



Epidemiology and Control Strategy of Tuberculosis at Guelma Province of Northeastern Algeria

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Abstract

Background: Tuberculosis (TB) is a severe infectious disease that has significant adverse effects on the human body. In recent years, TB infections have re-emerged, with numerous cases recorded in various regions worldwide. This poses a major public health challenge for healthcare agencies. **Objective:** We aim to analyze positive cases recorded in the "TB Diseases Statement Register," understand the epidemiology of TB, and assess its evolution. **Methodology:** This retrospective study was conducted in Guelma Province, northeast Algeria, from 2010 to 2013. Over the past decades, TB infection rates in Guelma have shown a bell-shaped fluctuation trend. **Results:** The disease primarily affects adults aged 16 to 45 years. A significant difference was observed in infection rates based on geographical location, sex, age, and the bacterial site of infection (internal versus external pulmonary). **Conclusion:** Despite the implementation of the TB-DOTS (Tuberculosis Directly Observed Treatment Short-course) program in Algeria to control the disease, new strategies should be adopted to further reduce TB cases. [Bangladesh Journal of Infectious Diseases, June 2026;13(1):8-13]

Keywords: epidemiology; Guelma; public health; TB-DOTS; tuberculosis

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Introduction

Tuberculosis (TB) is an infectious and contagious disease caused by *Mycobacterium tuberculosis* (MB) with human-to-human transmission; it spreads through the air¹. Humans are the only reservoir of tuberculosis, enabling the transmission of this disease from an infectious subject to a healthy person². It can affect all organs except the skin, hair, and nails^{3,4}. The most common form is pulmonary tuberculosis inside lung, which is also the only contagious form of the disease^{2,3}. Despite numerous anti-TB strategies, it remains a

public health problem for a large portion of the global population^{5,6}. Over one-third of the global population is infected with the Koch bacillus². According to the annual report of the World Health Organization, in 2024, 1.4 million persons exterminated by tuberculosis⁷. Several periods in the evolution of the epidemiological situation of tuberculosis have been identified, corresponding to socio-economic changes or shifts in disease management^{8,9}. After that, there is a significant reduction in the annual risk of TB infection, the number of cases has slowed and started to

stabilize¹⁰. From 1990 onwards, the trend in tuberculosis incidence stagnated and then increased¹¹.

One of the main factors driving the tuberculosis epidemic is the emergence and spread of drug-resistant (MDR-TB and TDR-TB), both in new cases and previously treated patients' prevention and control¹², by adopting new approaches and strategies for combating the infection.

Actually, tuberculosis remains a diagnostic challenge. This is partly due to the non-specific nature of symptoms, which are often overlooked by patients and insufficiently analyzed by practitioners⁸. The definitive diagnosis of TB requires demonstrating *M. tuberculosis* bacilli through microbiological, cytopathological, or histopathological methods¹³. The diagnosis of pulmonary tuberculosis (PTB) and extrapulmonary tuberculosis (EPTB) is based on the isolation of tubercle bacilli through direct sputum smear examination or the culture of mycobacteria from the tuberculosis complex⁸. The diagnosis of extrapulmonary tuberculosis is more complex, often requiring invasive procedures to obtain material like bone biopsy, cerebrospinal fluid, liver biopsy^{8,14}.

Optimal management of pulmonary tuberculosis cases can significantly reduce the disease's contagiousness and the emergence of multidrug-resistant strains¹⁵. The recommended duration of treatment for pulmonary tuberculosis is six months¹³. For extrapulmonary tuberculosis, the treatment duration depends on the location of the disease and the patient's immune status. It ranges from six to 12 months, but in some cases, it can extend to 18 months¹⁶. Recent experimental studies recommended the intermittent administration of anti-TB medications to obtain a better result. Since then, most countries have adopted the WHO-endorsed standardized treatment regimens, either daily or thrice-weekly intermittent, as part of their National TB Control Programs¹³.

This study aimed to assess the epidemiological profile of tuberculosis cases in Guelma Province (2010 - 2023). Additionally, we focus on analyzing the trend of TB cases over the last decade to understand the evolution of the disease better and propose effective control strategies.

Methodology

Study Area: Guelma province (36° 27' 43.70" N - 7° 25' 33.89" E) is a city in northeastern Algeria, located 60 km from the Mediterranean Sea, 100 km from the metropolitan city of Constantine, and 150

km from the Tunisian border (Figure I), and covering an area of 3686 km² with a population of 570.114, resulting in an average population density of 155 inhabitants per km² in 2021¹⁷. It is situated in the center of the northeastern part of the country, linking between the coastal cities in north (Annaba and Skikda) and the hauts-Plateaux cities in the south (Oum El-Bouaghi and Souk Ahras).

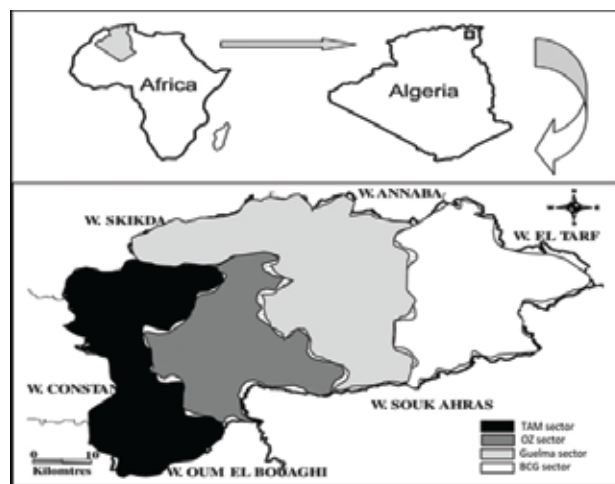


Figure I: Geographical situation of the study area (Guelma province, northeast Algeria). Four healthcare sectors, TAM: Tamlouka, OZ: Oued-Zenati, Guelma and BCG: Boucheougouf

Study Settings and Population: Data on tuberculosis (TB) cases were collected from 2010 to 2023 in Guelma Province. These cases were documented in the "TB Diseases Statement Register" obtained from the Tuberculosis and Respiratory Diseases Control Service. A systematic and retrospective study was conducted; the dataset extracted from the fourth healthcare sector was arranged as a matrix¹⁸.

Study Procedure: In terms of the healthcare organizational structure, Guelma Province is divided into four healthcare sectors like Guelma sector (Guelma), Boucheougouf sector (BCG), Oued-Zenati sector (OZ), and Tamlouka sector (TAM). A tuberculosis (TB) case was included in this study and added to the dataset only if the patient's sputum sample tested positive for *Mycobacterium tuberculosis* (MB-positive) using standardized Ziehl-Neelsen specific staining procedures¹⁹. Data collection was conducted in accordance with an ethical protocol, ensuring the anonymity of patients' personal information. Four deterministic factors related to TB-positive patients were analyzed, sex (male or female), age group (0 to 15 years, 16 to 30 years, 31 to 45 years, 46 to 60 years, ≥60 years), TB localization (extrapulmonary

or pulmonary), and the patient's healthcare sector (Guelma, BCG, TAM, OZ).

Statistical Analysis: A significance level (α) of 5% was considered for all analyses. The data were organized into a matrix based on the four deterministic factors: sex, age group, TB localization, and the patient's healthcare sector. The seasonal Mann-Kendall test was applied to identify trends associated with the annual variation of TB cases. Additionally, Sen's slope estimator was calculated to determine the magnitude of the observed trend²⁰. The Kruskal-Wallis and Mann-Whitney tests were applied to compare TB cases across the four factors. Statistical analyses were performed using XLSTAT 2014.5.0321.

Ethics Statement: All procedures of the present study were carried out in accordance with the principles for human investigations (i.e., Helsinki Declaration 2013) and also with the ethical guidelines of the Institutional Research Ethics Committee. Formal ethics approval was granted by the local ethics committee. Participants in the study were informed about the procedure and purpose of the study and confidentiality of information provided. All participants consented willingly to be a part of the study during the data collection periods. All data were collected anonymously and were analyzed using the coding system.

Results

Timeline series of tuberculosis cases: The trend of tuberculosis cases in Guelma during these last decades follows a bell-shaped curve. The maximum number of cases recorded in this province was 522 cases in 2015. The number of cases never dropped below 200 cases (2010 to 2023). But, the trend of TB cases progresses randomly and did not follow an exponential function (Figure II). The mean number of TB cases recorded during the study period was 324 ± 69 . Tuberculosis cases in the Guelma province (2010 to 2023) did not exhibit an annual trend. Instead, the trend of reported cases fluctuated unpredictably throughout the study period (Kendall's tau = -0.309, p-value = 0.1387). The annual progression of tuberculosis cases followed a bell-shaped curve (Sen's estimator = -5.08, confidence interval [-54.2; 51.5]) (Figure II).

We observed a significant difference in tuberculosis cases recorded during our sampling between men and women (Mann-Whitney test: $U = 2$, p-value < 0.0001) and based on the location of the bacteria within the body (external vs. internal lung) (Mann-Whitney test: $U = 2$, p-value < 0.0001).

Additionally, tuberculosis cases in Guelma province varied significantly based on the patient's age (Kruskal-Wallis test: $K = 58.6$, p-value < 0.0001) and their geographical locality (Kruskal-Wallis test: $K = 49.97$, p-value < 0.0001).

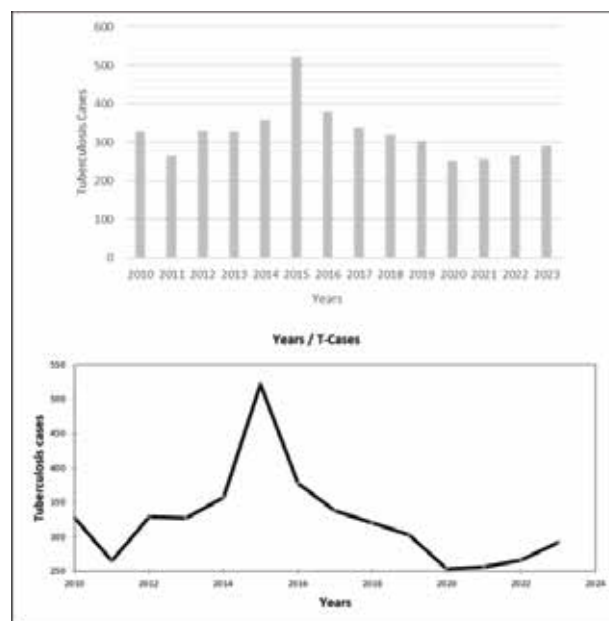


Figure II: Annual progression of tuberculosis cases in Guelma province (2010-2023)

Social characterization of Tuberculosis cases

Age Group Distribution: According to the results obtained, two significant peaks are observed in the age group of 16 to 30 years, with 1,549 cases, accounting for 34.2% of the cases. This is followed by the 31 to 45 years age group, with 1,236 cases, representing 27.3% of the total. In contrast, the lowest number of tuberculosis cases was recorded among individuals under 15 years old (0 to 15 years), with 387 cases, or 8.5% of the total (Figure III).

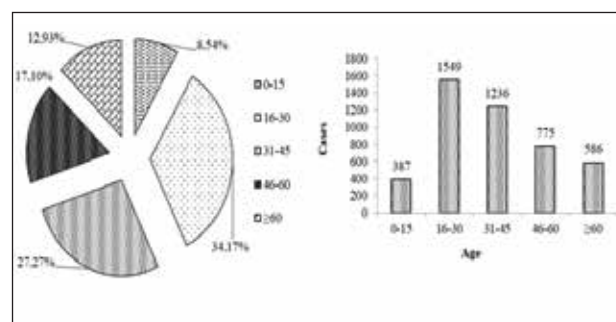


Figure III: Distribution of tuberculosis cases in Guelma province (northeast Algeria) according to age of patient

Gender Distribution: Among the 4,533 people with tuberculosis, females are the most affected, accounting for 2,864(63.2%) cases, while males account for 1,669(36.8%) cases, resulting in a sex ratio of 0.58 (Figure IV).

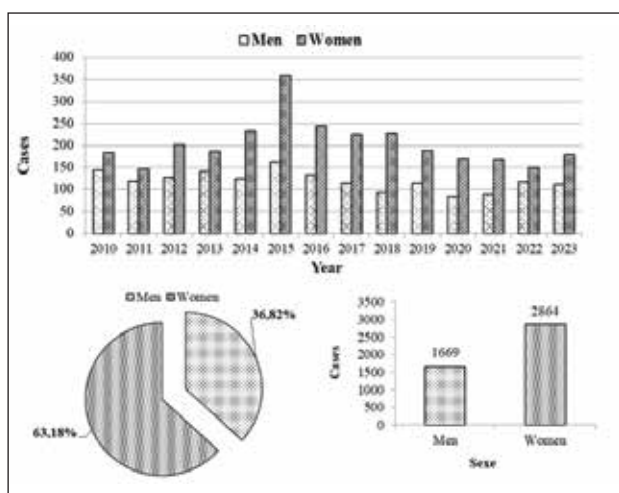


Figure IV: Showing tuberculosis cases in Guelma province (northeast Algeria) according to sex of patient

Patient's Locality: The results indicate that the sector with the highest number of tuberculosis cases is the Guelma sector, with 2,766 cases, accounting for 61.0% of the total. It is followed by the Bouchegouf sector, with 913(20.1%) cases, and the Oued Zenati sector in third place, with 632(13.9%) cases. The lowest number of cases was recorded in the Tamlouka sector, with 222(4.9%) cases (Figure V).

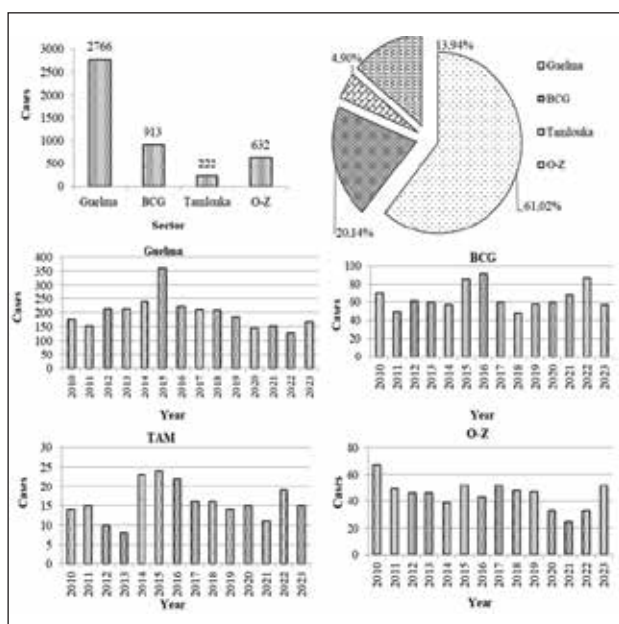


Figure V: Showing tuberculosis cases in Guelma province (northeast Algeria) according to sectors

Discussion

The major part of tuberculosis cases in Guelma Province (northeast Algeria) were reported among women aged 16 to 45 years. The primary hotspot for the disease was identified in the Guelma sector (the county town), which also exhibits the region's highest population density. Carcione et al²² highlighted that isolation measures play a critical role in reducing the spread of epidemics. Furthermore, according to the World Health Organization²³, Algeria has implemented the DOTS program under “Category 4 – Full Coverage” as part of its tuberculosis control strategy. Despite the implementation of tuberculosis (TB) control programs by the health department and policymakers, a significant number of cases continue to be recorded annually. For instance, during this study conducted in Guelma, more than 200 cases were reported each year starting in 2010 (cumulative effect), with the number showing a positive trend of increase annually. Dye²⁴ reported that Africa has the highest estimated incidence rate, at 356 per 100 000 population per year; in Guelma province, our data show that the average of cases recorded between 2010 and 2023 is 323 ± 68 cases per year.

In Guelma Province, TB cases are likely underestimated. The confirmed TB-positive cases reported in this study highlight the need for an effective action plan to reduce infection rates. Additionally, we suppose that the peak in cases recorded between 2014 and 2015 may be linked to climatic conditions in Guelma, which could favor the dispersal of *Mycobacterium tuberculosis*²⁵. Moreover, large-scale screening efforts may have significantly influenced the number of cases detected²⁶.

The critical situation is primarily attributed to the absence of compulsory screening for tuberculosis (TB). The confirmed cases recorded during this study were largely the result of necessary screenings conducted in response to severe symptoms presented by patients. The probability of TB incidence during the first examination contact between the patient and doctor is often excluded in the general case. Despite its widespread prevalence, tuberculosis (TB) infection continues to progress silently and rapidly in shared spaces such as schools, dormitories, and workplaces. This issue is primarily due to a lack of clinical awareness. TB, whether affecting the lungs externally or internally, is highly contagious²⁷, making thorough examination and screening essential. However, the cough associated with TB can often be mistaken for symptoms of other conditions. As a result, TB screening is not routinely practiced, despite its cost-effectiveness and the importance of patient compliance²⁸.

Adults (≥ 16 years) are more exposed to tuberculosis (TB) than other age groups⁹. Our findings suggest that individuals under 30 are particularly prone to contracting this infection. Bhardwaj et al²⁹ also noted that people under 35 are more frequently exposed to TB. The majority of TB cases, approximately 90.0%, occur in adults aged 16 and older, with over 50.0% of these cases affecting locations outside the lungs. In terms of gender, Natarajan et al⁸ and Mounchili et al⁹ observed that males are more commonly affected by TB. In Guelma, the incidence rate of tuberculosis is higher among females than males. This gender inequality may be attributed to the social dynamics of Algerian society, where females frequently engage in close-contact gatherings within households, potentially facilitating the transmission of tuberculosis.

Conclusion

Urgent control strategies and action plans are highly recommended in Algeria to curb the progression of tuberculosis. Implementing self-acting screening programs is essential due to the complex character of this infection. Additionally, further epidemiological studies across other regions of the country are needed to provide a comprehensive overview of disease progression and to develop an effective control strategy.

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Conflict of interest:

The authors declare no conflict of interest. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Financial Disclosure

The author(s) received no specific funding for this work.

Authors' contributions

This study follows an ethical approach during data sampling, data analysis and proof writing. MR: Concept, Design and Manuscript preparation. FD and AB: data acquisition and experimental studies. MH: Concept, Design and Manuscript Review. MB: Design, Data analysis and Manuscript Editing. This article has been read and approved by all the authors.

Data Availability

All data that support the findings of this study are included within the article.

Ethics Approval and Consent to Participate

Ethical approval for the study was obtained from the Institutional Review Board. As this was a prospective study the written

informed consent was obtained from all study participants. All methods were performed in accordance with the relevant guidelines and regulations.

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