Risk Factors in Transmission of Tuberculosis Infection in Mombasa, Kenya: An Epidemiological Descriptive Study

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SAY and MFO did the study design and wrote the protocol. Authors RRS and RCAO did the statistical and literature searches while analyses of study was done by authors SAY, MFO and RRS. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Background: Tuberculosis is an infectious disease with an estimated 2 million deaths every year. In 2013 the estimated global burden of disease was 9 million cases. Many patients get infected as a result of ignorance of the risk factors that contribute to disease transmission.
Aim: This study was aimed to determine the risk factors in pulmonary tuberculosis among patients attending various clinics in Mombasa.
Study Design: Hospital and laboratory based descriptive cross-sectional study was carried between May 2012 and May 2013 in Coast Provincial General Referral hospital (CPGH), Tudor, Port-Reitz, Mlaleo, Likoni and Mikandani districts and Sub-districts hospitals.

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Methodology: Tuberculosis was diagnosed following standard clinical bacteriological and radiological procedures. Sputa from 500 tuberculosis suspects underwent mycobacteriologic evaluation using Ziel Nelsen smear microscopy, Lowenstein and Jensen and BACTEC MGIT 960 culturing. Consenting participants were screened for HIV infection by enzyme -linked immunosorbent assay. Patients were required to respond to a structured questionnaire on risk factors for transmission. Data collected from group were compared using univariate and multivariate analysis. The level of significance was set at $p<0.05$ and for each statistically significant, odds ratios and confidence interval were computed.

Results: A Total, 210/500 (42%) of the suspects had mycobacterial disease and 78/210 (37.1%) were HIV co-infected. There were significantly more females than males associated with pulmonary tuberculosis infection (x^2=4.26, df=3; $p<0.001$). Monthly income was significant in disease with 130 (61.9%) of patients earning less than 5000 per month (2.65 (OR=2.65; 95% CI: 1.40-6.23, $p<0.041$). HIV (OR=2.18; 95% CI: 1.03-4.65, $p<0.034$), smoking (OR=2.16; 95% CI: 0.13-1.39, $p<0.041$) and overcrowding (OR=2.71; 95% CI: 1.41-5.62, $p<0.051$) were also statistically significant risk factors for pulmonary tuberculosis.

Conclusion: Among TB patients in Mombasa Kenya, there was high prevalence of the TB risk factors. Effort should be given in creating awareness of the risk factors associated with TB transmission in order to reduce the rate of infection.

Keywords: Tuberculosis; risk factors; transmission.

ABBREVIATIONS

TB-Tuberculosis; PTB-Pulmonary Tuberculosis; WHO-World Health Organization; MTB-Mycobacterium Tuberculosis; HIV-Human Immunodeficiency Virus; WHO-World Health Organization; ELISA-The Enzyme Linked Immunosorbent Assay; ERC-Ethical Review Committee.

1. INTRODUCTION

Tuberculosis is a communicable disease resulting from infection with *Mycobacterium tuberculosis* whose principal reservoir is man and other *mycobacterium* belonging to the *Mycobacterium tuberculosis* complex [1]. Although it affects any part of the body, only active pulmonary type of the disease can be transmitted from one person to the other through droplets carrying TB bacillus. In 1993, the World organization (WHO) declared TB a global emergency [2]. It is estimated that between years 2009-2025 nearly one billion people will be newly infected, 200 million people will get TB and 40 million are likely to die from it if control programs do not improve [3]. Tuberculosis is a disease of the poor and under privileged. With improved socio-economic conditions and availability of effective drugs, spread of TB infection has been effectively controlled in many parts of the world. In industrialized countries this disease is generally associated with identified high risk groups such as the elderly, immigrants from TB high prevalence areas, the homeless, drug and alcohol addicts [4,5,6,7].

Kenya is ranked 13th on the list of 22 high burden tuberculosis countries in the world and 5th in Africa [8]. The HIV/AIDS pandemic has substantially altered the epidemiology of tuberculosis. Many persons with *Mycobacterium tuberculosis* and HIV have a 5-10% annual risk of developing active TB. The double impact of TB and HIV co-infection is keeping large number of people trapped in poverty with these diseases that reinforce each other. An estimated 170 million working days are lost each year as a result of TB and the health sector is burdened by the cost of drugs and treatment [9]. The country had an incidence rate of 160 new smear positive cases per 100,000 people in 2012. Several studies have cited various risk factors implicated in TB and spread of the disease in order to assist in proper utilization of public healthcare resources and prioritize targets for TB control. In this connection, the most significant independent risk factor associated with active pulmonary or extra-pulmonary TB is HIV infection contributing to ongoing transmission among individuals [10,11]. Age has also been shown as a risk factor in increasing TB incidence while women have been found to be more susceptible to TB than men probably due to the effect of female hormones or under reporting of TB cases [12,13]. Other risk factors include; past history of TB in the family, smoking, place of residence, place of origin, malnutrition and alcoholism [14,15,16,17]. In countries with low TB incidence, immigrants from countries with high TB prevalence constitute

potential increased risk for recent transmission of infection to local populations [18,19]. In some industrialized countries, TB revival has been linked to certain risk factors, such as overcrowding, reduced funding, poverty, homelessness, improper TB management and negligence in implementing TB control programme [20,21,22]. Silicosis, an occupational disease occurring among mine workers exposed to silica dust, predisposes TB and non-tuberculous mycobacteria (NTM) infections [23]. Other researchers reported the occurrence of TB transmission in hospitals in association with healthcare workers born in countries with high TB burden but without further continued spread [24]. An association between tuberculosis (TB) and body wasting has been long recognized. Malnutrition impairs host immunity and predisposes to TB while TB itself can cause malnutrition [25]. Few studies in Kenya have focused on the risk factors that could be associated with tuberculosis infection in Kenya. The aim of this study was to determine risk factors in pulmonary tuberculosis patients attending various TB clinics in Mombasa.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Mombasa County which has a population of 1,031,266 by the year 2012. The population is steadily growing due to rural-urban migration and immigration from unstable countries. The total area Mombasa is 109 Km^2 with about 60% of the people living overcrowded informal settlements in the form of shelters. Residents are of mixed ethnicity and are engaged in low-income generating activities, mainly informal sector and small trading. The County has rapid population growth and is characterized by low socio-economic indicator. This creates huge demands on health facilities and inability to keep pace with the environment, continued economic prosperity, public health and quality of life of residents. Tuberculosis and HIVAIDS are the leading causes of deaths in the area representing 50%.

2.2 Study Site and Population

The study was conducted at Ganjoni clinic, Coast provincial General hospital (CPGH), Mlaleo Health and Mikindani Health Centers, Likoni, Portreizt and Tudor district hospitals. These hospitals were selected because they serve populations at high risk for TB due to high HIV prevalence or social-cultural practices that favour TB transmission. These hospitals like all others at their levels have chest clinics where TB patients obtain health care respectively.

2.3 Study Design

This was hospital and laboratory based descriptive cross-sectional study carried out between May 2012 to May 2013. It was carried out to provide a snap-shot (one point measurements) description of prevalence of TB and risk factors associated with it. Personal data was classified by demographic characteristics. Clinical data was classified by TB diagnosis, exposure and other critical illnesses such HIV status. Personal habits critical to infection were also classified as smoking history, number of cigarettes smoked per day and alcohol consumption.

2.4 Inclusion and Exclusion Criteria

All adult patients 18 years and above suspected of having TB and resident in Mombasa County for at least six (6) months, not on anti-TB chemotherapy and consented to participate in the study were recruited. Tuberculosis suspects who were below 18 years and unwilling to participate in the study and not meeting the above inclusion criteria were excluded.

2.5 Sampling Frame and Patient Characteristics

Mombasa County was purposively sampled because of high cases of TB and HIV co-infection. The sampling frame consisted of all the public health facilities within the study area. After the selection of the study sites, each was allocated a proportionate number of study subjects based on the level of health care delivery system and the average client attendance in the past one month before embarking on the study. To minimize bias in selecting study subjects, consecutive sampling was used hence every alternate TB suspect who satisfied the inclusion criteria was selected for the study between 2012 and 2013.

2.6 Collection of Demographic Data

A structured and pre-tested questionnaire was used to obtain participant demographic data (age, sex, and marital status), social economic status (education level, average monthly income,

type of residence, size of the house) and personal habits relevant to TB infection (smoking, alcohol consumption). As in most analysis on poverty issues in the Kenya family, income was considered the principle socio-economic indicator in this study.

2.7 Collection of Sputum and Blood Samples

A specialist medical doctor working in the TB clinic performed the necessary clinical and diagnostic work. Diagnostic was made based on the combined evaluation of clinical, radiological and laboratory features. Three sputum specimens (spot, early morning, spot) were collected from 500 TB suspects under the supervision of trained and competent medical staff. The patients were advised to rinse their mouth twice with water before producing the specimen and this helped to remove food and any contaminating bacteria in the mouth. They were instructed to take two breaths, coughed vigorously and expectorated the material into the sterile 50ml blue cap screw-capped bottle. This process allowed sputum to be produced from deep in the lungs. The TB suspects were asked to hold the sputum container close to the lips and spit into it gently after a productive cough. At the peripheral laboratory, the standard Acid-fast (AFB) direct smear microscopy using Ziehl-Neelsen (ZN) staining was done on the initial sputum to confirm TB diagnosis of suspected patients. A second sputum specimen was then collected which was refrigerated at $4^{o}C$ and transported to the Central reference Laboratory (CRL) weekly for culture. A total of 500 participants consented phlebotomy for HIV testing. Test was also done according to manufacturer's instruction. Blood samples were delivered in vacutainer brand sterile interior ethylene diamine-tetra-acetic acid (EDTA) tubes and used for HIV testing. The safety for research assistants and healthcare workers during collection and handling of sputum specimens was ensured by observing the WHO guidelines.

2.8 Microscopic Examination of Specimens

Sputum smears were examined for acid-fast bacilli (AFB) after staining following ZN method (Ebersole, 1992). The degree of ZN smear positivity was quantified as 1+ for 10-100 AFBs per 100 fields, 2+ for 1-10 AFBs per field (50 fields) and 3+ for >10 AFBs per field (20 fields).

For less than 10 AFBs per 100 fields, the exact number of AFBs was indicated. A suspect was considered to be ZN smear positive if at least one specimen was positive.

2.9 Isolation of and Identification of *Mycobacterium tuberculosis*

Sputum specimens were processed for isolation of mycobacteria following standard protocols. A participant with at least one positive culture (MGIT and/or LJ) was considered as a TB case, while those with three negative culture results were regarded as not having TB. The suspects with ZN smear positive but culture negative sputa were treated as smear negative pulmonary TB cases.

2.10 HIV Testing

Blood samples were tested for HIV antibodies according to the Kenyan national testing algorithm for voluntary counseling and testing by using Determine HIV1/2 (Abott laboratories, Japan co. LTD), Capillus HIV1/2 (The Trinity Biotech, Ireland) and Unigold H1/2 (Trinity Biotech, Ireland) rapid test kits and positives confirmed with the enzyme linked immunosorbent assay (ELISA).

2.11 Radiological Examination

Chest X-Ray (CXR) was taken for all patients irrespective for their HIV status. For tuberculosis patients, the X-Ray was taken before commencing anti-TB drugs. Chest X-Rays were taken in anterior-posterior view and read by the Radiologist. The X-Ray was reported as unilateral/bilateral infiltration with/without cavities, infiltration with hilar lymph node enlargement and unilateral/bilateral pleural effusion. The radiological findings were used together with clinical information such as chronic cough for more than two weeks, weight loss and chronic fever to make diagnosis of smear/culture negative pulmonary tuberculosis. For the smear/culture positive pulmonary cases, chest X-Ray were not considered in making the diagnosis.

2.12 Data Management and Analysis

Demographic data were confidentially obtained from the TB suspects by clinicians / nurses running the chest clinics. Results of ZN smear microscopy, culture, and HIV tests were

confidentially sent to the respective clinicians / nurses. Provisions of these data were made available to the clinicians/ nurses for the purpose of managing the patients. Data was recorded on questionnaires, register books, ELISA reader print-outs and species evaluation sheets. The data was coded, entered into MS Excel 8.0 and processed using a statistical package for social sciences (SPSS) version 16.5 software for windows. The chi-squared (χ^2) test was used to compare categorical data and logistics regression to analyze multivariate data. Univariate odds ratio (OR) and 95% interval (CI) were calculated to assess risk factors (gender and age-group) with regard to HIV infection. The strength of an association. *p* values of <0.05 were considered statistically significant.

3. RESULTS

3.1 Socio-demographic Characteristics of the Sample Population

A total of 500 participants suspected of having tuberculosis (TB) were enrolled into the study at the four study sites. 54.2% males and 45.8% females. The calculated overall TB prevalence among tuberculosis suspects was 42.0% (210/500) and was higher in females (45.9%) than males (38.7%) which was statistically significant (Chi sq 2.573, p<0.001). The proportion of PTB cases was higher among the age groups 25-34 and 35-44 (42.9% vs 29.0%), both were statistically significant (OR=5.46; 95% CI: 2.31-12.88, p<0.031) and (OR=3.16; 95% CI: 1.61-8.13, p<0.050). Primary education was associated with TB (OR=2.60; 95% CI: 1.63-4.31, p<0.041). Respondents in secondary and college levels of education had a prevalence of 51.0% and 24.7% respectively which was statistically significant (Chi sq 27.660, p<0.0003). Another parameter that was compared was occupational status of the subjects and outcome of sputum examination. High prevalence rate was among self-employed 45.2% (OR=2.14; 95% CI: 1.5-4.02, p<0.010), formal employment 33.3% (OR=0.84; 95% CI: 0.45-1.63, p<0.034). In marital status, higher prevalence rate was observed among the married 56.7% (OR= 2.16; 95% CI: 0.98-4.52, p<0.047) and lower in widowed 0.6% (OR=0.46; 95% CI: 0.18-1.11, p<0.035). The adjusted OR showed that married (OR=2.35; 95% CI: 1.15-4.84) and divorced (OR=3.37; 95% CI: 1.57-5.52) were statistically significant risk factors for tuberculosis (p<0.05) (Table 1). Sputa from 185 (88.1%) of the TB suspects were ZN smear positive and 25 (11.9%) ZN smear negatives. The proportion of smear positive cases among males and females were 95 (45.2%) and 90 (42.9%) respectively. There was a significant difference between gender and smear positive (χ^2=1.077; df=4; p> 0.072). All the two hundred and ten TB patients who were diagnosed with *Mycobacterial* disease were culture positives (100%).

3.2 Risk factors in the Transmission of Tuberculosis in Mombasa County

Several demographic factors were analyzed including income, gender and age all of which were found to be significant in transmission PTB (p<0.05). Income emerged as a major significant factor in the spread PTB. Among the patients sampled 61.9% were earning less than 5000 Kshs. 14.3% were earning 5001-10,000 Ksh and only 20 (9.5%) were earning more than 15,000Ksh. Housing conditions were found to have had an effect on TB infection with 132 (62.9%) patients living in single rooms and only 28 (13.3%) patients were living in houses that had more than 5 rooms. Among those living in single rooms 70 were living with more than two people with some households having as many as 6 people. Ninety (42.9%) patients were consuming alcohol while 120 (57.1%). Regarding smoking, ninety (42.9%) were smokers compared to non smokers (57.1%) and this difference was statistically significant (OR=2.16; 95% CI: 0.13-1.39, p<0.041). Seventy eight (37.1%) were HIV co-infected .The unadjusted odds ratio (OR) showed that income (OR=2.65; 95% CI: 1.40-6.23, p<0.001), HIV (OR=2.18; 95% CI: 1.03-4.65, p<0.034) and overcrowding (OR=2.71; 95% CI: 1.41-5.62, p<0.051) were statistically significant risk factors for pulmonary tuberculosis However on logistic regression, only those staying in single rooms are more likely to suffer from pulmonary tuberculosis (OR=3.17; 95% CI: 1.23-6.5, p<0.033 (Table 2).

4. DISCUSSION

Majority of the patients in this study were female (45.9%). In France, male sex was highly associated with TB infection [26], while in Russia 72% of the patients were male [27]. The reasons for higher male prevalence and incidences are poorly understood and need further investigation. Regarding risk factors for TB infection in this study, 61.9% of the patients who were earning less than ksh 5000 per month were likely to

contract the disease. This is similar to other studies which cited low income groups as being most likely to be infected with TB [28]. In England and wales, poverty was a strong factor leading to mortality [29]. A study by Dye et al. [15] from 134 countries revealed that incidences of tuberculosis were falling more quickly in countries with high income than those in low income. A study in the United States found that poverty was also a risk factor in tuberculosis infection [30].

Table 1. Demographic characteristics of patients in descriptive epidemiology study of pulmonary tuberculosis infection

Characteristics:	PTB- (Suspects)	PTB+ (Cases)	OR (95% C.I)	P-value
Age in Years				
18-24	27 (9.3%)	1 (0.5%)	1.000****	
25-34	143 (49.3%)	89 (42.4%)	5.46 (2.31-12.88)	0.031
35-44	86 (26.7%)	61 (29.0)	3.16 (1.61-8.13)	0.05
45-54	23 (7.9%)	40 (19.1%)	2.13 (0.15-1.07)	0.25
55+	11 (3.8%)	19 (9.0%)	0.21 (0.02-1.82)	0.31
Education level				
No education	0 (0.0%)	2 (1.0%)	1.000****	
Primary	24 (8.3%)	49 (23.3%)	2.60 (1.63-4.31)	0.041
Secondary	159 (54.8%)	107 (51.0)	1.31 (1.51-3.20)	0.35
College	107 (36.9%)	52 (24.7%)	0.72 (0.25-1.42)	0.165
Sex				
Male	124 (42.8%)	105 (50.0)	1.000****	
Female	166 (57.2%)	105 (50.0)	0.92 (0.41-1.31)	0.68
Marital status				
Divorced	3 (1.0%)	3 (1.4%)	1.000****	
Married	162 (55.9%)	119 (56.7%)	2.16 (0.98-4.52)	0.047
Unmarried	117 (40.3%)	75 (35.7%)	0.84 (0.45-1.63)	0.481
Widowed	8 (2.8%)	13 (0.6%)	0.46 (0.18-1.11)	0.035
Employer				
Unemployed	84 (29.0%)	41 (19.5%)	2.14 (1.15-4.02)	0.01
Self employed	75 (25.9%)	95 (45.2%)	1.000****	
Formal employment	130 (44.8%)	71 (33.8%)	0.84 (0.45-1.63)	0.034
Student	1 (0.3%)	3 (1.4%)	0.46 (0.18-1.11)	0.233

Table 2. Risk factors in the transmission of tuberculosis in Mombasa County

Characteristic	Attribute	PTB- (suspects)	PTB+ (cases)	OR (95% C.I)	P-value
Income	< 5000	35 (12.1%)	130 (61.9%)	1.00**	
	5001 - 10000	65 (22.4%)	30 (14.3%)	2.65 (1.40-6.23)	0.041*
	10001 -15000	50 (17.2%)	30 (14.3%)	0.38(0.12-1.23)	0.042*
	15001 - 20000	140 (48.3%)	20 (9.5%)	0.65 (0.23-0.96)	0.026*
Housing (No. of rooms)	Single	50 (17.2%)	132 (62.9%)	2.71 (1.41-5.62)	0.051*
	2 - 4	70 (24.1%)	50 (23.8%)	0.12(0.32-0.81)	0.061
	>5	170 (56.7%)	28 (13.3%)	1.00**	
Smoking	Smokers	120 (41.4%)	90 (42.9%)	2.16(0.13-1.39)	0.041
	Non smokers	170 (58.6%)	120 (57.1%)	1.00**	
Alcohol consumption	Consumption	50 (11.3%)	90 (42.9%)	5.25 (0.16-7.39)	0.095
	Non consumption	250 (89.7%)	120 (57.1%)	1.00**	
HIV Status (n=78)	HIV+	49 (16.9%)	78 (37.1%)	2.18(1.03-4.65)	0.034*
	HIV-	241 (83.1%)	132 (83.1%)	1.00**	

*PTB+=Pulmonary tuberculosis smear positive; PTB-=Pulmonary tuberculosis smear negative; OR=Odds ratio; CI=Confidence interval; P-value=Level of marginal significance; *Statistically significant association; **Reference exposure*

From the data, smoking and alcohol consumption were associated with TB infection with 37.1% of the patients being smokers and 42.9% being alcohol consumers. A study in Russia found that 62% of the TB patients were alcohol abusers which were associated with an increase in drug resistance and relapse. It can be hypothesized that it is due to the close contact that takes place in pub as opposed to other gatherings. A systematic review of association between alcohol use and tuberculosis found those who consumed more alcohol per day and have an alcohol disorder and an elevated risk of active tuberculosis [31]. In the Philippines TB was attributed to drinking and smoking and this caused the patients to delay in seeking treatment [32]. In India transmission of TB in children was found to be influenced by among other factors exposure to environmental tobacco smoke [33]. Another study in the Greater Vancouver regional district in Canada showed that smear positive patients had a history of alcohol abuse [34]. According to the present study, smokers have a 2.16 times higher risk of developing TB than non smokers after controlling for the effects of other factors. The association between tobacco smoking and TB is well described [35,36]. The prevalence reported in this study does not differ significantly from those reported in other studies in Africa [37]. A study in South Africa reported a prevalence of 21.8% while a study in Malaysia reported 40.3% [38]. These differences could attributed to background smoking prevalence in the general population. The prevalence of background tobacco smoking in Kenya population particularly Mombasa is limited because population based surveys have not been conducted. Recent work on the physiological effects of nicotine, the major toxic compound in tobacco smoke showed that it turns off the production of tumour necrosis factor-alpha by lung macrophages there by rendering smokers more susceptible to the progression of latent infection to active disease [39].

Overcrowding was also found to be associated with incidences of TB with 63.9% of families living in single rooms some as many as eight people. This is because single rooms have less space facilitating the spread of the infection. This is similar to studies done in other parts of the world that showed overcrowding was one of the factors contributing to TB infection [40,41].

In this study, age was found to be an important factor with 71.9% of the patients being under 45 years and only 28.1% above the age of 45 years.

A report by Giovanni et al. [42], shown that TB incidences were associated with young adult age which creates a main obstacle towards a sound economic and social development of where TB is endemic. In an editorial report, TB incidences were associated with young adult age which creates a main obstacle towards a sound economic and social development of countries where TB is endemic. In South Africa tuberculin skin test increased from 28% in 5-10 years old to 88% in 31-35 year olds while in Gambia 90% of the patients were below the age of 49 years [43].

In this study, prevalence of TB-HIV co-infection was 37.1%. HIV co-infection is the most potent immunosuppressive risk factor for developing active TB disease and Individual studies conducted in both high and low-burden TB countries have attributed increasing TB incidence to HIV infection. HIV co-infection exacerbates the severity of TB disease while additional TB co-infection accelerates HIV replication in affected organs including lungs and pleural [44]. Cell-mediated immunity is a crucial component in the host defence against *Mycobacterium tuberculosis* that is weakened by HIV infection resulting in increased risks in reactivation of TB and commonly results in widespread dissemination causing EPTB. Tuberculosis also accelerates HIV progression through increased systemic immune activation [43,44].

5. CONCLUSIONS

Among TB patients in Mombasa, Kenya, there is high prevalence of the known TB risk factors. This study showed that risk factors such as age, female, smoking, unemployment, poverty, overcrowding, alcoholism and HIV are independently associated with pulmonary TB. These factors may play a role in the progression of TB infection to disease. There is a need in the community to create awareness in population on risk factors that lead to TB transmission in order to reduce the incidence of the disease. Targeting reducing prevalence of the risk factors may lead to better TB control in the country.

ETHICAL ISSUES

The proposal for this study was approved by Kenyatta University Ethical Review Committee-ERC (No PKU 018/115). It was approved by the ministry of education, Science and Technology (MOEST). Clearance was also obtained from respective district health authorities and hospital administrations. The purpose of the study was

explained to the participants in English, Kiswahili or local language before consent was sought. The study was conducted in accordance with the declaration of Helsinki. Code numbers rather than names were used to identify candidates in order to maintain confidentiality. The study did not expose candidates to any unusual risks as competent hospital staff obtained sputum and blood specimens from candidates using standard procedures.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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