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Original Article

Pulmonary and Extra-Pulmonary Tuberculosis Burden in Southern Libya: A Five-Year Epidemiological Survey at Sebha Medical Center

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ABSTRACT:

Background: Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains a significant public health challenge affecting both pulmonary and extrapulmonary systems. This study investigated the clinical distribution and demographic patterns of TB among hospitalized patients at Sebha Medical Center, highlighting the infection burden in Sebha and its surrounding regions. **Methods:** A descriptive, cross-sectional, laboratory- and radiology-based epidemiological survey was conducted from 2022 to August 2026. The study evaluated 152 confirmed TB cases admitted to Sebha Medical Center. **Results:** Out of 152 patients enrolled, 61.8% presented with pulmonary TB and 19.1% with extrapulmonary TB. Young adults aged 20-35 years constituted the most frequently affected group, accounting for 48.0%. A significant male predominance was observed among notified TB cases, indicating a marked gender disparity. Out of 142 known nationalities, Libyan nationality accounted for 47.4% of cases. High clusters were concentrated in Sebha city. Among the extra-pulmonary manifestations, abdominal/lymph node TB was the most prevalent site (24.1%). Coinfection with HIV/AIDS, HBV and HCV was also documented in this study. **Conclusion:** Tuberculosis is a critical threat in southern Libya, primarily affecting the working-age population. Driven by migration and social mobility, the disease is overwhelmingly pulmonary, posing a severe risk for airborne community transmission. This highlights an urgent need for enhanced screening, robust surveillance, and targeted public health interventions in Sebha.

Keywords: Libya, Sebha, *Mycobacterium tuberculosis*, coinfection, BCG vaccination

Introduction:

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains one of the world's leading infectious causes of death, despite being preventable and curable [1]. According to the World Health Organization (WHO) Global TB Report 2024, TB has re-emerged as the primary cause of death from a single infectious agent globally, surpassing COVID-19, which had previously disrupted diagnostic services and clinical outcomes during the pandemic. The global burden is disproportionately distributed, with adults accounting for approximately 90% of cases and men experiencing higher infection rates than women. In 2023 alone, TB caused an estimated 1.25 million deaths, including 1.09 million among HIV-negative individuals and 161,000 among people living with HIV. Geographically, the disease exhibits significant spatial aggregation, with the highest concentrations of cases in South-East Asia (45%) and Africa (24%) [1].

In Libya, TB has been a persistent public health challenge for centuries, and the country is classified by World Health Organization as a moderate-burden nation. In 2021, an estimated 4,000 cases were detected, translating to an incidence rate of approximately 59 cases per 100,000 individuals [2–4]. While case notifications temporarily declined from 2,209 in 2019 to 1,744 in 2020 due to pandemic disruptions, they rebounded to 1,932 in 2021 across both host and migrant populations. This ongoing transmission is exacerbated by a decade of civil conflict, infrastructure decay, and a massive influx of displaced populations and transnational migrants living in substandard conditions. By January 2021, the International Organization for Migration (IOM) documented over 570,000 migrants in Libya, with 39% residing in severely overcrowded, unsanitary environments with restricted healthcare access—conditions that heavily facilitate the aerosol transmission of *M. tuberculosis*. Given Libya's position as a major transit hub with the longest Mediterranean coastline in Africa, it continuously attracts low- to medium-skilled labor from high-incidence countries, directly influencing the local re-emergence of the disease [5–7]. Recent spatiotemporal mapping of TB trends across Libya revealed that while national incidence peaked in 2015 and hit its lowest recorded levels in 2024, geographical and sex disparities persist; the eastern region reported the highest burden, and males were significantly more affected than females nationwide [8]. This male predominance mirrors that of older localized studies. For instance, an epidemiological comparison between Al-Khums and Tarhuna in 2018, as well as a long-term analysis of Tripoli, Zawiya, and Zuwara spanning 2002–

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2017, consistently demonstrated higher infection rates in men than in women [9]. Moreover, Libya's extensive porous southern borders border African nations with severe epidemics of both TB and HIV, threatening to accelerate regional rates of HIV/TB co-infection, which accounted for 187,000 deaths globally in 2021[10,11]. Migrants traversing these routes face steep healthcare barriers—including language differences, lack of insurance, and cultural disparities—which lead to diagnostic delays and poor clinical outcomes [12].

Crucially, the Fezzan region acts as the primary gateway and transit hub for migration corridors leading from Sub-Saharan Africa (predominantly Niger, Chad, and Sudan) through informal borders into northern Libya and Europe. Sebha**,** the largest city in Fezzan, sits at the epicentre of this route. As Sebha Medical Center (SMC)is the apex tertiary healthcare institution in southern Libya, the vast majority of local acute TB cases, both migrant and non-migrant, are admitted here for initial stabilization and treatment before being transferred to the National Center for Disease Control (NCDC) in Sebha for long-term follow-up.

Despite its critical epidemiological positioning, localized research on the precise dynamics of tuberculosis (TB) in southern Libya remains sparse. To address this data gap, this study investigates the demographic characteristics and clinical distribution of pulmonary and extra-pulmonary TB among patients admitted to the Sebha Medical Centre (SMC)**.** Furthermore, we evaluate the prevalence of critical metabolic and infectious comorbidities within this cohort, specifically focusing on Diabetes Mellitus (DM), HIV, Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV).

Materials and Methods

Study Design and Setting: The study population comprised 152 confirmed cases of tuberculosis (TB) admitted to the center between 2022 and August 2026**.**

Data collection: Demographic and clinical data for all enrolled patients were retrospectively extracted from the official medical records. The collected parameters included: demographics **(**Age, gender, residence, and nationality), clinical characteristics and presence of comorbidities. Ethical approval was obtained from the Research Ethics Committee of SMC.

Laboratory confirmation*:* Sputum samples were collected from individuals suspected of having pulmonary TB. Diagnostic confirmation was performed using the GeneXpert system at the National Center for Disease Control (NCDC) in Sebha. Specifically, the Xpert MTB/RIF Ultra Assay was utilized on the GeneXpert Instrument System. This assay is a semi-quantitative, nested real-time polymerase chain reaction (PCR) *in vitro* diagnostic test designed for the rapid detection of *Mycobacterium tuberculosis* DNA and rifampicin resistance. For extra-pulmonary TB (EPTB) manifestations (such as abdominal TB, psoas abscesses, and vertebral involvement), diagnostic confirmation was established through a multidisciplinary approach. This included microscopic and biochemical analysis of aspirated fluids as well as characteristic Radiological findings on ultrasound, X-ray, and Computed Tomography (CT) scans.

Statistical analysis:

Statistical analysis was performed using **t**he Statistical Package for the Social Sciences **(**SPSS)**.** Categorical variables were expressed as frequencies and percentages. The chi-square (X^2) test was used to assess the statistical associations between demographic factors. A *p*-value of < 0.05 was considered statistically significant.

Results:

Tuberculosis (TB) remains a major public health challenge in developing countries, including Libya, where comprehensive epidemiological data is frequently lacking. This deficiency is particularly pronounced in southern Libya, where the scarcity of reliable data on the prevalence of *M. tuberculosis* infections obscures the true disease burden. Consequently, this study aims to highlight the severity of the TB situation in the region. Epidemiological data were collected from 152 clinical cases admitted to the Sebha Medical Center between 2022 and August 2026.The patient cohort comprised diverse nationalities with suspected TB infections: 72 Libyans (47.4%), 28 Nigeriens (19.7%), 19 Sudanese (13.4%), 17 Chadians (12%), 2 Eritreans (1.4%), and 1 case each from Senegal, Syria, Palestine and Mauritania (0.7% each). Nationality records were missing for 10 cases (6.6%); therefore, all percentages were calculated compared to the total known nationalities **(Table 1).** The patient population is heavily skewed toward young-to-middle-aged working adults. The sample exhibits a highly significant age concentration ($p < 0.0001$), with nearly half of the cohort clustered within a single 15-year range; specifically, the 20-to-35 age bracket accounts for 48.0% (n = 73) of the total population. The remaining participants are distributed across the 36-to-50 group (27.0%, n = 41), the over-50 group (16.4%**,** n = 25), and the under-20 cohort (8.6%, n = 13). Furthermore, the data showed a stark gender disparity, with TB being significantly more prevalent in males (80.9%, n = 123) than in females (19.1%, n = 29) with a sex ratio (M: F) of 4.24: 1 (**Table 1).**

Table 1: Epidemiological Profile of TB Cases (N=152)

Demographic Category		Patient count	Percentage
	Male	123	80.9%

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Gender	Female	29	19.1%
Nationality (n=142)	Libyan	72	47.4%
	Nigerien	28	19.7%
	Sudanese	19	13.4%
	Chadian	17	12%
	Eritrean	2	1.4%
	Senegalese	1	0.7%
	Syrian	1	0.7%
	Mauritanian	1	0.7%
	Palestinian	1	0.7%
	Missing	10	6.6%
Age Groups	Under 20	13	8.6%
	20 to 35 years	73	48.0%
	36 to 50 years	41	27.0%
	Over 50 years	25	16.4%

Note: Nationality was missing for 10 patients, so the total known nationalities are 142 cases

In this research, the Demographic characteristics of pulmonary and extra-pulmonary TB were also studied. The incidence of Pulmonary TB was 94 cases out of 152 (61.8%), while extra-pulmonary TB was observed in 29 (19.1%) cases. In this study, 29 cases of TB (19.1%) showed both PTB and EPTB (**Figure. 1**).

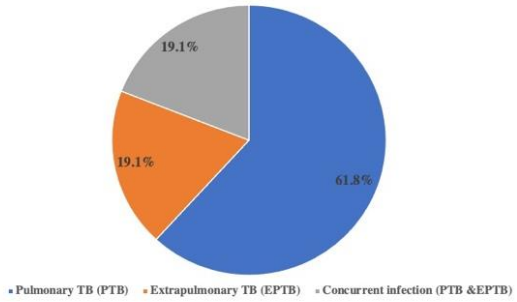


Figure 1: Percentage of pulmonary tuberculosis (PTB) and extrapulmonary tuberculosis (EPTB) among the sample

A total of 58 patients presented with extra-pulmonary tuberculosis (TB) across various anatomical sites. The most prevalent manifestation was Abdominal / Lymph node TB**,** affecting 14 patients (24.1%)**.** Pleural effusion was identified in 10 patients (17.2%)**,** while musculoskeletal involvements including psoas abscess, vertebral TB, and Pott's disease were observed in 9 patients (15.5%)**.** Miliary TB was reported in 8 patients (13.8%)**.** The least common presentation in this cohort was meningeal TB**,** which was documented in 5 patients (8.6%); see **Table2**.

Table 2: Distribution of Extrapulmonary TB Cases (N=58)

Anatomical site	**Patient count (n)**	**Percentage (%)**
Abdominal / Lymph node TB	14	24.1%
Pleural Effusion	10	17.2%
Psoas Abscess/vertebral / Pott's Disease	9	15.5%
Miliary TB	8	13.8%
Meningeal / CNS TB	5	8.6%

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Another Extra-pulmonary site	12	20.7%
Total	58	100.0%

Demographic characteristics of pulmonary (PTB) and extrapulmonary (EPTB) groups according to age groups were also studied in this research, and more details are found in **Table 3.**

Table 3: Demographic characteristics of pulmonary (PTB) and extrapulmonary (EPTB) groups according to age groups

Age group (Y)	**PTB (n=94) (61.8%)**	**EPTB (n=29) (19.1%)**	**PTB & EPTB(n=29) (19.1%)**	**Total (N=152) (100.0%)**
Under 20	8	3	2	13
20–35	44	11	18	73
35–50	26	9	6	41
Over 50	16	6	3	25

Pulmonary Tuberculosis is the most common presentation in this cohort, accounting for 61.8% (94/152) of all recorded cases. The total patient load is almost equally split between Libyan nationals **(**47.4%, n=72**)** and non-Libyan migrants **(**46.1%, n=70**).** Non-Libyan migrants presented with a slightly higher proportion of Pulmonary TB **(**48.9%, n= 46/94**)** compared to Libyans **(**44.7%, n= 42/94**).** Conversely, Libyan patients made up the majority of both Extrapulmonary TB (50.0%**)** and mixed (PTB & EPTB) presentations (54.5%**) (Figure 2).**

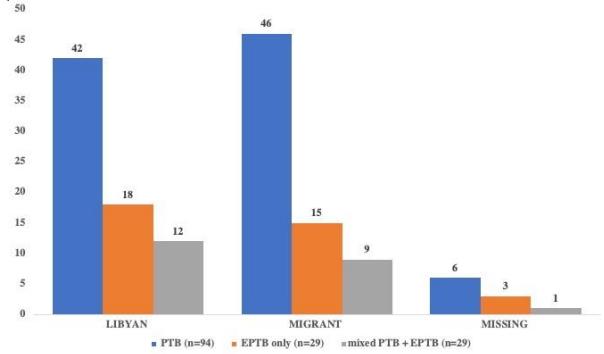


Figure 2: Classification of Tuberculosis Types Across Local and Migrant Populations.

The Pearson Chi-Square test yields *p* value > 0.05 that means there is no statistically significant evidence between anatomical site of EPTB and nationality within this cohort. Geographical tracking demonstrated prominent variations in TB distribution throughout Fezzan, heavily concentrated in Sebha **(**48%, n= 73**),** Ubari **(**11.8%**,** n= 18**),** and Qatrun **(**7.2%, n=11**).** The populations within correction and rehabilitation facilities and prisons also represented a prominent subcohort **(**16.4%**,** n= 25). Peripheral areas accounted for the remaining cases: Murzuq (6.6%**,** n=10**),** Wadi Alshatti (3.9%, n=6), Um Al-Araneb (2.6%, n=4**),** Ghat and Traghan **(**1.3%, n=2**)** each, Al-Jufra (0.7%, n=1**) (Figure. 3).**

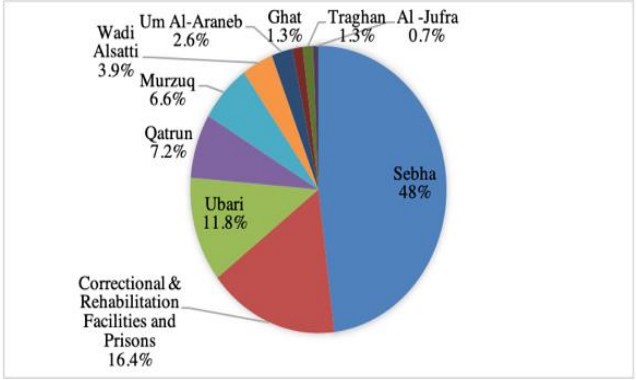


Figure 3: Percentage of tuberculous patients across different Fezzan.

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Crucially, localized screening highlighted distinct ethnic and structural vulnerabilities, capturing 25 Tuareg patients within Sebha and Ubari**.** This study also evaluated the prevalence of comorbidities within the patient sample. The vast majority of the sample, representing **(**86.2%**,** (n = 131), had no recorded comorbidities. Overall DM in this study was observed in 13/152 (8.6%), and strictly concentrated within three specific cohorts, Libyan, Sudanese and Chadian. HIV/AIDS was documented in **(**4.6%, n = 7) of the cohort. 3 Libyan patients have coinfected with HIV, 2 Chadian patients, one Sudanese and one Nigerien have HIV coinfection **(Table 4).**

Table 4: Distribution of TB Comorbidities Among Patients from Four Selected Nationality Groups (N = 136)

Nationality	Total number	Diabetes mellitus	HIV/AIDS	HBV	HCV
Libyan	n=72	10 (13.9%)	3 (4.2%)	1 (1.4%)	1 (1.4%)
Sudanese	n=19	2 (10.5%)	1 (5.2%)	3 (15.8%)	0 (0.0%)
Chadian	n=17	1 (5.9%)	2 (11.8%)	0 (0.0%)	0 (0.0%)
Nigerian	n=28	0 (0.0%)	1 (3.6%)	0 (0.0%)	0 (0.0%)

Note: The other nationalities have no comorbidities with TB; therefore, they were excluded from this table.

Among the cohort of 25 tuberculosis (TB) patients identified within the correction, rehabilitation, and prison facilities, active viral coinfections were documented in several cases. Human immunodeficiency virus (HIV) coinfection was detected in three individuals, comprising one Libyan, one Chadian, and one Sudanese national. Furthermore**,** HBV coinfection was confirmed in four patients, 4/152 (2.6%), affecting three Sudanese nationals and one Libyan national. HCV coinfection was observed in a single case 1/152 (0.7%).

Discussion:

Tuberculosis (TB) remains a major global public health challenge and a significant cause of mortality, particularly among immunocompromised populations such as individuals living with HIV. Despite its global impact, there is a general lack of comprehensive data on *Mycobacterium tuberculosis* in Libya as a whole, and within its southern cities specifically. The highest risk period for acquiring a TB infection typically spans adolescence and early adulthood, a trend largely attributed to a wider network of social contacts outside the household [13]. In the present study, the 20–35 age cohort was overwhelmingly affected, accounting for 48.0% of cases. This aligns with established trends indicating that active, working-age individuals face higher risks due to greater mobility and increased social interaction. Our finding is supported by other established trends indicating that active, working-age individuals face higher risks due to greater mobility and increased social interaction [14]. Additionally, our data revealed a substantial gender disparity, with males representing 80.9% of clinical cases. This stark difference highlights a massive demographic imbalance that may be linked to occupational exposure or regional migration dynamics. This finding concurs with previous research reporting higher TB infection rates in males than in females, [8, 15, 16], though it contrasts with other studies that documented a higher prevalence among females [17-18].

Furthermore, we could also observe in this study that TB infection rate was higher among Libyan patients than foreign nationals **(**47.4%), consistent with findings reported by Faisal [14]. Nevertheless, non-Libyan nationals accounted for 46% of the observed cases, reflecting regional migration patterns from neighboring Sub-Saharan African nations and the broader region.

In terms of clinical manifestation, the incidence of pulmonary TB **(**61.8%**)** was higher than extra-pulmonary TB. This outcome mirrors numerous TB studies documenting that pulmonary manifestations generally exceed extra-pulmonary cases [19–21]. However, this finding contrasts with research by other authors who noted an increase in extra-pulmonary tuberculosis over their respective study periods [18]. EPTB can be detected in any organ system, including the lymph nodes, pleura, urogenital tract, abdomen, bones, meninges, and central nervous system (CNS), or it may present in disseminated or miliary forms [22]. In this study we found that abdominal lymph node TB represented the highest rate **(**24.1%**)** of all extra-pulmonary cases in this cohort. Although tuberculosis of the central nervous system (CNS TB) is an uncommon consequence of *M. tuberculosis*, it represents the most severe manifestation of the disease, demanding immediate clinical attention due to its rapid progression and high risk of permanent neurological damage [23]. Our findings highlight that tuberculous meningitis (TBM) accounted for 8.6% of EPTB. This prevalence of TBM may be attributed to several compounding factors, including localized living environments, unequal access to healthcare infrastructure, and historical variations in national Bacillus Calmette-Guérin (BCG) vaccination programs that significantly dictate clinical severity [24]. These combined challenges frequently result in prolonged delays in healthcare-seeking behavior. Consequently, diagnosis is often delayed until the pathogen has already disseminated into critical extrapulmonary forms like TBM.

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The intersection of Tuberculosis (TB) and Diabetes mellitus (DM) represents a critical global health challenge that is strongly associated with poor therapeutic outcomes [25-26]. Clinically, DM nearly doubles the risk of mortality while significantly elevating rates of treatment failure and relapse. This heightened susceptibility is primarily driven by DM-induced alterations in both innate and adaptive immune responses [27,28]. Within the present study's TB cohort, 13 patients presented with comorbid DM**;** 10 of these individuals were Libyan nationals, while the remaining were of other nationalities.

HIV co-infection substantially elevates the risk of developing active TB by 12 to 20 times compared to individuals without HIV. The prevalence of TB-HIV co-infection is well-documented globally [29,30]. Conversely, the chronic immune stimulation resulting from active TB accelerates HIV/AIDS disease progression; consequently, tuberculosis remains the leading cause of death from an infectious agent among people living with HIV/AIDS worldwide. The clinical management of tuberculosis (TB) is increasingly complicated by syndemic interactions with viral pathogens, most notably HIV, HBV, and HCV [31]. In the present study, the detection of seven cases of TB/HIV co-infection**,** alongside observed HBV and HCV co-infections, highlight a critical intersection of infectious diseases within the population, emphasizing the need for targeted comprehensive screening and integrated therapeutic strategies.

Prisons face a major TB crisis, with infection rates 10 times higher than outside communities. This rapid spread is driven by crowded cells, poor ventilation, and weak medical infrastructure [32-35]. Our study found 3 patients with both TB and HIV, highlighting how common and dangerous this co-infection is in correctional facilities.

Libya made the BCG vaccine mandatory for all newborns in 1971, establishing itself as the first nation to implement the vaccine on a massive scale through a single intradermal dose [36]. While most of the infected patients in this study were Libyan, it remains unknown whether these specific individuals had actually been vaccinated. The ability of the BCG vaccine to stimulate T-cell responses and provide long-term protection against tuberculosis varies significantly from person to person and across different environments [37]. This biological variability, combined with external factors that alter individual vaccine efficacy, explains why certain individuals within a mandated population can still contract tuberculosis. A significant cluster of infected patients was identified within the Tuareg community residing in Ubari and Sebha's Al-Tayuri neighborhood. Al-Tayuri's large Sub-Saharan migrant population creates unique environmental and social dynamics. Consequently, further epidemiological investigations are recommended to determine how these specific socio-demographic and structural conditions influence the spread of the disease. Furthermore, the public health sector must closely oversee vaccination efforts within this community while actively improving the accessibility of treatment.

Conclusion:

This study provides critical insights into the epidemiological profile of *Mycobacterium tuberculosis* in the understudied region of southern Libya. The findings reveal that tuberculosis remains a significant public health threat, primarily impacting the active, working-age demographic. These demographic trends underscore the roles that social mobility, occupational exposure, and regional migration dynamics play in driving transmission. Clinically, the overwhelming predominance of pulmonary TB over extrapulmonary forms emphasizes the high potential for ongoing community transmission via aerosol droplets. Consequently, the findings of this study highlight the need for urgent public health interventions, enhanced diagnostic screening, and robust surveillance frameworks in the Sebha region

Recommendation:

- **Institutional Screening:** Screen inmates at entry, isolate active cases, and optimize cell ventilation to prevent outbreaks.
- **Co-infection Management:** Standardize universal, mutual screening and integrated treatment for TB, HIV, and viral hepatitis.
- **Epidemiological Research:** Investigate BCG vaccine efficacy and why vaccinated individuals still develop active TB.
- **Community Interventions:** Deploy culturally tailored education to reduce stigma, overcome language barriers, and speed up detection

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