 year olds have the highest rates for all forms of new TB.

Overtime there has been a small decrease in case notification rates for all new cases and all new smear positive cases for both males and females (Figures 11a and 11b, 12a and 12b). Children and young adults (15-24 years) saw the most minimal change over time. Adult's aged 64 years and above were the only group to experience increases in TB cases rates.

From the age sex distribution (figures 13-16), it is clear the most vulnerable age group is that of 15-44, the most vulnerable group being those aged 15 to 44 the most economically productive segment of the population.
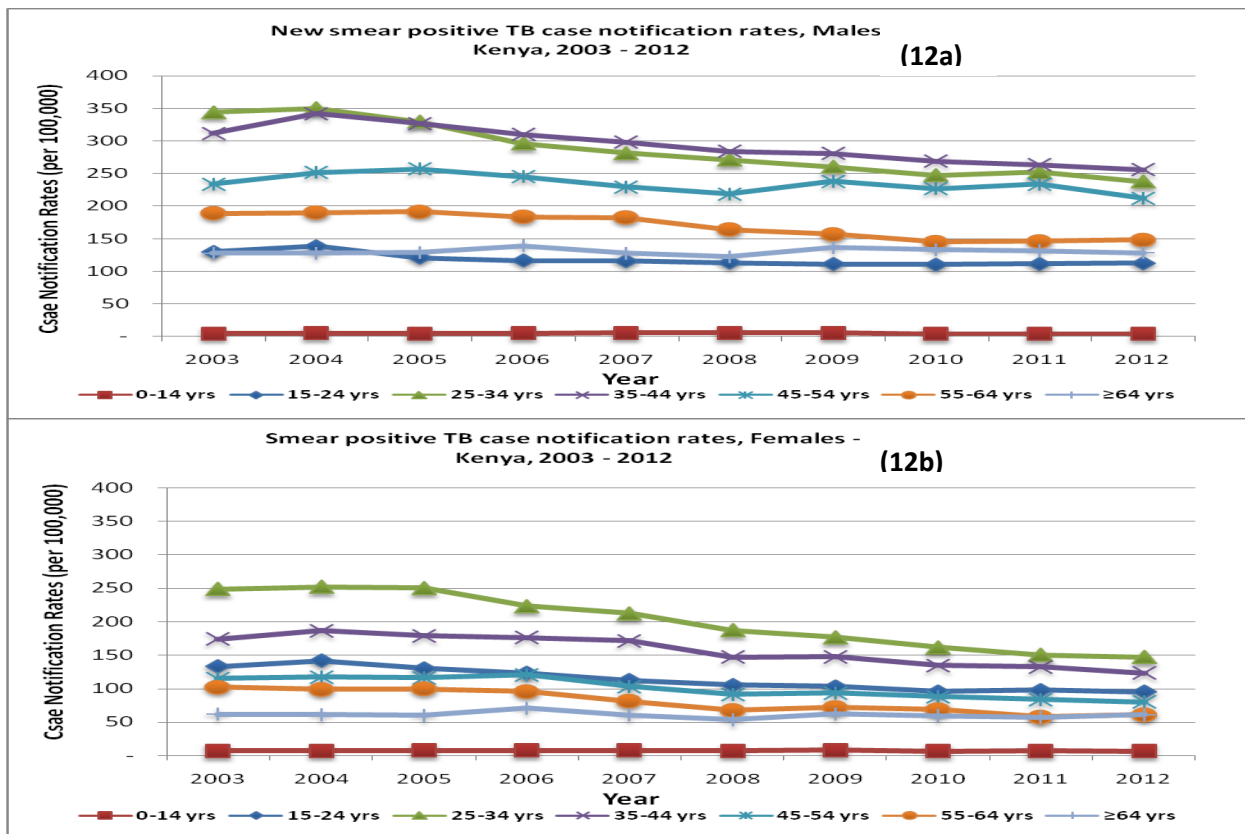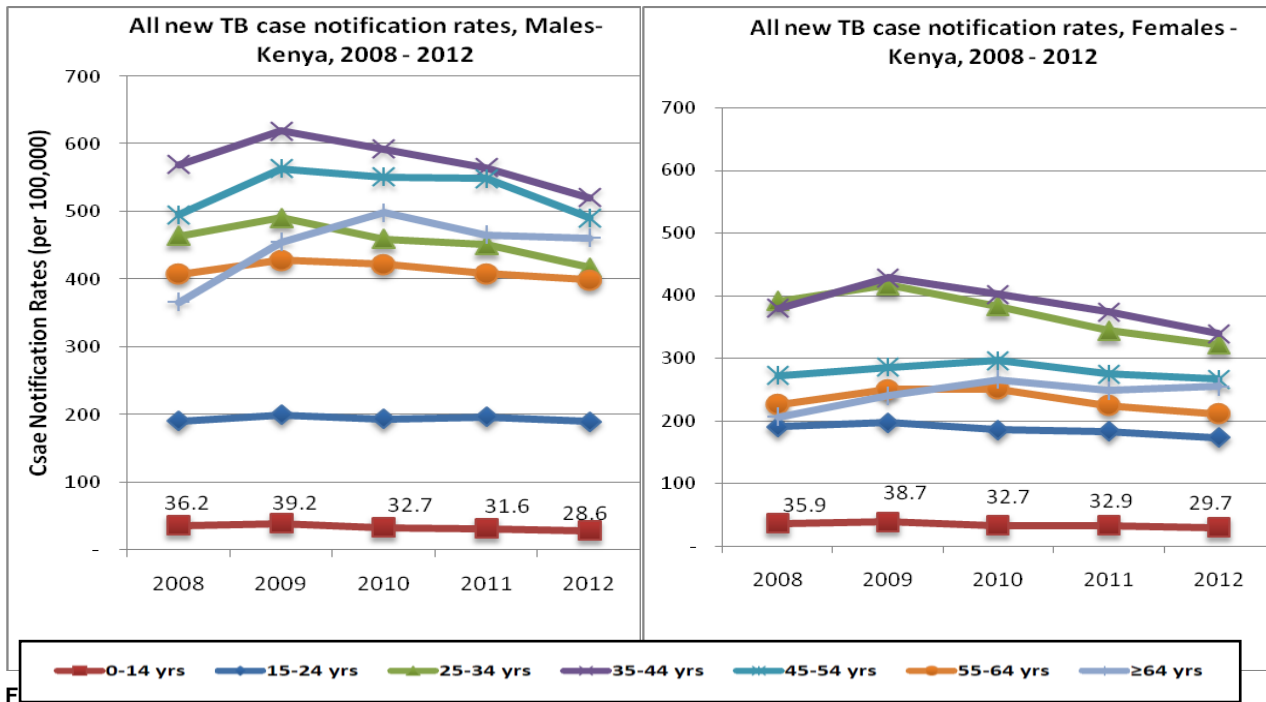
Figures 12a and 12b. New smear positive case notification rates per 100,000 among males and females in Kenya from 2003 – 2012.

It further shows that those mostly affected are in the age group 25-34 years. Interesting observation though is depicted in (figure 13) which shows that there is a bi-modal peak at age 15 and 25 years of age amongst the

female smear positive TB cases.

National-level TB data disaggregated by age (Figures 12-16) suggest that although the rate of TB in
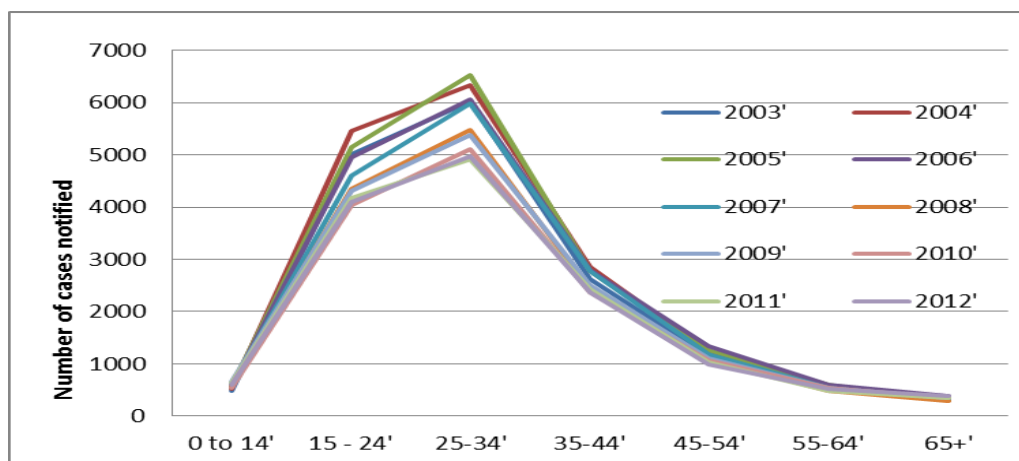
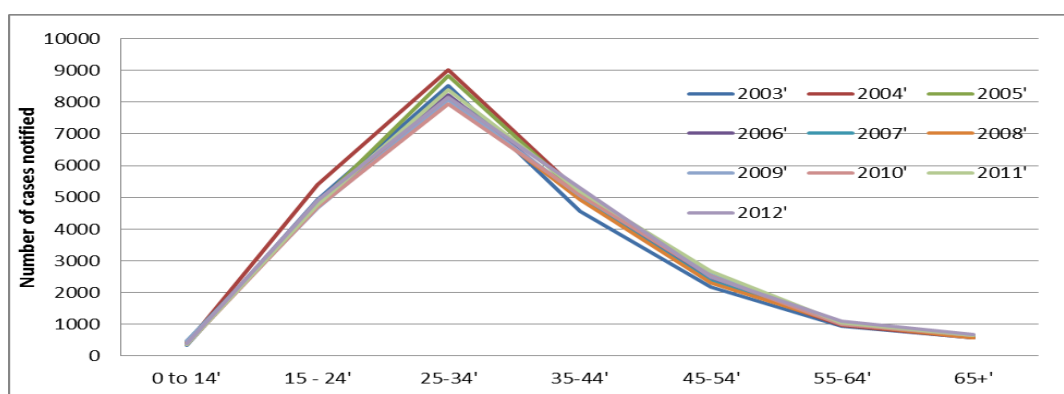**Figure 13.** Distribution of females with smear positive TB per age group

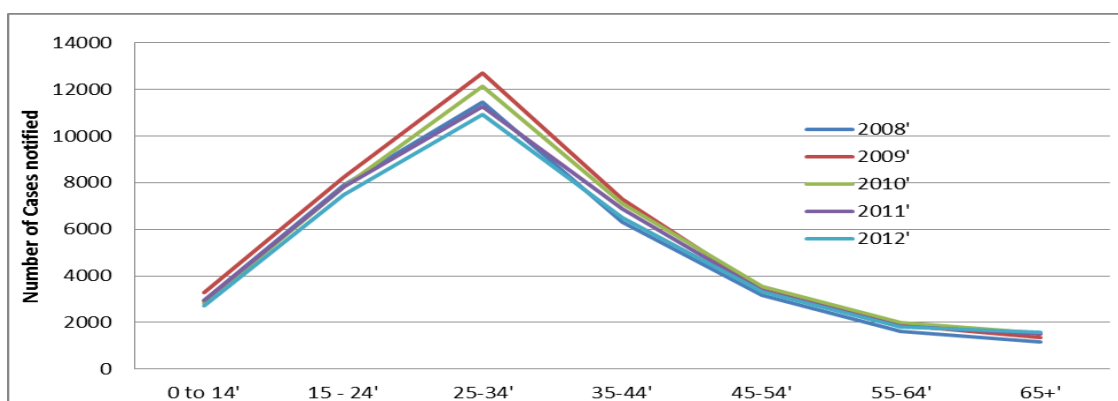**Figure 14.** Distribution of males with smear positive TB per age group

Figure 15. Distribution all forms of TB for females per age group

the elderly (≥64) has been consistently lower than rates among middle-aged adult males or females (i.e., 35-44 and 45-54 age groups), it has gradually increased while rates in younger groups have declined.

TB in High Risk Groups

In Kenya, data on TB in high risk groups are largely available only about persons living with HIV/AIDS. HIV remains the predominant risk factor for developing TB in Kenya. The TB programme has continued to successfully test more TB cases for HIV over time. Although rates of HIV remain high among persons with TB who know their status, more than one-third of TB cases have HIV, HIV prevalence among TB cases has been decreasing (Figure 17). There has been
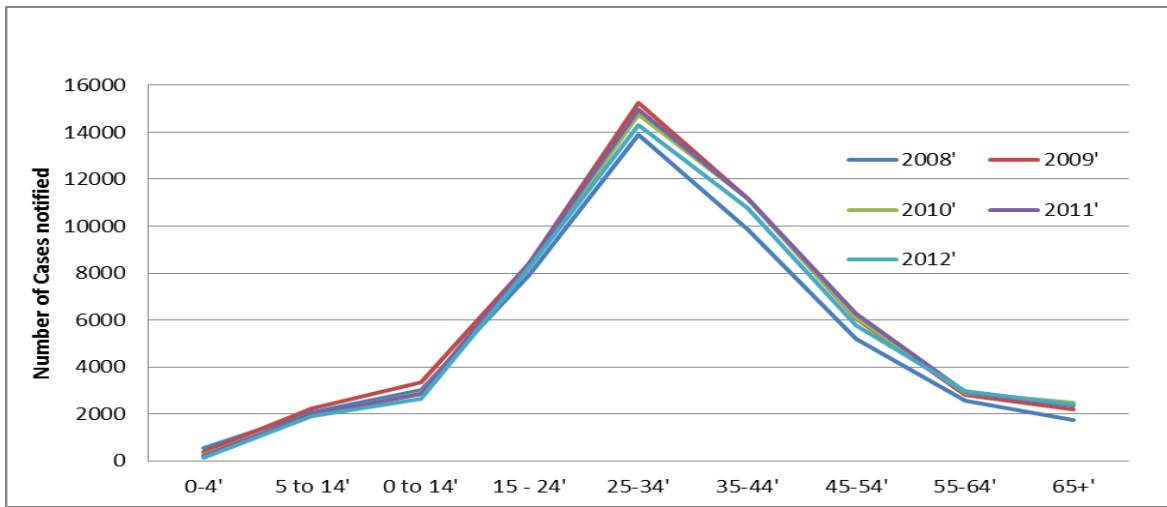
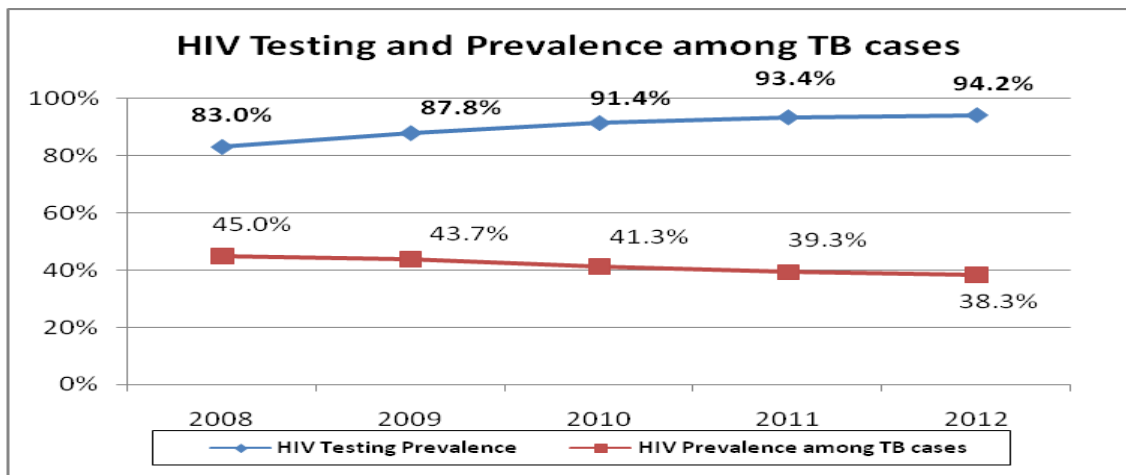**Figure 16**. Distribution all forms of TB for males per age group

Figure 17. The percentage of TB cases who are tested for HIV, and the percentage of TB cases tested for HIV who are HIV positive – Kenya, 2008-2012.
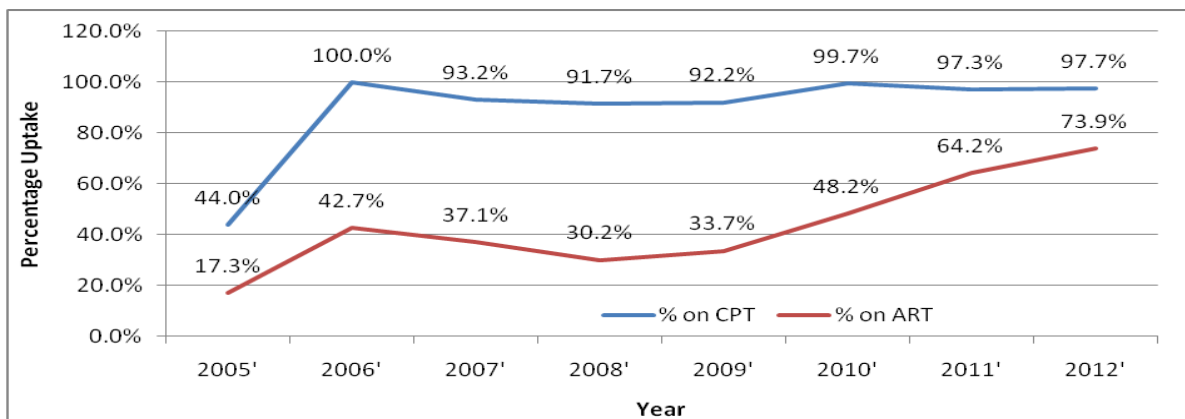
Figure 18. CPT and ART uptake in Kenya 2005-2012

significant effort to reduce the burden of HIV among TB patients through the implementation of TB/HIV collaborative interventions with the main focus being provision of CPT and ART to HIV positive TB patients.

There has been significant increase in CPT uptake from 44% in 2005 to 97% by the end of 2012 while ART uptake increased form a low figure of 17% in 2005 to 74% by the end of 2012 (Figure 18).

DISCUSSION

The burden of TB disease in Kenya has shown consistent decline in the last 8 years. This result is consistent with the findings by Sitienei *et al.* (2013). The key disease burden measures incidence, prevalence and mortality has shown marked decline over the last couple of years, however, prevalence and mortality have high levels of uncertainty WHO (2012).

Although mortality estimates have high levels of uncertainty, there has been marked decline in the estimates of TB deaths among the HIV patients. This in part could be attributed to high HIV testing and initiation of ART treatment among HIV positive patients WHO (2012).

It is expected that with a robust surveillance system, notifications should provide good approximations to TB incidence DLTLD (2013). Kenya over the last 14 years has notified cumulatively 1,378,592 TB cases DLTLD (2013). Year by year trend has shown that Kenyan TB epidemic peaked in the year 2007 and has been on a decline since then with an average decline of 5% over the last 8 years. The highest decline in the TB case notification was reported between the years 2012-2013 at 12%. There has been consistent trend in the case notification rates from both the Kenyan TB data and WHO estimates DLTLD (2013).

In this paper, it has been further demonstrated that the proportion of childhood TB has remained fairly consistent over the years. With more attention currently being directed at childhood TB through better diagnostic tools and improvement of surveillance systems it could reduce the gap in understanding childhood TB epidemiology, (Glaziou *et al.* (2015), WHO (2013)).

In Kenya, a large proportion of TB has been those who have been confirmed to have TB using smear microscopy examination with this proportion ranging (37-43) %, the extra-pulmonary ranges from (15-18)% and the smear negative TB cases ranging between (33-42)%.

Kenya began the disaggregated reporting for age and sex in the year 2008, while adopting the case based surveillance system in the year 2012 DLTLD (2013). The disaggregation has clearly shown that tuberculosis continues to take greater toll on those in the age groups 25-44 years, this being the most economically productive group. The average age of a TB patient has increased from 33.7 to 37.7 between the year 2012 and 2013. Fewer children aged 0-4 years have consistently been reported to have tuberculosis.

From the age sex case notification rates it can be seen that tuberculosis continues to be a male disease with rates in males being approximately 1.5 times higher than in female in the most productive age groups 25-64 years. This trend is similar for both all forms of TB and smear positive. It was however, noted that the age sex distribution for smear positive TB was bimodal for females while unimodal for males. This result is consistent with results in Sitienei et al. (2013). However, for all forms of TB the peakedness of the distribution is unimodal at the same age groups 25-34 years. At present there is no plausible explanation for the difference in the age sex distribution peakedness for smear positive TB Sitienei et al. (2013). It can however be hypothesized that it could be because of early sexual activity in female which predisposes them to HIV and consequently tuberculosis. There is thus need for further studies to explain the difference. Other possible hypothesis that have been advanced include biological differences in the risk of infection and subsequent TB disease Thorson *et al.* (2007), differences due to gender roles in different communities which predisposes men to TB disease (Borgdorff *et al.* (2000), Connolly and Nunn (1996)) and the hypothesis that it could be that women access services to a greater extent than men in some settings or that disease progression could be slower on average in women Glaziou *et al.* (2015).

Sitienei et al (2013) showed that HIV is the single most important factor that caused resurgence of TB in Kenya and there is a twin relationship between HIV and TB. This historical twin relationship has been shown by K'Oyugi and Muita (2002). To understand TB epidemiology in Kenya, understanding the close relationship between TB and HIV is critical. The data from the surveillance system show that upon the adoption in Kenya of the WHO interim policy on TB/HIV collaborative activities in 2004, WHO (2004) with Kenya adopting the policy in 2005. The HIV testing rose from 83 to 94% with HIV sero prevalence declining from 45% to 38% by the end of 2012. It had further been shown that those countries with high HIV prevalence have also high burden of TB. Narain and Lo (2004). Given the role HIV plays in the development of TB disease provision of ART and isoniazid (INH) prophylaxis has increasingly played the role in the prevention of TB in individuals with HIV and latent TB infection. (Glaziou *et al.* 2015, Straetemans *et al.* 2010, Glaziou *et al.* 2011). Kenya has made significant strides in addressing the dual burden with 74% of the HIV positive TB patients accessing ART within TB clinics free of charge from the government by the end of 2012 DLTLD (2013).

The association between poverty and tuberculosis has been well established and widespread in literature of TB risk factors. It has been shown that TB prevalence is significantly higher among people living below the poverty line compared with those above the poverty line and the situation is even more dire among the marginalised people, where TB could be 1.5 times more prevalent Muniyandi and Ramachandran (2008). Further, it has been shown that TB can contribute to moving individuals into poverty by reducing patients' physical strength and ability to carry on normal routine

work (Patton and Ng, 2006; Sagbakken, 2008; WHO, 2005; Hansel *et al.,* 2004).

CONCLUSION

Kenya's TB epidemiology has evolved over time and it has been characterised by a period where there was increase in the TB cases reaching a peak in the year 2007 after which there was a decline which began to accelerate in the year 2011. The gains which have been witnessed should be sustained. What is equally notable is the clear epidemiologic shift in age indicating reduced transmission in the younger age groups.

All indications are that the TB epidemic in Kenya is on a downward trend and the country is on course to halting the beginning to reverse the effects that the epidemic has caused.

To sustain the gains made in containing TB in Kenya, efforts must also be made in addressing the risk factors majorly HIV and what has been demonstrated that the burden of HIV on TB patients has been addressed in the country but focus should be on universal access to ART for those who are eligible and access to the INH prophylaxis.

Further, to sustain the gains social determinants in health must be addressed given that TB affects the most vulnerable in the population and should include strengthening partnership across all the sectors that are involved. Further systematic analysis should be carried out to understand the socio economic dynamics of TB patients in order to address the well-being of the TB patients. Kenya is on course to achievement of millennium development goals (MDGs) of halting and beginning to reverse the incidence and prevalence to tuberculosis.

To better understand mortality, greater focus should be given to improvement of mortality statistics though strengthening of collaboration with the civil registration system in the country and supporting the improvement in the capacity to certify and code cause of death in health facilities and consider initiation of verbal autopsies to obtain an understanding of cause of death amongst those deaths which occur in the community (at home).

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