

Influencing Factors on *Mycobacterium tuberculosis* that Causes Tuberculosis (TB) in Benghazi: Environmental and Behavioral Factors

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Abstract: *Mycobacterium tuberculosis* is the causative agent of TB. There are two types of TB; pulmonary TB and extrapulmonary TB. Ignorance, poverty, overcrowding, poor hygiene, especially during the war and economic depression, malnutrition, smoking, and drug addiction are the major factors, and the primary sources to increase of TB rate. Libya is one of the developed countries that are suffering from this serious disease. In this research paper, TB patients' data were collected in the period of 2018, 2019 and 2020 from the Statistical Department of Quefia Chest (Respiratory Diseases) Hospital in Benghazi, and the total number of patients was determined. The factors that are leading to the occurrence of TB were studied through a questionnaire that includes social and demographic information, and other factors. The total number of patients was 510 cases, and most of them are males, unemployed, smokers, and those with low educational levels.

Keywords: Mycobacterium tuberculosis, Pulmonary tuberculosis, Extrapulmonary tuberculosis, Acid-fast bacilli

1. Introduction

Genus *Mycobacterium* is aerobic, irregular, slightly branched (Schlegel, 1993), Gram-positive, and staining by acid-fast stain (Ryan and Ray, 2004). This genus is classified within the Mycobacteriaceae, which belong to the Actinomycetales (EPA, 1999 & Rastogi, Legrand and Sola, 2001). *Mycobacterium tuberculosis* that is discovered for the first time by Dr Robert Koch in 1882 (Sakula, 1982) considered the most important species of Mycobacteria (Ryan and Ray, 2004); this is due to the fact that it causes TB (Ryan and Ray, 2004; WHO, 2014; ATS, 2017; WHO, 2018) that is one of the worldwide serious infectious diseases, that causes death over the past 200 years (Paulson, 2013). Its infection is primarily for the lungs; for that, the disease is called pulmonary TB. It also infects other parts of the human body, in this case, is called extrapulmonary TB (WHO, 2014; ATS, 2017; WHO, 2018). This bacterium is a thin bacillus (WHO, 2018), grows at 37°C, and its mean generation time is 12 to 24 hours. It is resistant to drying, to several disinfectants, and to acids and alkalis; this is due to its hydrophobic lipid surface (Ryan and Ray, 2004).

Infection with *Mycobacterium tuberculosis* occurs through its spread in air contaminated by droplets of TB patients after coughing (WHO, 2014; ATS, 2017; WHO, 2018). The most important factors leading to the increase of TB rate are ignorance, poverty, overcrowding, and poor hygiene, especially during the war and economic depression (Ryan and Ray, 2004), moreover, malnutrition, smoking and alcohol drinking (WHO, 2018). *M. tuberculosis* is considered opportunistic and often causes TB when the body's immunity is weakened (Murray *et al.*, 1998). Evidence of this is that people with HIV (WHO, 2014), diabetes (WHO, 2018), kidney failure, or who are taking certain immunosuppressive drugs, such as TNF-alpha

blockers, are more susceptible to TB (ATS, 2017). Based on the report of TB control in the Eastern Mediterranean Region; the level of the HIV epidemic and the correlation with TB incidence in Libya in 2007 was among the countries in the concentrated epidemic ($\geq 5\%$ in risk groups) (WHO, 2010).

Susceptibility to TB is associated with variants in the *ASAP1* gene encoding a regulator of dendritic cell migration (Curtis *et al.*, 2015). The source of TB in children is large in the case of the female is the source (Sinfield *et al.*, 2006). The associated risk of TB often increases with prolonged exposure to temperature and rainfall (Kuddus, McBryde, and Adegboye, 2019). The ability of *M. tuberculosis* to cause TB is higher among men, in particular, young men (WHO, 2014; WHO, 2018).

Detection of *M. tuberculosis* is carried out through a microscopic test, Sputum cultures, bronchoscopy of a sample of lung, as well as a chest X-ray and CT chest scan (WHO, 2014), furthermore, the Xpert® MTB/RIF assay that is recommended by WHO as a rapid molecular test (WHO, 2018). About almost 100 years ago the Bacilli Calmette-Guérin (BCG) vaccine was developed to prevent TB in children, and although it is widely used, it is ineffective in preventing TB in adults (WHO, 2017). Libya is among the countries that give this vaccine to children, despite the number of adults with TB is still high, as in the period between 2010 and 2018, 1778 cases were recorded only in Benghazi by Quefia Chest Hospital, including 49 mortality cases (Jwili *et al.*, 2020). This research paper aims to determine the TB incidence rates, which were registered at the Quefia Chest Hospital in Benghazi in 2019 and 2020. In addition, to highlighting the influencing factors on *M. tuberculosis*, which lead to TB in Benghazi.

2. Materials and Methods

Data collection

TB patients' data were collected in the period of 2018, 2019 and 2020 from the Statistical Department of Quefia Chest Hospital in Benghazi. These data include the date of entry and departure from the hospital, gender, age, region, nationality, TB associated diseases, escape and mortality cases. The conditions surrounding the patients, which is the main cause of their infection with TB in some cases, were identified through a questionnaire that includes 100 cases. For instance, the nature of the residence, the standard of living and education, as well as smoking, drinking alcohol and using drugs.

Statistical analysis

The collected data were analyzed by using SPSS software, Version 23, the International Business Machines Corporation (IBM). The total number of patients admitted during the period of 2018 to 2020 was determined. The percentages of all cases were estimated based on gender, age categories, nationality, region, and hospitalization period. Chi-Square test was applied to estimate the probability of association between the diagnosis and all tested factors (Jweli *et al.*, 2020). Furthermore, Chi-Square test was performed to assess the correlation of the factors recorded in the questionnaire with the incidence of TB.

3. Results

Statistical analysis for the total number of infected cases with TB

The number of TB cases between 2018, 2019 and 2020 reached out to 510 cases. The largest number of cases was recorded in 2019 (185 cases, 36.27%), and the lowest was recorded in 2020 (159 cases, 31.18%) (Image 1). Male cases showed the highest percentage of infection (70%, 357 cases), while female cases were the lowest (30%, 153 cases) (Image 2). An increase in the infection rate was observed for the age category 20-29 (31.57%, 161 cases), while the decrease in the infection rate was noted in the age category < 20 (6.67%, 34 cases) (Image 3). The Libyan nationality showed the maximum infection rate (80.59%, 411 cases), compared to other nationalities, which recorded the minimum infection rate, as nationalities from Southeast Asia (0.39%, two cases) (Image 4). Additionally, there is a huge rise in the incidence in Benghazi (56.47%, 288 cases), offset by a massive decline in the other cities as Musaid, Qatrun and Ras Lanuf (0.2%, One case) (Image 5). As for the length of the treatment period in the hospital, therefore majority of cases appeared to remain in the hospital under a month (51.37%, 262 cases), but the little numbers had been more than six months (1.18%, 6 cases) (Image 6).

On the other hand, the diagnosis of infected cases showed that Incidence of TB alone gave an extremely great percentage among the infected (76.08%, 388 cases), whilst there were several cases of TB accompanied by various other diseases at the same time, which gave a quite little percentage (0.2%, one case) such as TB + TBM, TB + Intestinal TB and TB + Pneumothorax (Table 1 & Image 7). Important notes were taken regarding 49 cases of patients, 30 of whom; escaped from the hospital (61.22%), in addition

to 16 deaths (32.65%). It was also seen within this group; 3 cases were discharged from the hospital without completing the treatment on their own responsibility (6.12%) (Image 8).

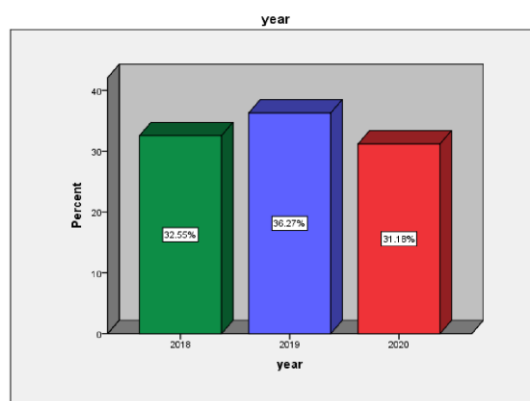


Image 1: TB rates by years of study

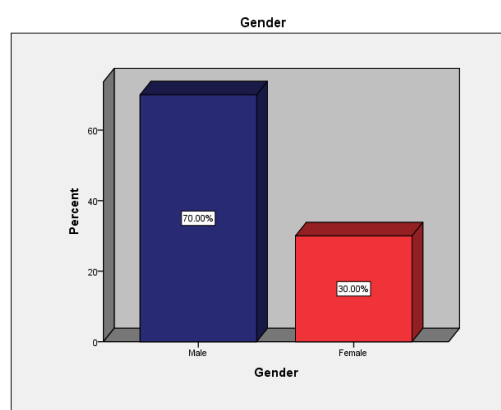


Image 2: TB rates for gender

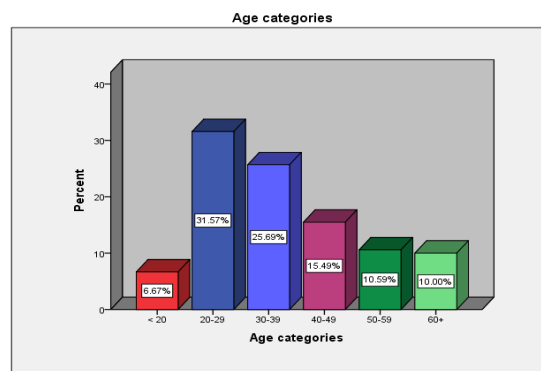


Image 3: TB rates for age categories

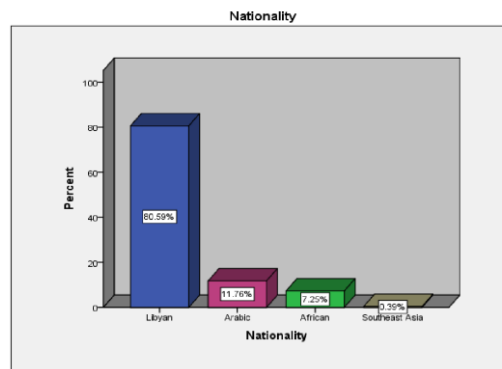


Image 4: TB rates by nationality

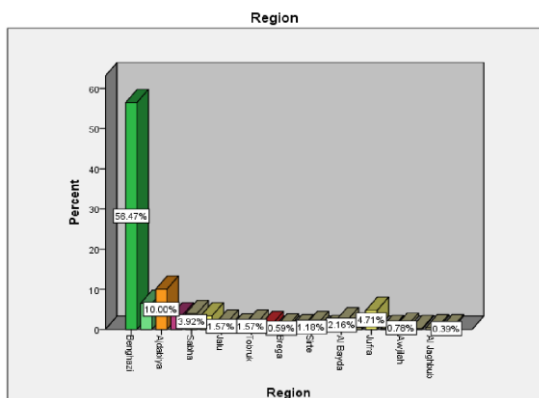


Image 5: TB rates for regions

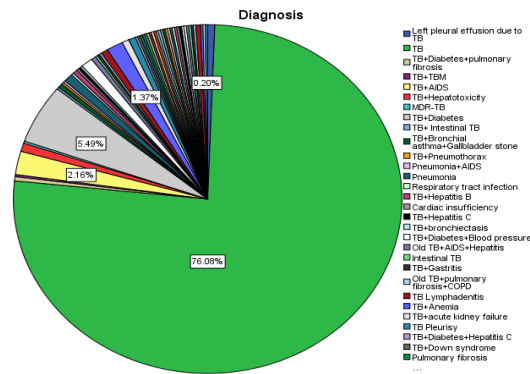


Image 7: Diagnosis of the study cases

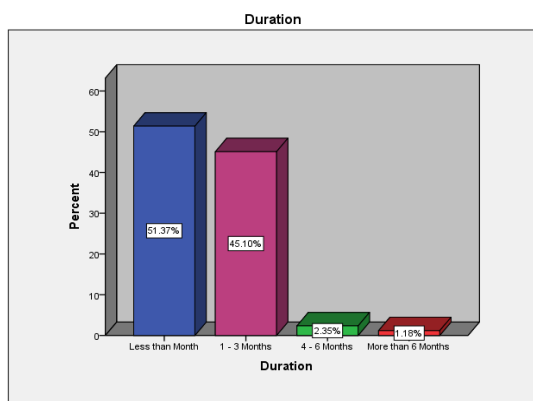


Image 6: TB rates by hospitalization period.

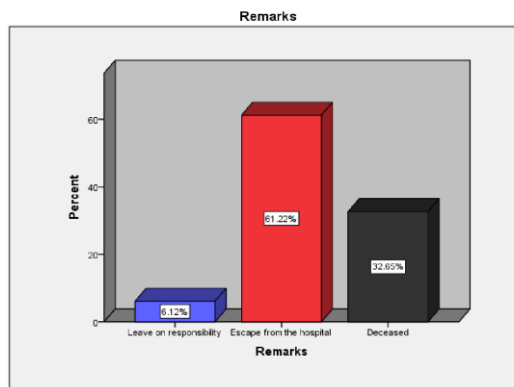


Image 8: Remarks for some cases of TB patients

Table 1: Diagnosis of the study cases

	Frequency	Percentage	Valid Percent	Cumulative Percent
Left pleural effusion due to TB	3	.6	.6	.6
TB	388	76.1	76.1	76.7
TB + Diabetes + pulmonary fibrosis	2	.4	.4	77.1
TB + TBM	1	.2	.2	77.3
TB + AIDS	11	2.2	2.2	79.4
TB + Hepatotoxicity	4	.8	.8	80.2
MDR-TB	1	.2	.2	80.4
TB + Diabetes	28	5.5	5.5	85.9
TB + Intestinal TB	1	.2	.2	86.1
TB + Bronchial asthma + Gallbladder stone	2	.4	.4	86.5
TB + Pneumothorax	1	.2	.2	86.7
Pneumonia + AIDS	1	.2	.2	86.9
Pneumonia	4	.8	.8	87.6
Respiratory tract infection	1	.2	.2	87.8
TB + Hepatitis B	2	.4	.4	88.2
Cardiac insufficiency	1	.2	.2	88.4
TB + Hepatitis C	1	.2	.2	88.6
TB + bronchiectasis	1	.2	.2	88.8
TB + Diabetes + Blood pressure	5	1.0	1.0	89.8
Old TB + AIDS + Hepatitis	2	.4	.4	90.2
Intestinal TB	1	.2	.2	90.4
TB + Gastritis	1	.2	.2	90.6
Old TB + pulmonary fibrosis + COPD	1	.2	.2	90.8
TB Lymphadenitis	3	.6	.6	91.4
TB + Anemia	7	1.4	1.4	92.7
TB + acute kidney failure	3	.6	.6	93.3
TB Pleurisy	3	.6	.6	93.9
TB + Diabetes + Hepatitis C	1	.2	.2	94.1
TB + Down syndrome	1	.2	.2	94.3
Pulmonary fibrosis	1	.2	.2	94.5
TB + deep vein thrombosis	1	.2	.2	94.7

AIDS	1	.2	.2	94.9
TBM	1	.2	.2	95.1
TB + Pneumonia	1	.2	.2	95.3
TB + Spinal TB	1	.2	.2	95.5
Pleural effusion + BPH + Diabetes	1	.2	.2	95.7
TB + Diabetes + Blood pressure + Hypothyroidism + Hepatitis B	1	.2	.2	95.9
Right pleural effusion due to TB + Diabetes + Kidney failure	1	.2	.2	96.1
Rheumatoid arthritis	1	.2	.2	96.3
TB + Diabetes + Cardiac insufficiency	1	.2	.2	96.5
TB + Rheumatism	1	.2	.2	96.7
TB + Diabetes + kidney failure	1	.2	.2	96.9
TB +Blood pressure + Cardiac insufficiency + Rheumatism	1	.2	.2	97.1
Bronchial asthma + Diabetes + Pneumonia	1	.2	.2	97.3
TB + AIDS + Hepatotoxicity	1	.2	.2	97.5
Kidney failure + Diabetes + Blood pressure	1	.2	.2	97.6
TB + Lung abscess	1	.2	.2	97.8
TB + Psychosis	1	.2	.2	98.0
TB + kidney failure + Blood pressure	1	.2	.2	98.2
Old TB + Pneumonia + AIDS	1	.2	.2	98.4
Bronchial asthma + hypothyroidism	1	.2	.2	98.6
TB + thrombosis in leg	1	.2	.2	98.8
TB + TB Pleurisy + Diabetes + Hepatotoxicity	1	.2	.2	99.0
Pleural effusion	2	.4	.4	99.4
TB + AIDS + Blood pressure	1	.2	.2	99.6
TB + TB Lymphadenitis	1	.2	.2	99.8
TB + Hepatotoxicity + thrombus	1	.2	.2	100.0
Total	510	100.0	100.0	

Statistical analysis of questionnaire factors

The cases of TB patients included in the questionnaire were one case from 2018, 56 cases from 2019, and 43 cases from 2020. There were 75 cases of males, and 25 cases of females. The largest number of age categories was recorded for 20-29 (58 cases), and the smallest number for < 20. The nationalities of the patients were 70 cases for Libyan, 17 cases for Sudanese, 5 cases for Chadian, and other cases were Egyptian, Moroccan, Ethiopian and Bangladeshi (two cases for each nationality). Most of the cases were from Benghazi (59 cases), and the least were from Murzuq, Tripoli, Jufra, Sirte and Tobruk (one case for each city). The greatest number of cases live in a small house (51 cases), followed by those who live in apartments (35), and the least of them live in a villa (4 cases). The rate of cases increases in a house consisting of 3-5 rooms (55 cases) and decreases in a house consisting of more than 5 rooms (5 cases). 44 cases have 3-5 family members, while the cases that have few individuals (less than 3 individuals) are 12 cases. The individuals who live in rooms with two people were recorded the highest number of infections (39 cases), unlike, those who live in rooms with more than 3 people, which were recorded the lowest number (10 cases). The educational level describes that the largest number of patients (88 cases) have an average level of education, and the others (12 cases) have a university education level. 72

cases are considered to be of limited income, but the other cases (28 cases) are of medium income.

According to the career, the unemployed are the most infected cases (25 cases), whilst the least infected cases (one case) have different careers such as a cook assistant, an airport worker and a barber. The number of cigarette smokers increased among the affected cases (46 cases), and decreased among non-smokers (29 cases), followed by those who were exposed to passive smoking (25 cases). Hookah smokers gave 10 cases, whereas non-smokers gave 81 cases, and those exposed to passive smoking gave 9 cases. 12 out of the 100 tested cases are drinking alcohol. 10 cases use drugs, and 90 cases do not use them. 7 cases among the infected were dealing with prisons, but the other (93 cases) did not deal with them. Further, 4 cases were recorded that they dealt with illegal immigration centers, and 96 cases did not deal with them. 9 cases of family members who were previously infected with TB were recorded, while the rest of the cases (91 cases) did not get recorded any previous infection with TB among members of their families. By looking at Table 2, which describes the diagnosis for all cases of the questionnaire, it is concluded that the cases of pulmonary TB are the highest (90 cases), and the other cases (10 cases) varied between infections with extrapulmonary TB only, and with pulmonary TB alongside other types of extrapulmonary TB or other diseases non-TB.

Table 2: Diagnosis of questionnaire cases

	Frequency	Percentage	Valid Percentage	Cumulative Percent
Valid TB	90	90.0	90.0	90.0
MDR TB	1	1.0	1.0	91.0
TB + TB pleurisy	1	1.0	1.0	92.0
TB pleurisy	2	2.0	2.0	94.0
TB + Neck abscesses	1	1.0	1.0	95.0
TB meningitis + Hepatic TB	1	1.0	1.0	96.0
(Pulmonary TB) Negative sputum for *AFB	2	2.0	2.0	98.0

	TB + Right pleural effusion	1	1.0	1.0	99.0
	TB pleurisy + Right pleural effusion	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

*Acid-fast bacilli.

Chi-Square test

It was concluded from the chi-square test, which applied on the total number of infected cases with TB (510) that there is a significant correlation between the diagnosis and each of the gender and duration of hospitalization at $\alpha = 0.05$. Moreover, there is a highly great association between the diagnosis and each of the age categories and regions at $\alpha = 0.001$.

According to the chi-square test which was applied on the questionnaire factors; the results display that there is a relation between the incidence of TB and each of the genders and the type of residence at $\alpha = 0.05$. Furthermore, the results reported a strong relation between the incidence of TB beside infection with other diseases at $\alpha = 0.01$. In addition, the results concluded that there is a major correlation between the incidence of TB and career at $\alpha = 0.001$.

4. Discussion

TB still poses a risk in Libya, as evidence of 510 cases that have been recorded during only three years (2018-2020) at Quefia Chest Hospital in Benghazi. Another research was conducted in Benghazi from the beginning of 2009 to mid-2010, in which 430 TB cases were recorded, including 4 cases of multidrug-resistant TB (MDR-TB) (Abbar *et al.*, 2014). Albarouni *et al.*, 2014 in Tripoli, isolated 216 isolates of *M. tuberculosis* complex from patients, which were subsequently subjected to Drug Susceptibility Test (DST). The test concluded that the prevalence of drug resistance *M. tuberculosis* (MTB) for the tested isolates was low (9 isolates). Ismail, Farag and Abdul Ilah, 2014 conducted a study on data of forty years from 1974 to 2014 taken from the National Center for Tuberculosis and Chest Diseases in Tobruk and recorded 995 TB cases. In the period of 2007-2017, the incidence of TB was compared between two Libyan cities, where 56 cases were recorded in Tarhona, and 235 cases in Alkoms (Aldhuh *et al.*, 2018). In the period between 2010-2018, 1778 cases of TB patients were registered in the same aforementioned hospital in Benghazi (Jwieli *et al.*, 2020).

As with most research on TB, the incidence rate of males is higher (357 cases) compared to females (153 cases). However, no difference was observed in the incidence rate of the both genders in the study of Abbas *et al.*, 2010 in Riyadh, Saudi Arabia. In a study of demographic and phenotypic characterization of drug-resistant *M. tuberculosis* isolated from patients living in Rivers State, Nigeria, the incidence rate of females was higher than males (Gborieneomie *et al.*, 2019). The age category 20-29 showed the highest rate of infection, in contrast, to the study of Abbas *et al.*, 2010, which showed the highest rate in the age category ≥ 50 , but both studies agree that the age category < 20 showed the lowest infection rate. Pongwittayapanu *et al.*, 2018 noticed in their study that the most infected age category is 30-39, and the lowest infected category is ≥ 50 .

Libyan citizens have the greatest rate of infection compared to other nationalities, while Abbas *et al.*, 2010 found that the greatest rate of infection was for nationalities from sub-Saharan countries compared to Saudi citizens. Several studies agree that TB and HIV are co-infection, which appeared in 18 patients in this study, among these studies, Molaeipoor *et al.*, 2014, Souriant *et al.*, 2019 and Gborieneomie *et al.*, 2019. Observing that 30 patients escaped from the hospital without taking treatment may be an indication of depression. It has been found in considerable research papers that there are many cases of people who become depressed after they infected by TB (Sweetland *et al.*, 2017; Wang *et al.*, 2018; Dasa *et al.*, 2019; Molla, Mekuriaw and Kerebih, 2019; Ambaw *et al.*, 2020 and Shrestha *et al.*, 2020).

The cases of TB patients that included in the questionnaire were 75 cases of males, and 25 cases of females. This result agrees with the study of Shrestha *et al.*, 2020. There is also a slight similarity in both studies, in addition to the study of Ambaw *et al.*, 2020 in terms of the most infected age groups, (20-29), (18-24) and (18-30) respectively. Whereas in the study of Molla, Mekuriaw and Kerebih, 2019, and Kahase *et al.*, 2021, the most infected age groups were (25-34) and (31-45) respectively. Benghazi is the region with the highest number of TB infections, this may be due to, primarily it is the area of the hospital in which this study was conducted, and on the other hand, possibly because it is the second city in Libya in terms of population number or overcrowding. This agrees with several research papers that have found that a higher proportion of TB patients live in urban settings (Wang *et al.*, 2018; Miandad *et al.*, 2019; Molla, Mekuriaw and Kerebih, 2019 and Kahase *et al.*, 2021).

Poverty, malnutrition, low educational level and lack of knowledge about TB are among the factors that lead to TB infection (Solliman *et al.*, 2012; Wang *et al.*, 2018; Dasa *et al.*, 2019; Miandad *et al.*, 2019; Molla, Mekuriaw and Kerebih, 2019; Ambaw *et al.*, 2020; Shrestha *et al.*, 2020 and Kahase *et al.*, 2021). This agrees to some extent with the results of the questionnaire presented in this study, which is that the most casualties were for those who live in small houses, houses consisting of 3-5 rooms; families have 3-5 members, average educational level, and people with limited income. Sundry research have proven that workers in health centres; especially physicians and nurses who treat TB patients may be more likely to be infected by TB (Abbas *et al.*, 2010; Costa *et al.*, 2011; Pongwittayapanu *et al.*, 2018 and Liew *et al.*, 2018). In this research paper, it was found that the unemployed are the most vulnerable to being infected by TB. Smoking appears to be one of the factors that stimulate TB bacteria to cause the disease, and this is evident from the questionnaire, which showed that the largest numbers of patients are smokers. This result was reported in the research of Shrestha *et al.*, 2020.

5. Conclusion

TB is considered to be one of the most serious and life-threatening diseases in Libya. Moreover, most people infected by this disease are young men (20-29). It is clear that the factors that have a strong association with stimulating *M. tuberculosis* and increase the cause of TB are poverty and the accompanying living in unsanitary housing, or overcrowding, as well as malnutrition and weak body immunity, also the incidence of other diseases besides TB. Other factors causing the spread of TB among Libyan citizens are the low educational level and lack of knowledge about this disease. In addition to the nature of the career, where the greatest number in the tested sample in this study was unemployed, most of who go to cafes constantly, and practice behaviors that lead to the spread of TB, for instance, smoking. The researchers of this paper concluded to a necessary question; as long as all the Libyan TB patients "in particular" have taken the BCG vaccine; should the World Health Organization urge scientists to develop a new, more effective vaccine?

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