Biochemical and Hematological Changes Among People With Active Pulmonary Tuberculosis Infection Living in Densely Populated Areas in Nairobi County

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Abstract

Background: People living in Kenyan slums are at a higher risk of developing tuberculosis. The risk includes infection with multi-drug-resistant tuberculosis strains. With the latest data reported in the year 2021 on Kenya's tuberculosis prevalence, the survey identified a prevalence of 251 per 100,000 adult populations. It is important to continuously update knowledge on the prevalence of tuberculosis to ensure 2030 tuberculosis end strategy control measures are effectively leading to a decrease.

Methods: Performing tests for the identification of bacteria using the GeneXpert technique. Positive GeneXpert results counted against negative results and hence the prevalence of tuberculosis determined. Hematological and biochemical alterations associated with tuberculosis infection was done. Complete blood count and erythrocyte sedimentation was performed to determine hematological changes and liver function test to determine biochemical changes. The liver functions test was performed using a biochemistry auto analyzer where manufacturers' instructions was followed. Sensitivity of anti-TB drugs was accessed by Culture and sensitivity

Results: Twenty-nine (29) sputum specimens generated positive results for *Mycobacterium tuberculosis* while one hundred and thirty-three (133) negative. The percentage distribution of *Mycobacterium tuberculosis* infection was 17.9% positive and 82.1% negative. Out of the twenty-nine study subjects, whose results were positive, eighteen (18) were males 62% while eleven were females 38%. The overall prevalence of *mycobacterium tuberculosis* was 17.9 % with a male and female distribution of 18 (11.1 %) and 11 (6.8 %) respectively. Many hematological and biochemical changes were significantly high compared to their controls. Among 25 sputum specimens which were cultured, 18 had growth of mycobacterium tuberculosis. The culture growth was subjected to drug sensitivity testing using the following anti-biotic i.e. streptomycin, isoniazid, rifampicin and ethambutol. Twelve (67%) culture growths were sensitive to streptomycin and six (33%) were resistant to streptomycin. Five (28%) culture growths were sensitive to isoniazid and thirteen (73%) were resistant to isoniazid. Five (28%) culture growths were sensitive to rifampicin and thirteen (73%) were resistant to rifampicin. Eight (44%) culture growths were sensitive to ethambutol while ten (56%) culture growths were resistant to ethambutol.

Conclusion: Improved TB treatment regimens and quick antibiotic sensitivity testing are necessary in light of the rise of multi-drug resistant and extreme drug resistant tuberculosis infection.

Key Words: Tuberculosis, Culture and sensitivity, Hematological and Biochemical parameters.

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1. Background

Tuberculosis is a contagious, infectious disease of the upper respiratory tract caused by a pathogen called *Mycobacterium tuberculosis* complex (Cohen *et al.*, 2019). *Mycobacterium tuberculosis* is classified under gram-positive acid-fast bacilli (Khan *et al.*, 2019). Tuberculosis majorly affects the upper respiratory tract and the lungs (Bisht *et al.*, 2015). It can occasionally extend to the spine, brain, and kidney, among other bodily regions (Dey *et.al*, 2022). Tuberculosis can either be active or latent (Carranza *et al.*, 2020). Active tuberculosis is a serious multi-organ disease that majorly affects the lungs (Choudhary *et al.*, 2021). It results from primary infection or reactivation of latent tuberculosis (Jilani *et al.*, 2018). In Active tuberculosis, signs and symptoms are clinically manifested (Sia *et al.*, 2011). Active tuberculosis makes a person sick and can spread the disease to other people in close contact.

Transmission of the bacteria *Mycobacterium tuberculosis* occurs between individuals through tiny droplets of air when the person sneezes, or coughs they propel these tiny air droplets (Tellier *et al.*, 2019). It is then taken up by alveolar macrophages, which thereafter block phagolysosome formation. This formation gives

the ability to replicate unhindered intracellularly (Du Plessis *et al.*, 2020). The immune system is ineffective since it is hidden inside host cells. It forms a protective granuloma to sustain a long-term infection (Pathak *et al* 2021). Delayed seeking of medication leads to further spread to others. Tuberculosis manifests in several ways including cough, fevers, night sweats, and weight loss (Stuck *et al.,* 2015).

Infection with tuberculosis has a devastating impact on the hematopoietic system (Firdaus *et al*., 2020). All hematological cellular components are produced and have a shorter lifespan as a result of tuberculosis (Oyer *et al.,* 2021). Additionally, plasma coagulation factors may be impacted, leading to consequences that can be fatal (Shayam *et al.,* 2016). The metabolism of iron, folate, and vitamin B12 is disrupted as a result. Hematological alterations are also a side effect of the drugs used to treat tuberculosis infection (Minardi *et al.,* 2021). Hematological alterations can occasionally help make a diagnosis, determine the prognosis, identify the complications of an underlying infection, and determine the need for and effectiveness of treatment (Bala *et al.,* 2015).

In individuals with tuberculosis, biochemical alterations are another important issue that should be taken into account (Sales *et al.,* 2023). Examining the signs of liver toxicity before and after starting anti-TB medication is crucial (Chaves *et al.,* 2015). The majority of documented instances of hepatic dysfunction are said to transpire during the initial three months of initiating medication (Gafar *et al.,* 2019). These result from anti-tuberculotic medication effects. With the long-term use of antituberculotic medications such rifampicin, isoniazid, ethambutol and streptomycin. Adverse drug reactions have grown to be a significant clinical issue, particularly when used in combination (Amir *et al.,* 2016). The biochemical and hematological alterations in tuberculosis infection will be evaluated in this investigation.

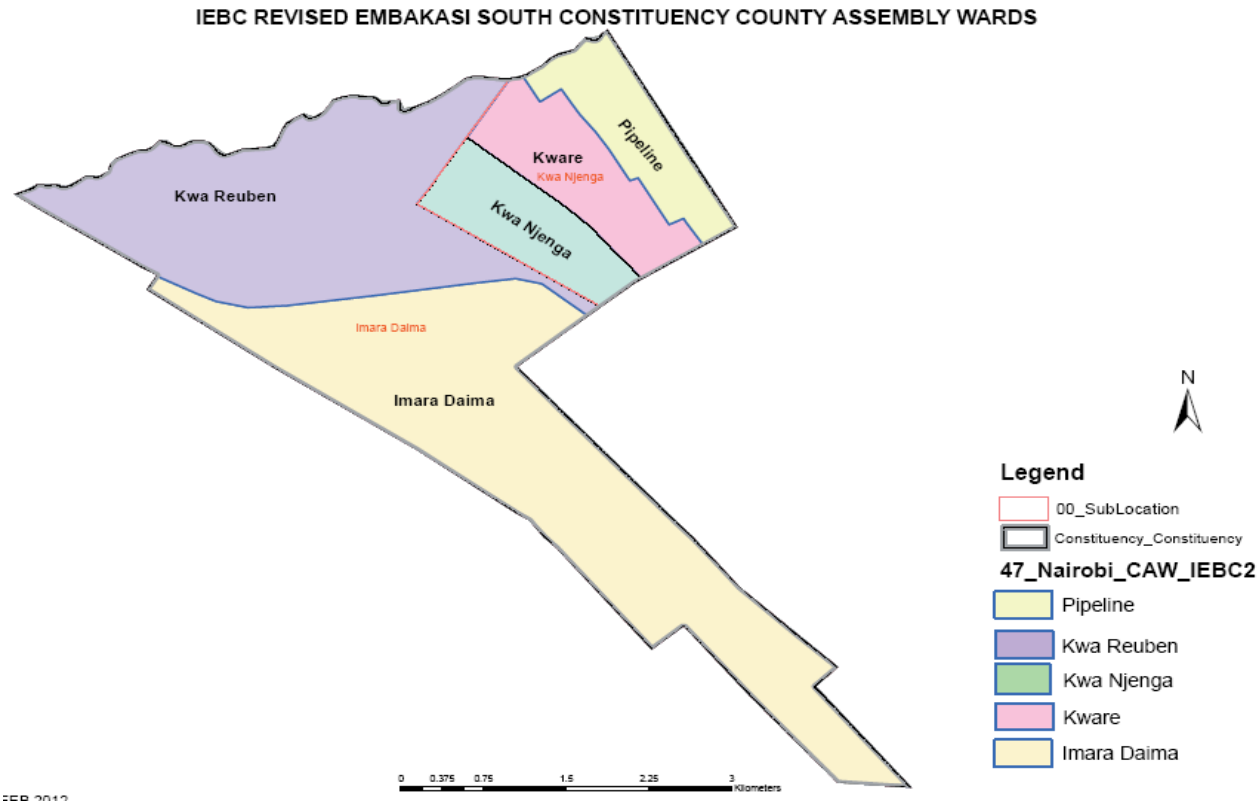
Antibiotics can be used to both treat and prevent *Mycobacterium tuberculosis* (Sulochana *et al.,* 2022). The stage or kind of tuberculosis infection determines how it should be treated. *Mycobacterium tuberculosis* infection cannot be effectively treated with antibiotics in high-prevalence environments because of treatment toxicity, uncertain treatment durability, and extensive treatment regimens (Young *et al.,* 2020). Medication used to treat active pulmonary tuberculosis includes rifampicin, ethambutol, streptomycin and isoniazid. Because of its potent early bacterial activity, isoniazid is a crucial first-line antibiotic (Jhun *et al.,* 2020).

However, the bacteria have been reported to develop resistance to conventional medication (Fair *et al.,* 2014). Drug-resistant tuberculosis has a treatment efficacy below 50% and can develop into a progressive untreatable disease (Salhotra *et al.,* 2020). The most typical form of resistance to anti-tuberculosis treatments nowadays is isoniazid (INH), either alone or in combination with other medications. The prevalence of INH resistance without concomitant rifampicin (RIF) is 7.9% in cases of *Mycobacterium tuberculosis* that have not yet been treated and 7.1 % in instances that have (Zhang *et al.,* 2020).

2. Materials and methods

2.1 Study Area

The slums of Mukuru Kwa Njenga and the pipeline are located in Nairobi County, which is the capital city of Kenya. They are neighboring slums which shares its borders with the industrial area commercial zone to the south, the Jomo Kenyatta international airport to the north, and other expanding suburban communities in the Embakasi region, such as Denholm estate. Although they stretch into Makadara and Starehe consistencies, they are part of the Embakasi south constituency. Mukuru Kwa Njenga is one of Nairobi's biggest slums. They are located in the unused land along the Nairobi/Ngong River the city's industrial district, between the outering road, North Airport Road, and Mombasa Road. More than 100,000 people live there. Whole families live in these slums which makes a good study site due to close proximity of housing hence enhances spread of tuberculosis.



2.2 Study design and sample collection

In order to provide a thorough understanding of the phenomenon under inquiry, a mixed-method approach was used. Descriptive statistics were used to evaluate the quantitative data in order to spot patterns and trends, and thematic analysis was used to study the qualitative data in order to find recurrent themes and subtle insights.

2.3 Inclusion criteria and exclusion criteria

Included study candidates were patients displaying symptoms of active pulmonary tuberculosis following consent. Exclusion was based on alternative diagnoses such as lung cancer, pneumonia, and inability to provide enough sputum

2.4 Laboratory procedures and Quality Assurance

Sputum samples from all the patients with prolonged coughing, fevers, and chest for more than two weeks was collected in a sterile container and GeneXpert was performed for diagnosis of active pulmonary tuberculosis. GeneXpert is a disposable cartridge-based equipment system for nucleic acid amplification. The reagent that comes with the test

was combined with the collected sputum, and the cartridge holding this combination was inserted into the GeneXpert machine. At this stage, the procedure was automated. The prevalence of tuberculosis was calculated by counting and recording both positive and negative slides.

With the use of a sterile syringe, 3–4 ml of peripheral venous blood was aseptically extracted and then placed into a tube containing 0.2 ml of an EDTA solution (4%) solution. The test was conducted using a hematology analyzer to assess various hematological alterations. The remaining 2 ml of blood was utilized to determine the erythrocyte sedimentation rate. Before the readings were obtained, the blood was poured into a Westergren tube till the zero mark and let to stand vertically for an hour. Hemoglobin, leukocyte count, red blood cell count, mean cell volume, mean cell hemoglobin, hematocrit, mean corpuscular hemoglobin concentration, and ESR is among the hematological parameters that was examined.

To investigate biochemical changes routine laboratory testing was performed including liver function tests, Aspartate transaminases (AST), Alkaline transaminases (ALT), Alkaline phosphatase (ALP), and kidney function tests including potassium, sodium, creatinine, and urea levels. The place where venipuncture was done was sterilized using cotton swabs. Blood was withdrawn from the vein by use of a needle and a syringe. It was then stored in a red top vacutainer which makes blood to clot because it does not contain an anticoagulant. It was

then centrifuged at 1500rev/sec for 3 minutes and then the serum was separated and placed in crystal vial tubes. The serum was placed in a biochemistry auto analyzer to analyze biochemical analytes according to the manufacturer's instructions.

The samples which turned positive for gene expert were taken to National reference laboratory for culture and sensitivity. The fully automated BACTEC MGIT 960 was used by the manufacturer's instructions to perform a culture and sensitivity test for *Mycobacterium tuberculosis*. The Centers for Disease Control and Prevention (CDC) recommends a turnaround time of 2-4 weeks after receiving the samples for culture and sensitivity testing. BACTEC MGIT 960 is superior to other culture systems in terms of turnaround speed and sensitivity. The MGIT (Mycobacteria Growth Indicator Tube) system is a method used to detect the presence of *Mycobacterium tuberculosis* by; collecting sputum specimen, decontaminating the specimen to remove other bacteria that might be present. This helps to isolate the *Mycobacterium tuberculosis* and reduce the chance of false positives. A proportion of the specimen is then inoculated into MGIT tube containing liquid growth medium. The medium typically contains nutrients that support growth of mycobacteria. The MGIT tube also contains a fluorescent sensor embedded in the bottom. This sensor measures the concentration of oxygen and detects changes in carbon dioxide levels within the tube. Incubation is done by placing inoculated MGIT tube in a specialized instrument called an MGIT instrument which provides optimal conditions for bacterial growth, including controlled temperature and agitation. The instrument continuously monitors the MGIT tubes to fluorescence. As *Mycobacterium tuberculosis* grow and metabolize nutrients in the medium, they consume oxygen and produce carbon dioxide, which correlates with bacterial growth. When Mycobacterial growth occurs, the oxygen level decreases and the carbon dioxide level increases, leading to an increase in fluorescence. When the fluorescence reaches a predetermined threshold, it indicates that mycobacterial growth has occurred in the tube. This triggers an alert in the MGIT instrument, signaling that the tube is positive for Mycobacterial growth. Once a positive signal is detected, further testing, in this case drug susceptibility testing is performed to determine appropriate antibiotic treatment.

Mycobacterium tuberculosis isolates were found in eighteen (18) patients for their susceptibilities to isoniazid (INH), Ethambutol (ETH), streptomycin (STR) and rifampin (RIF). The selection of the most appropriate antibiotic therapy for patients with mycobacterial infections is aided by the measures that AST by MGIT takes to provide vital information regarding the susceptibility of mycobacterial isolates. For the MGIT procedure, 0.5 milliliters of test organism suspension were added to an MGIT containing 0.1 microgram of isoniazid per milliliter, streptomycin (STR) 4.0 micrograms/milliliter, Ethambutol (EMB) 5.0 micrograms/milliliter, and 1.0 microgram of rifampicin per milliliter, along with a growth control MGIT. The tubes were checked every day while being incubated at 37 degrees. According to the interpretation of the MGIT AST data, the tubes containing isoniazid and rifampicin were classified as resistant if they did not glow within two days after the positive growth control did, and susceptible if they did occur within that time frame.

The true extent of drug resistance in *Mycobacterium tuberculosis* around the world is unknown because it is challenging to guarantee representative populations have been sampled and because most parts of the world lack the infrastructure and quality control mechanisms necessary to perform drug sensitivity testing and culture. This study will help to determine the sensitivity or resistance of the *Mycobacterium tuberculosis* strain to each tested drug. Rifampicin, isoniazid, streptomycin, and ethambutol effectiveness and resistance for *Mycobacterium tuberculosis s*ample cultures will be evaluated in this way.

2.4 Data Analysis

The raw data was filled into Statistical Package for Social Science (SPSS) version 26 software for analysis. Frequency distribution of all variables was obtained and illustrated using pie charts, bar graphs and frequency distribution tables. Comparison between qualitative variables was made using the Z score test, T tests and chi-square and a p-value less than 0.05 was considered statistically significant. Linear regression and Analysis of variance (ANOVA) was used to find out correlation between variables.

2.5 Ethical approval

Study was approved by Mount Kenya University Institutional Scientific Research and Ethical Committee with approval number (Ref no:MKU/ISERC/2782). Research license was obtained from National Commission for Science, Technology and Innovation (NACOSTI)
(NACOSTI/P/23/26875)

3. Results

3.1 Demographics

One hundred and sixty-two (162) study subjects were recruited in the current study. The composition distribution of the study subjects was one hundred and eleven males (111) and fifty-one females (51). The age distribution of the study subjects was five- months (0.5 years) up to seventy-eight (78 years) with an average age of thirty -six years (36 years).

3.2 The prevalence of *Mycobacterium tuberculosis* for study subjects visiting Pipeline and Mukuru Kwa Njenga slums health facilities.

Sputum specimens were collected from the study subjects and qualitatively analyzed. Twenty-nine (29) sputum specimens generated positive results for *mycobacterium tuberculosis* while one hundred and thirty-three (133) generated negative results for *mycobacterium tuberculosis.* This study had a total of 111 males and 51 males enrolled for this study. The percentage distribution of *Mycobacterium tuberculosis* infection was 17.9% positive and 82.1% negative. Out of the twenty-nine study subjects, whose results for *Mycobacterium tuberculosis* were positive, eighteen (18) were males translating to 62% while eleven were females translating to 38%. Therefore, the overall prevalence of *mycobacterium tuberculosis* for study subjects visiting Pipeline and Mukuru Kwa Njenga slums health facilities was 17.9 % with a male and female distribution of 18 (11.1 %) and 11 (6.8 %) respectively as shown in table 1 below. On the other hand, one hundred and thirty-three (133 (82.1%) study subjects turned to be *Mycobacterium tuberculosis* negative. The gender distribution was 93 (57.4 %) males and 40 (24.6 %) females as shown in Table 1 below.

Table 1: Prevalence of *Mycobacterium tuberculosis* for study subjects visiting Pipeline and Mukuru Kwa Njenga slums health facilities

Gender	Number of study subjects	Positive	Negative
Male	111 (100%)	18 (11.1%)	93 (57.4%)
Female	51 (100%)	11(6.8 %)	40 (24.6%)
Total	**162 (100%)**	**29(17.9%)**	**133 (82.1%)**

The prevalence of *Mycobacterium tuberculosis* infection in different age classes and sex in Mukuru Kwa Njenga was determined as shown in figure shown below. The prevalence of *Mycobacterium tuberculosis* infection was highest in both male and female aged between 30-39 years old. Children below 1-year old had no infection of *Mycobacterium tuberculosis.* Only female patients aged between 1-9 years old had the bacterial infection. In addition, only male patients aged between 60-69 years old had the infection. However, the prevalence of *Mycobacterium tuberculosis* infection was not significantly different in male and female patients across all age classes, t_7=1.3, CI=95%, p=0.2.

The prevalence of *Mycobacterium tuberculosis* infection in different age classes and sex in Mukuru Kwa Njenga was determined as shown in figure 1.4. The prevalence of *Mycobacterium tuberculosis* infection was highest in both male and female aged between 30-39 years old. Children below 1-year old had no infection of *Mycobacterium tuberculosis.* Only female patients aged between 1-9 years old had the bacterial infection. In addition, only male patients aged between 60-69 years old had the infection. However, the prevalence of *Mycobacterium tuberculosis* infection was not significantly different in male and female patients across all age classes, t_7=1.3, CI=95%, p=0.2.

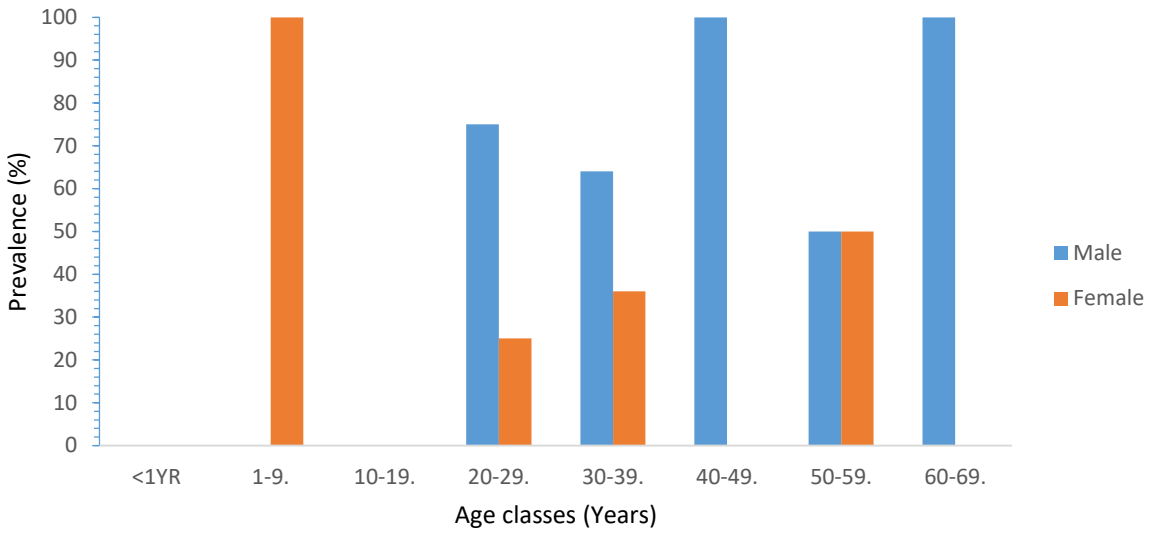


Figure 1: Prevalence in different age and gender.

3.3 The hematological and biochemical changes in patients diagnosed with tuberculosis infection

3.3.1 Biochemical changes

The Kidney Function Tests were determined in twenty-eight (28) patients. The Urea, Electrolytes, Creatinine parameter levels did not differ significantly with sex, $p>0.05$.

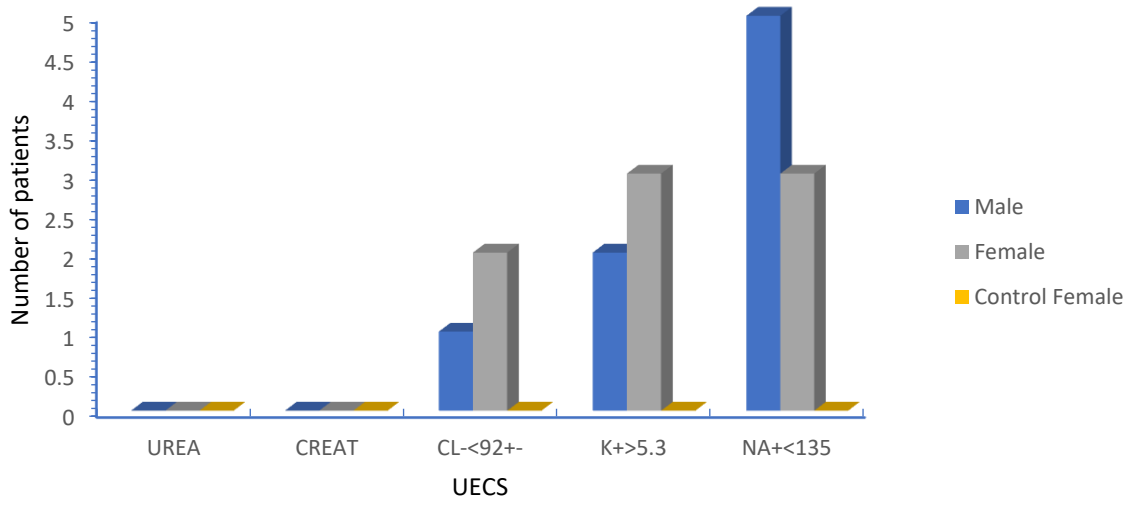


Figure 3: **Different kidney function tests parameters in regards to gender.**

The Liver Functions Tests were determined in twenty-eight (28) number of patients alongside controls. Similarly, the determined Liver Function Tests parameter levels did not differ significantly with sex, p>0.05.

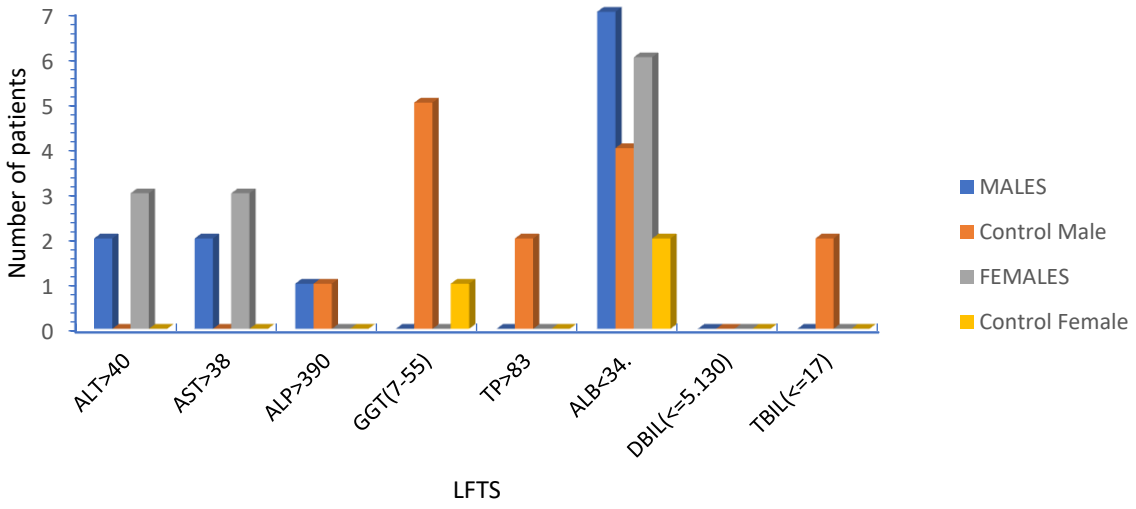


Figure 4: Different parameters of Liver Function Tests in Males and Females

The following biochemical parameters were analyzed for the study subjects whose sputum analysis for *Mycobacterium tuberculosis* turned positive and also for healthy individuals who formed the control group of the study. The biochemical parameters and the mean concentration of the study subjects(patients) and the healthy individuals (control subjects) were as follows: potassium (k+): patient (4.6 mmol/l) and control subjects (4.3 mmol/l), the mean difference was not statistically significant(p=0.118). Sodium (Na+): patients (132 mmol/l) and control subjects (142 mmol/l), there was a statistically significant mean difference. (p=0.033). Chloride (cl-): patient (101 mmol/l) and control subjects (100 mmol/l), there was no statistically significant mean difference (p=0.715). Blood urea nitrogen (bun): patient (3.8 mmol/l) and control subjects (4.1mmol/l), the mean difference was not statistically significant (p=0.34). Creatinine (Creat: patient (94 µmol/l) and control subjects (90 µmol/l), the mean difference was not statistically significant (p=0.333). Total protein (Tp): patient (73g/l) and control subjects (72 g/l), the mean difference was not statistically significant (p=0.679). Albumin (Alb): patient (30g/l) and control subjects (46 g/l), the mean difference was statistically significant (p=0.000). Aspartate aminotransferase (AST): patients (28iu/l) and control subjects (13/l), the mean difference was statistically significant (p=0.000). Alanine aminotransferase (ALT): patients (28iu/l) and control subjects (10 iu/l), the mean difference was statistically significant (p=0.000). Alkaline phosphatase (ALP): patients (152iu/l) and control subjects (135iu/l), the mean difference was not statistically significant (p=0.430). Gamma glutamate transferase (ggt): patients (30iu/l) and control subjects (12iu/l), the mean difference was statistically significant (p=0.000). Total bilirubin (tb): patients (11 µmol/l) and control subjects (9 µmol/l), the mean difference was not statistically significant (p=0.107). Direct bilirubin (db): patients (2.9 µmol/l) and control subjects (1.8 µmol/l), the mean difference was statistically significant (p=0.005). All the above information is as shown in table 2 and 3.

Table 2: Clinical Chemistry Biochemical Changes

Paired Samples Statistics					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	pk	4.611	28	.8867	.1676
	ck	4.321	28	.5116	.0967
Pair 2	pna	132.14	28	21.102	3.988
	cna	141.57	28	5.487	1.037
Pair 3	pcl	100.93	28	6.655	1.258
	ccl	100.43	28	2.456	.464
Pair 4	pbun	3.786	28	.9497	.1795
	cbun	4.082	28	1.2031	.2274
Pair 5	pcreat	94.32	28	17.508	3.309
	ccreat	90.00	28	14.340	2.710
Pair 6	ptp	73.00	28	5.907	1.116
	ctp	72.36	28	5.684	1.074
Pair 7	palb	29.86	28	8.835	1.670
	calb	45.89	28	5.940	1.123
Pair 8	past	28.18	28	10.684	2.019
	cast	13.36	28	8.225	1.554
Pair 9	palt	28.46	28	16.847	3.184
	calt	9.75	28	6.461	1.221
Pair 10	palp	152.46	28	94.970	17.948
	calp	135.29	28	63.780	12.053
Pair 11	pggt	30.21	28	12.876	2.433
	cggt	11.50	28	7.141	1.350
Pair 12	ptbili	11.36	28	3.664	.692
	ctbili	9.243	28	4.6025	.8698
Pair 13	pdbili	2.911	28	1.5081	.2850
	cdbili	1.825	28	1.1686	.2208

Key: p=patient, c=control subject,

Table 3: Clinical Chemistry Biochemical Changes

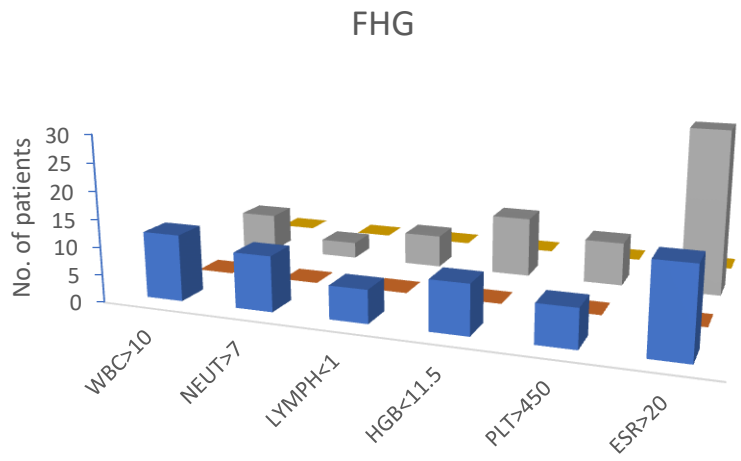
Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	Df	Sig. (2-tailed)
Pair 1	pk - ck	.2893	.9476	.1791	-.0782	.6567	1.615	27	.118
Pair 2	**pna - cna**	**-9.429**	**22.152**	**4.186**	**-18.018**	**-.839**	**-2.252**	**27**	**.033**
Pair 3	pcl - ccl	.500	7.162	1.354	-2.277	3.277	.369	27	.715
Pair 4	pbun - cbun	-.2964	1.6165	.3055	-.9232	.3304	-.970	27	.340
Pair 5	pcreat - ccreat	4.321	23.203	4.385	-4.676	13.319	.986	27	.333
Pair 6	ptp - ctp	.643	8.125	1.535	-2.508	3.793	.419	27	.679
Pair 7	**palb - calb**	**-16.036**	**10.543**	**1.992**	**-20.124**	**-11.948**	**-8.049**	**27**	**.000**
Pair 8	**past - cast**	**14.821**	**14.765**	**2.790**	**9.096**	**20.547**	**5.312**	**27**	**.000**
Pair 9	**palt - calt**	**18.714**	**16.456**	**3.110**	**12.333**	**25.095**	**6.018**	**27**	**.000**
Pair 10	palp - calp	17.179	113.435	21.437	-26.807	61.164	.801	27	.430
Pair 11	**pggt - cggt**	**18.714**	**15.085**	**2.851**	**12.865**	**24.563**	**6.565**	**27**	**.000**
Pair 12	ptbili - ctbili	2.1143	6.7100	1.2681	-.4876	4.7161	1.667	27	.107
Pair 13	**pdbili - cdbili**	**1.0857**	**1.8777**	**.3548**	**.3576**	**1.8138**	**3.060**	**27**	**.005**

Key: p=patient, c=control subject,

3.3.4 Hematological changes

Hematological changes in patients with *Mycobacterium tuberculosis* infection were analyzed as shown in the figure below. Higher number of females had ESR more than 30mm/hr. The FHG parameters were significantly higher in males compared to their controls, t_5=6.7, p=0.001. Similar observation was in females t_5=2.7, p=0.04. However, the FHG levels were not significantly different between male and female patients, p>0.05.



	WBC>10	NEUT>7	LYMPH<1	HGB<11.5	PLT>450	ESR>20
Male	12	10	6	9	7	16
Control Male	0	0	0	0	0	0
Female	7	3	6	11	8	30
Control Female	0	0	0	0	0	0

Figure 5: Significant Full Haemogram parameters affected in regards to gender.

The hematological parameters and the mean concentration of the study subjects (patients) and the healthy individuals (control subjects) were as follows: erythrocyte sedimentation rate (ESR): patient (50 mm/hr) and control subjects (3 mm/hr), the mean difference was statistically significant (p=0.000). Red blood cell count (rbc): patient (3.7 X10^6/UL) and control subjects (4.3X10^6/UL), the mean difference was statistically significant (p=0.002). Hemoglobin concentration (hb): patient (11 g/dl) and control subjects (14 g/dl), the mean difference was statistically significant (p=0.000). Hematocrit (hct): patient (34%) and control subjects (42%), the mean difference was statistically significant (p=0.000). Mean cell volume (mcv): patient (83 fl) and control subjects (98 fl), the mean difference was statistically significant (p=0.000). Mean cell hemoglobin (mch): patient (26 pg) and control subjects (32pg), the mean difference was statistically significant (p=0.000). Mean cell hemoglobin concentration (mchc): patient (29 g/dl) and control subjects (32 g/dl), the mean difference was statistically significant (p=0.006). Platelets (plt): patient (410 X 10^6/UL) and control subjects (272 X 10^6/UL), the mean difference was statistically significant (p=0.000), total white blood cell count (wbc): patient (11.8 X 10^3/UL) and control subjects (6.3 X 10^3/UL), the mean difference was statistically significant (p=0.000). Neutrophils (neu): patient (69%) and control subjects (52 %), the mean difference was statistically significant (p=0.000). Lymphocytes (lym): patient (31%) and control subjects (39%), the mean difference was statistically significant (p=0.000). Eosinophils (eos): patient (2.9%) and control subjects (2.7 %), the mean difference was not statistically significant (p=0.6). Monocytes (mon): patient (6.6%) and control subjects (4.7 %), the mean difference was not statistically significant (p=0.016). Basophils (bas): patient (0.4%) and control subjects (0.3%), the mean difference was statistically significant (p=0.042). All the above information is as shown in table below 4 and 5.

Table 4: Hematological Changes A

Paired Samples Statistics					
		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	Prbc	3.760	30	.9231	.1685
	cRBC(10^6/UL	4.353	30	.5680	.1037
Pair 2	Phb	10.973	30	2.0529	.3748
	cHB(g/dl))	14.00	30	1.365	.249
Pair 3	Phct	34.03	30	5.846	1.067
	cHCT(%)	42.50	30	4.015	.733
Pair 4	Pmcv	82.67	30	7.102	1.297
	cMCV(fl)	98.07	30	8.346	1.524
Pair 5	Pmch	26.10	30	4.397	.803
	cMCH(pg)	31.57	30	2.285	.417
Pair 6	Pmchc	29.30	30	4.786	.874
	cMCHC((g/dl)	32.17	30	2.036	.372
Pair 7	Pplt	410.97	30	160.762	29.351
	cPLT(10^3/UL	272.13	30	51.827	9.462
Pair 8	Pwbc	11.827	30	3.3717	.6156
	cwbc(10^3/UL)	6.337	30	1.8539	.3385
Pair 9	pneu(%)	69.37	30	8.732	1.594
	cN(%)	52.57	30	5.386	.983
Pair 10	plymp(%	31.10	30	8.953	1.635
	cL (%)	39.53	30	4.953	.904
Pair 11	peos(%	2.97	30	1.650	.301
	cE (%)	2.787	30	.8003	.1461
Pair 12	pmon(%	6.67	30	3.594	.656
	cM(%)	4.660	30	1.8926	.3455
Pair 13	pbas(%	.457	30	.2487	.0454
	cB(%)	.3053	30	.30832	.05629
Pair 14	pesr(mm/hr	50.40	30	17.708	3.233
	Cesr	2.70	30	1.343	.245

Key: Key: p=patient, c=control subject,

Table 5: Hematological Changes B

Paired Samples Test									
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	df	Sig. (2-tailed)
Pair 1	pRBC - cRBC(10^6/UL	-.5933	.9677	.1767	-.9547	-.2320	-3.358	29	.002
Pair 2	phb - cHB(g/dl))	-3.0267	2.3180	.4232	-3.8922	-2.1611	-7.152	29	**.000**
Pair 3	phct - cHCT(%)	-8.467	6.917	1.263	-11.049	-5.884	-6.704	29	**.000**
Pair 4	pmcv - cMCV(fl)	-15.400	11.961	2.184	-19.866	-10.934	-7.052	29	**.000**
Pair 5	pmch - cMCH(pg)	-5.467	5.050	.922	-7.352	-3.581	-5.930	29	**.000**
Pair 6	pmchc - cMCHC((g/dl)	-2.867	5.322	.972	-4.854	-.879	-2.950	29	**.006**
Pair 7	pplt - cPLT(10^3/UL	138.833	158.199	28.883	79.761	197.906	4.807	29	**.000**
Pair 8	pwbc - cwbc(10^3/UL)	5.4900	3.3429	.6103	4.2418	6.7382	8.995	29	**.000**
Pair 9	pneu(%) - cN(%)	16.800	11.287	2.061	12.585	21.015	8.152	29	**.000**
Pair 10	plymp(% - cL (%)	-8.433	9.769	1.784	-12.081	-4.786	-4.729	29	**.000**
Pair 11	peos(% - cE (%)	.1800	1.8585	.3393	-.5140	.8740	.530	29	.600
Pair 12	**pmon(% - cM(%)**	**2.0067**	**4.3037**	**.7857**	**.3996**	**3.6137**	**2.554**	**29**	**.016**
Pair 13	**pbas(% - cB(%)**	**.15133**	**.38883**	**.07099**	**.00614**	**.29653**	**2.132**	**29**	**.042**
Pair 14	**pesr(mm/hr – cesr**	**47.700**	**17.603**	**3.214**	**41.127**	**54.273**	**14.842**	**29**	**.000**

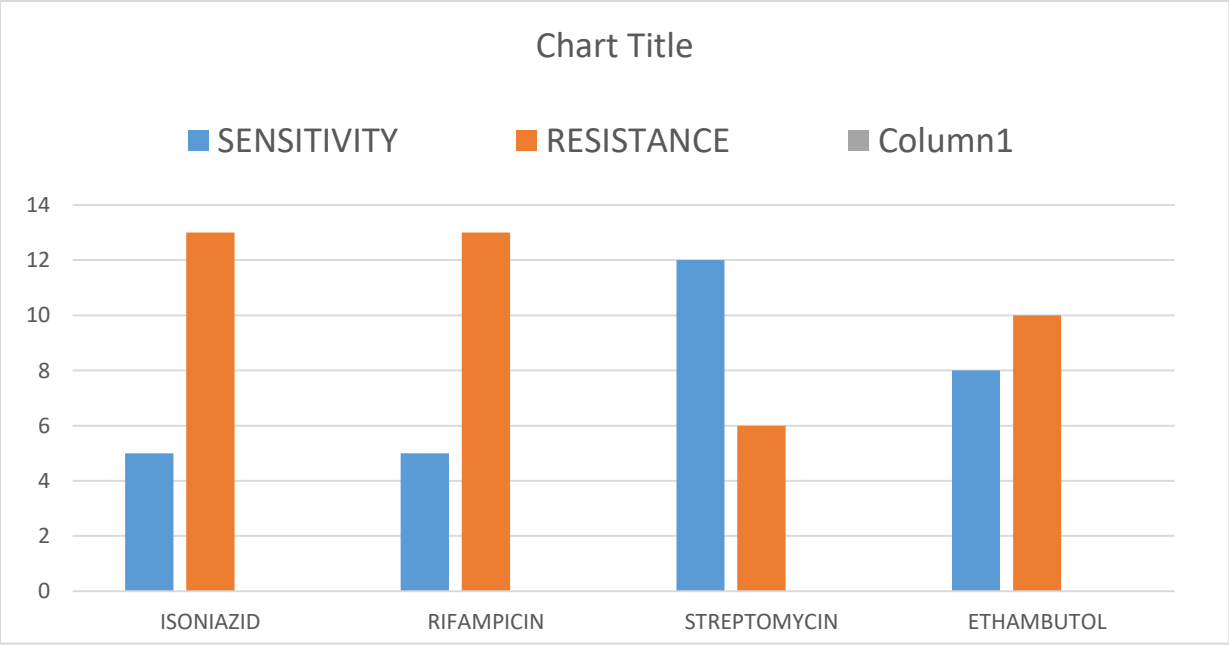
Key: p=patient, c=control subject,

3.4 In-Vitro assessment of the efficacy of first-line anti-tuberculosis drugs against *mycobacterium tuberculosis* by culture and sensitivity

Among the sputum specimens which were cultured, 18 had growth of mycobacterium tuberculosis. The culture growth was subjected to drug sensitivity testing using the following anti-biotic i.e. streptomycin, isoniazid, rifampicin and ethambutol. Twelve (67%) culture growths were sensitive to streptomycin and six (33%) were resistant to streptomycin. Five (28%) culture growths were sensitive to isoniazid and thirteen (73%) were resistant to isoniazid. Five (28%) culture growths were sensitive to rifampicin and thirteen (73%) were resistant to rifampicin. Eight (44%) culture growths were sensitive to ethambutol while ten (56%) culture growths were resistant to ethambutol. Among the four types of anti-biotic, streptomycin produced the highest sensitivity of 67 % whilst isoniazid and rifampicin produced the highest resistance of 73%. The above information is as shown in Table 4 below:

Table 6: culture and sensitivity pattern of Mycobacterium tuberculosis

Anti-biotic	Sensitive number (%)	Resistant number (%)
Streptomycin	**12(67%)**	**6(33%)**
Isoniazid	**5(28%)**	**13(73%)**
Rifampicin	**5(28%)**	**13(73%)**
Ethambutol	**8(44%)**	**10(56%)**



4. Discussion

Mycobacterium tuberculosis was present in 17.9% of research participants who visited the health facilities in the Pipeline and Mukuru Kwa Njenga slums. This study's finding is similar to that in Nigeria, 18.3% of 16,743 people who had tuberculosis screenings were found to have *Mycobacterium tuberculosis* (Ogbudebe et al., 2015). The age group of 30-39 was found to have the greatest reported *Mycobacterium tuberculosis* which is also to this study's findings. The national estimate from previous years is comparable to the study's estimate of the prevalence of positive tuberculosis cases. Although less than Nairobi County's 2016 forecasts, nevertheless. This may be the result of tactics created by the Sustainable Development Goals, which aim to implement policies that will end tuberculosis infection by 2030. The distribution of males and females was 18 (11.1%) and 11 (6.8%), respectively. Despite the fact that fewer women than men were chosen for this study, the results indicate that men are twice as likely as women to be infected. This stands in contrast to a 2016 study carried out in Kenya by Videlis Nduba, where women participated at a greater rate of 87% as opposed to 77% of men.

A nationwide tuberculosis survey conducted in Rwanda in 2014 found that men were five times more likely than women to have the illness. The differences in gender prevalence are assumed to be caused by either extrinsic (external) or intrinsic (biological) factors. Progesterone and testosterone may have an immune-suppressive effect, but estrogen may have an immune-enhancing effect. Men are more likely than women to experience risk factors such as indoor air pollution, smoking, hazardous alcohol use, HIV, malnourishment, and recurrent cases of tuberculosis.

Tuberculosis remains a serious infectious disease and public health issue in Kenya. It causes a variety of hematological and metabolic alterations. This study demonstrates that individuals with active pulmonary tuberculosis display a wide spectrum of abnormalities in hematological and biochemical changes in comparison to a control group of healthy individuals. Many of the variations agree with the results of previous studies. Apart from the lungs, TB also affects the bone marrow. Hematological disorders of note are linked to tuberculosis. These hematological traits can therefore be utilized as markers for the prognosis, diagnosis, and course of treatment. Since tuberculosis is a bacterial infection, leukocytosis has been seen in numerous investigations, including one conducted in Babylon by Ali Mohamad *et al.* in 2011.

According to this study, compared to healthy study participants, male and female tuberculosis patients had noticeably higher amounts of white blood cells, neutrophils, and lymphocytes. When compared to healthy controls, the white blood cell count in research participants with pulmonary tuberculosis was elevated ($p<0.000$), which is comparable to a study conducted in India by Rohini *et al* (2015). Patients with tuberculosis exhibiting elevated absolute white blood cell counts (7.7+-3.71*10^3 cells/Ul). White blood cell >10.6*10^3/Ul and white blood cells <3.6*10^3/Ul were characterized as leukocytosis and leukopenia respectively. This aligns with previous research from south eastern Nigeria, Ethiopia, Pakistan. When compared to a healthy control group, patients with active pulmonary tuberculosis exhibited noticeably higher mean absolute counts of white blood cells, neutrophils, lymphocytes, and platelets. Shat *et al* 2022 's study and this one are comparable.

Neutrophils (neu): the mean difference between the patient (69 percent) and control participants (52 percent) was statistically significant ($p=0.000$).). Poly-morphonuclear neutrophils are the most abundant type of white blood cells and play a central role in the immune response to bacterial pathogens Moefong et al.,2020 study correspond to this study in term of significance level

Lymphocytes (lym): patient (31%) and control subjects (39%), the mean difference was statistically significant ($p=0.000$). This study was conquering with (shah *et al*.,2022) whose study showed significance increase and decrease in lymphocytes.

The statistical significance of basophils was ($p<0.042$). Basophils with a statistical significance of $p<0.042$ indicate a difference between the study participants and the control group. This suggests that it is unlikely that the fluctuation in basophil count that has been seen is the result of random chance. This result is consistent with data from Umuhaia that shown a large increase in eosinophils following tuberculosis infection.

The patient group had a significant increase in MPV when compared to the healthy controls, which may be a sign of a continuous immune response or inflammatory process. This result could suggest an underlying medical issue, such as active lung tuberculosis. According to research done in Iraq, Sudan, South Eastern Nigeria, Guyana, and Jimma University, the average number of platelets among tuberculosis patients—both male and female—was much higher than in control groups (Gebreweld *et al.*, 2024).

Hemoglobin, red blood cell count, and hematocrit count (HCT) were all lower in tuberculosis patients compared to a healthy control group, regardless of gender. (Leon *et al.* 2016) concur with this. This study's findings on the prevalence of anemia are consistent with previous research. Males made up 30% and females made up 37% of the total positive cases. Comparable to studies carried out in Ethiopia, microcytic anemia represented for 47.8 percent of all anemia cases, while normocytic normochromic anemia accounted for 56.7 percent. It seemed that more women than men had low hemoglobin levels.

Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Albumin (ALB)and Gamma glutamate transferase (ggt): the mean difference was statistically higher in patients diagnosed with *Mycobacterium tuberculosis* than in healthy individuals with a significance of ($p=0.000$). Direct bilirubin (db), the mean difference was statistically elevated in the study subjects than in healthy individuals with p value of ($p=0.005$). Alkaline phosphatase (ALP), Total bilirubin (tb): the mean difference was not statistically significant ($p=0.430$, $p=0.107$) respectively. The mean ALT was significantly higher in tuberculosis patients than in healthy individuals which is consistent to research done in Gunaya. However, the finding contradicted with the finding of Manner *et al*, on biochemical parameters in relation to tuberculosis infection in Sudanese patients which showed significant decrease in ALT in tuberculosis patients.

Effective treatment of the disease, patient care, and infection control depend on the timely and correct detection of an active pulmonary tuberculosis infection and the evaluation of the infection's responsiveness to anti-TB medications. In addition, treating drug-resistant forms of tuberculosis is far more challenging than treating drug-susceptible strains. Drug-resistant tuberculosis (TB) is becoming more commonplace worldwide, which has brought attention to the need for prompt and reliable drug resistance identification in order to start patients on the right course of treatment as soon as possible.

Among 25 sputum specimens which were cultured, 18 had growth of *Mycobacterium tuberculosis*. The culture growth was subjected to drug sensitivity testing using the following anti-biotic i.e. streptomycin, isoniazid, rifampicin and ethambutol. Twelve (67%) culture growths were sensitive to streptomycin and six (33%) were resistant to streptomycin. Five (28%) culture growths were sensitive to isoniazid and thirteen (73%) were resistant to isoniazid. Five (28%) culture growths were sensitive to rifampicin and thirteen (73%) were resistant to rifampicin. Eight (44%) culture growths were sensitive to ethambutol while ten (56%) culture growths were resistant to ethambutol. This resistance patterns of isoniazid are similar to springers et al., 2023, isoniazid resistance was observed in 18 among 29 isolates found to be resistant to rifampicin, equivalent of 62.1%, while isoniazid was able to predict rifampicin resistance by 80.2% and in contrast with Al hajoj *et al.*, 2015 whose study had Isoniazid and rifampin resistance of 17.8% and 2.6%, respectively. Streptomycin exhibited the highest sensitivity of 67 percent among the four antibiotic classes, while isoniazid and rifampicin produced the highest resistance of 73 percent. The most prevalent mutation *in M. tuberculosis* strains that results in drug resistance is mono-resistance to isoniazid.

Conclusion

WHO's estimated tuberculosis prevalence in Kenya was lower than the first direct measure. It is more difficult to identify and treat the remaining cases when the burden is minimal. Kenya must continue to adopt routine case detection measures for the broader public while also implementing new and more active strategies that target high-risk populations, such as those living in the Nairobi slums. It is necessary, particularly consider hematological and biochemical tests when it comes to diagnosis, prognosis and treatment of tuberculosis infection as different parameters in different test aid in its elevation or decrease. Continuous use of antibiotics used to treat active pulmonary tuberculosis should be used accessed from time to time due to increase in drug resistance tb to ensure efficient treatment and prevention of active pulmonary tuberculosis.

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Competing interests

The authors declare no competing interests.

Abbreviations

TB; tuberculosis infection,
ANOVA; analysis of variance;
XDR: Multidrug resistant tb.

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