

Impact of Meteorological Parameters on Distribution of Pulmonary Tuberculosis in the City of Yaoundé, Centre Region of Cameroon

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Abstract: Tuberculosis remains a major health problem and particularly in the Centre Region of Cameroon where prevalence is still high in the city of Yaoundé. Climate has been proved to have impact on tuberculosis distribution. This study aimed at assessing possible association of TB notifications with some meteorological parameters. Daily, weekly, monthly and quarterly aggregates of tuberculosis diagnosis results for consecutive tuberculosis patients tested over one year (April 2010 until March 2011) at Jamot Hospital of Yaoundé were analysed (Microsoft excel and SPSS). A total of 665 tuberculosis patients were enrolled at the Jamot Hospital of Yaoundé during the study period. Weekly mean humidity and temperature were related to tuberculosis cases with respectively Pearson correlation coefficients of 0.291 and -0.342 even though the relation was weak. For the relationship magnitude 8.5% and 11.7% of the variance in tuberculosis cases were explained by weekly mean humidity and temperature respectively. A Poisson regression predicted more tuberculosis cases following weekly increase of humidity, a statistically significant result with $p < 0.001$. There was 12.1% decrease in the number of tuberculosis cases for each decrease of temperature per week. However, rainfall had no impact on tuberculosis notifications even though most cases were recorded in rainy season while seasonal index changed over time. In short, tuberculosis notifications showed to be associated to two meteorological parameters: mean ambient temperature and relative mean humidity. The highest peak was in the month of June during the rainy season. Data from this work may contribute to the National Tuberculosis Control Program to model tuberculosis variation from recorded tuberculosis notifications since years in order to find an indicator for better intervention strategies for disease control.

Keywords: Meteorological Parameters, Tuberculosis, Yaoundé

1. Introduction

Tuberculosis (TB) remains a major global health problem. In 2015, an estimated 10.4 million people developed TB and 1.8 million died from the disease. The case fatality ratio (the global proportion of people with TB who die from the disease) varied from under 5% in a few

countries to more than 20% in most countries in the WHO African Region [1]. Cameroon is a country with high TB incidence [2] with a high prevalence in the city of Yaoundé (17%) [3]. Due to the burden of TB, some factors has been shown to be linked to it spread like spatiotemporal changes [4]. Many studies have already been conducted to investigate the influence of climate in the evolution of TB

in many countries since it is a respiratory infectious disease which shows seasonality [5, 6, 7, 8, 9, 10]. In Cameroon, a similar study was done in the Southern South Western Region of Cameroon in 2006 [11]. Seasonal distribution in TB notifications has been confirmed, offering a variety of possible explanations for the findings [6]. When planning interventions to control a disease, it is essential to understand the burden of the disease [12] and epidemiological reports on the burden of active pulmonary TB patients according to climate and for instance meteorological parameters are scarce in Yaoundé. Indeed, climate in the South-West Region of Cameroon is different from the one in the city of Yaoundé (Centre Region of Cameroon) which is equatorial. It is characterized by the alternation of two dry seasons (long dry season from mid-November to mid-March and a short dry season from July to August) and two rainy seasons (one from mid-March to June and another rainy season from September to mid-November) with an average temperature of 24.3°C from 2000 to 2009, contrast between 16 and 31°C depending on the season and 1407.3 mm of water per year are recorded (data from Department of Meteorology in Yaoundé) not far from what had been reported before [13].

A deep understanding of temporal patterns in disease occurrence and its governing principles is valuable for designing preventive programs for disease control, tracking effectiveness of public health programs, and allocating scarce resources. Understanding the temporal patterns in

disease occurrence is valuable for formulating effective disease preventive programs [7]. In the absence of reliable data on TB linked to climate in Yaoundé, a research study must be undertaken in order to plan efforts against this threat. To our knowledge, no study has described the seasonality of TB in Yaoundé, therefore, the present investigation aimed to assess the impact of meteorological parameter variability on the distribution of pulmonary tuberculosis in Yaoundé in a period of one year as a pilot project.

2. Methodology

Type, duration and scope of the study

It was a descriptive cross-sectional study for 12 months period from April 2010 to March 2011 in which all the sputa of suspected volunteer patients with pulmonary tuberculosis from the Jamot Hospital of Yaoundé were analysed.

2.1. Location of Study

Yaoundé is the political Capital of Cameroon with 2,375,460 inhabitants and is located in the Centre Region. The climate is characterised by two peaks of rainy seasons in May and October following data from the last ten years (Figure 1). We chose Jamot hospital (Latitude: 3.900092N, Longitude: 11.521117E) as our study area since it is reference centre for respiratory diseases in Yaoundé.

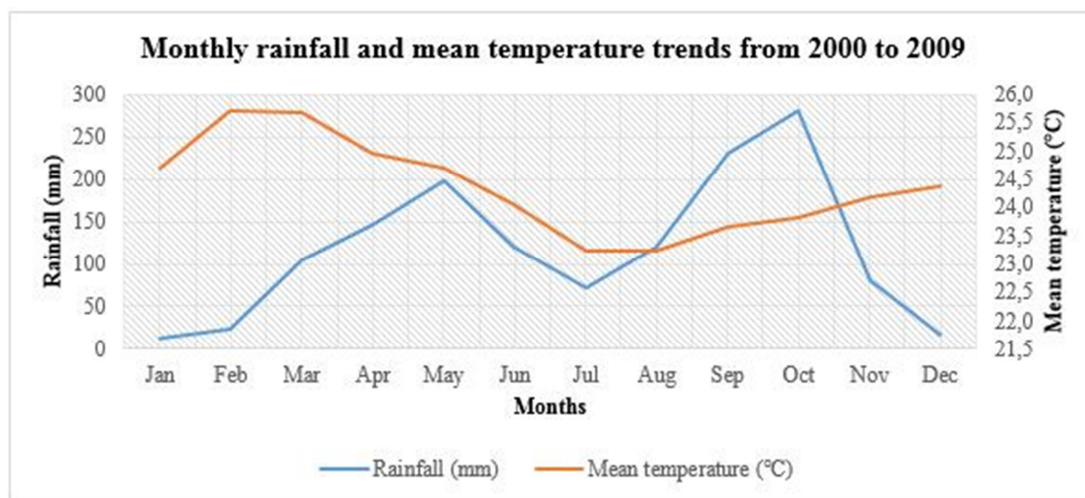


Figure 1. Rainfall and mean temperature trends in Yaoundé from 2000 to 2009 (Cameroon Ministry of Transport, 2009) [14].

2.2. Target Population

Our study population consisted of all TB suspects fulfilling the conditions defined below:

Inclusion criteria: it was included in this study sputa of pulmonary tuberculosis suspects of 15 years and older, who agreed to participate in the study.

Non-inclusion criteria: It was not included in this study sputa of TB suspects under the age of 15 years or those over 15 years who refused to give their consent.

2.3. Ethical Consideration

This study was in accordance with the ethical standards of the institutional ethics committee. Hence, Ethical Clearance N°126/CNE/SE/09 and an Administrative Authorization N°631.7-10 were respectively obtained from the Cameroon National Ethic Committee and the Cameroonian Ministry of Public Health. All data collection activities were carefully explained before and during the study. Signed informed written consent was obtained from

each enrolled patient who did not incur any cost for processing of the samples.

2.4. Data Collection and Processing

Data on rainfall (mm), mean temperature (°C) and relative humidity (%) between 1st April 2010 and 1st April 2011 were collected from Department of Meteorology which is accredited for meteorological data collection, documentation and dissemination (Ministry of Transport, Cameroon) at the Station: Yaoundé, Latitude: 3°50' N Longitude: 11°31' E Altitude: 760,0 M.

Socio-demographic and clinical data were collected from all registered individuals for diagnosis. The handling of sputa was done by Ziehl-Neelsen staining at the recruitment site and confirmed by auramine staining at Centre Pasteur of Cameroon.

2.5. Compilation of Time Series

All samples tested for TB contained the date of sample collection; thus the created time series was 100% complete since.

Possible impact of meteorological parameters on TB was assessed by aggregating the daily surveillance data into a weekly time-series of counts.

Average weekly ambient air temperature and relative humidity readings were then computed for the duration of the time series. The total volume of rainfall for a particular week was calculated using the daily rainfall measurements.

TB episodes were assigned to the week corresponding to the first day of that episode. A week was defined as seven consecutive days from Monday to Sunday, irrespective of any overlap between two calendar years. The first week of January 2010 (January 4th, 2010) was considered to be the first week of the time-series. Hence, for this study, the week-series commenced from the 13th week, beginning on March 29th, 2010 and ended on the 13th week beginning March 28th, 2011.

2.6. Meteorological Parameters and TB Distribution

We considered whether there was a relationship between the timing of the peaks of seasonal TB counts and the timing of the peaks of meteorological parameters. We established a time series Poisson regression model to identify the relationship between meteorological parameters and local TB incidence.

2.7. Seasonal Index

Seasonal Index (SI) of a period indicates how much this period typically deviates from the annual average. Since we had at least one full season of data which is required for computation of SI [15], we calculated it on monthly and quarterly bases.

2.8. Statistical Analysis

Demographic and clinical characteristics of TB patients were described using Chi Square and Fisher's exact tests. The weekly distribution of TB patients and meteorological parameters were graphed, and the relationship was assessed by correlation coefficient. We used Poisson regression to model the number of TB patients as a function of meteorological parameters. Trend of time series were computed by seasonal index. SPSS version 22.0 software was used for correlation to determine the temporal relationship and time series analysis for seasonal variation.

3. Results

3.1. Meteorological Parameters Reported

Characteristics of the study population were already described [16].

With the seasonal component, the trend in TB cases was apparently decreasing from the 20th week (month of august 2010) to the end of the year (Figure 2).

Two meteorological parameters seemed to explain significant amount of variance in TB cases. Weekly mean humidity and temperature were related to TB cases with respectively Pearson correlation coefficients of 0.291 (positive relationship $r = 0.085$) and -0.342 (negative relationship, $r = 0.117$) even though the relation was weak.

The magnitude of relationship between weekly mean humidity and amount of TB cases: 8.5% and 11.7% of the variance in TB cases are explained by weekly mean humidity and temperature respectively.

A Poisson regression was run to predict the number of TB cases from the study period based on the meteorological parameters (weekly accumulated rainfall, mean temperature and humidity). For every any weekly increase of humidity, 1.035 (95% CI, 1.017 to 1.053) times more TB cases, a statistically significant result, $p < 0.001$. There were a 12.1% ($\text{Exp [B]} = 0.879$; 95% CI: 0.829 to 0.933) decrease in the number of TB cases for each decrease of temperature per week. However, we could see that the rainfall was not statistically significant ($p = 0.437$; $\text{Exp [B]} = 1.001$; 95% CI: 0.999 to 1.003).

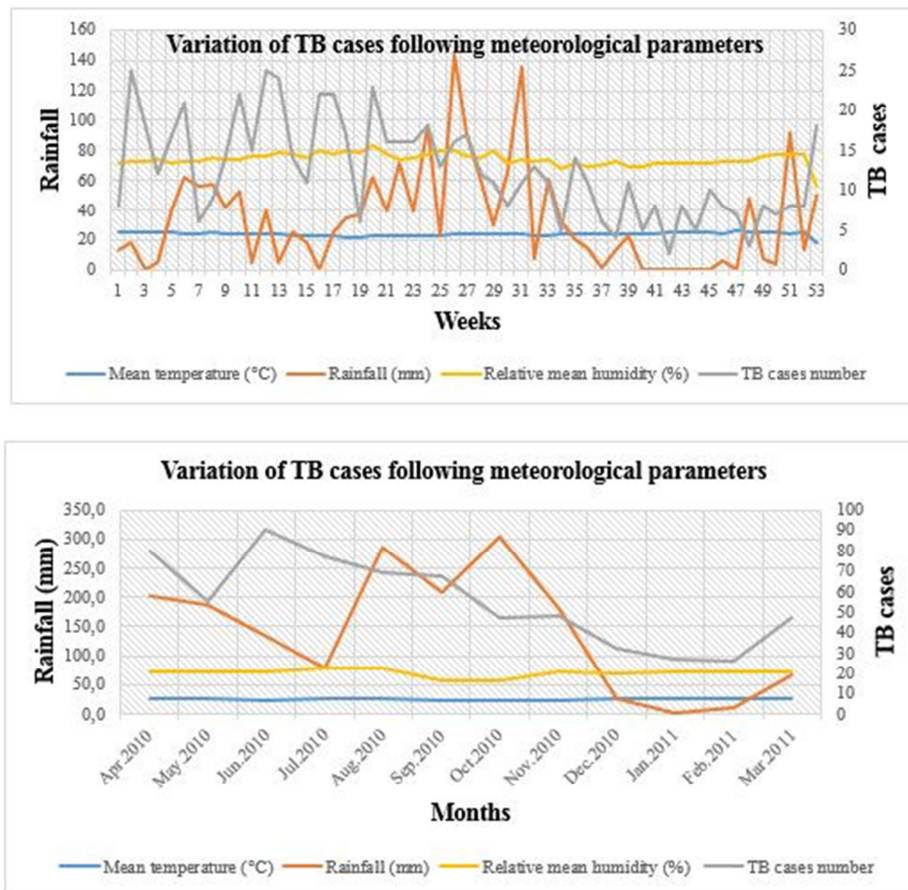


Figure 2. Weekly and monthly trends of TB case numbers over the study period following meteorological parameters reported March 29th, 2010 to April 1st, 2011.

3.2. Seasonal Index

Over the study period, on monthly basis, 62.2% increase rate of TB cases (SI= 1.62) were notified corresponding to the month of June and 53% decrease of TB cases (SI= 0.47) in September 2010. Overall, the high rate of TB cases was an increase of 35% for the second quarter of 2010 (SI= 1.35) with decrease of 40% TB cases (SI= 0.6) in the first quarter of 2011.

4. Discussion

This study aimed to look for impact of three meteorological parameters on the TB cases in Yaoundé: rainfall, mean temperature and relative humidity. Several studies have been conducted on TB distribution based on weather factors mainly in endemic regions and the present one showed variation of TB notifications in Yaoundé following two meteorological parameters: temperature and humidity. Meteorological parameters have been already shown to be linked to respiratory tract infections [17, 18] and for instance TB [19]: average temperature [6, 20], humidity [4] and even rainfall [4, 20].

Indeed, TB cases increased with relative humidity in this study and it has been suggested that high relative humidity may provide a favourable environment for *Mycobacterium* to

be attached to ambient particulates and stay in the air for a long time. Additionally, high relative humidity can exert profound effects on immunity-oriented problems through restricting the metabolism rate [4]. Conversely, temperature decrease had negative effect on TB notifications by reducing it and is similar to a study in 31 provinces in mainland China [4] and different from a study in Nigeria which is a neighbouring country to Cameroon with similar climatic environment where high pulmonary TB cases were characterised by low temperature [21]. Hence, high temperature may restrain the development of TB via affecting people's blood pressure, aspiration and biological vitality to increase the infection rate [22]. Also, the recombinant strain of *Mycobacterium* can stop growing and even could be destroyed when temperature exceeded 37°C [23].

Unlike the others (temperature and humidity), measured rainfall was not correlated with circulating TB even though there was a peak in the months of June coinciding with the rainy season in the city of Yaoundé but it was not statistically significant. Seasonal index for the second quarter matched with a rainy season following trends of precipitations in Yaoundé and indicated more TB cases in that period. Previous research in Cameroon has shown peak of TB infection coincides with the rainy season [11] and also another disease due to a mycobacterium (Buruli Ulcer) in

Akonolinga District [24], a neighboring area in the Centre Region of Cameroon.

The weekly and monthly peaks of TB were in 15th (April) and in 26th week (June) of 2010 respectively. On monthly basis, the fact that some patients were diagnosed late or in an advance state of TB can bias the inter month and/or season TB cases. For instance, some who were diagnosed at the beginning of a new season could probably been suffering (infected) since the previous one because it has been noticed that delays in the diagnosis and treatment of tuberculosis are potential stimuli of seasonal tuberculosis disease [25].

Since weak percentage of meteorological parameters explained variance in TB cases, it is important to look for other parameters in further studies. It has been demonstrated elsewhere that the statistical correlation between TB and rainfall may be due to several factors including: increased crowding with increased transmission; some have speculated that the seasonality of TB is mediated by vitamin D levels [26, 27]. Additionally, indoor activities, seasonal change in immune function, seasonal variation in food availability and food intake, sociodemographic parameters, Regional variation, age, and sex are important factors which can play a role in the tuberculosis notification variability [8, 25].

This study has several limitations: although we did not do the comparison with negative cases, thus a possible bias increases in our data. The present analysis was restricted only to sputum smear-positive cases of pulmonary TB.

We collected data only during one year, making it difficult to fully characterize details of seasonality like model prediction test or forecasts for predictions. Understanding TB seasonality may help TB programs to better plan and allocate resources for control activities considering the regularity of peaks of TB seasonality from periodic epidemic model that has already been formulated and studied [7]. Trend and prediction of time series is computed by using Autoregressive Integrated Moving average model [28]. On annual basis, we have only 12 observations and it is assumed at least 50 dealing or observations. More data in many years are needed to develop a model for trends and validate it because one year may be considered too short time for an epidemiologic study. But we think that our preliminary data could provide useful findings for further investigations since these data might induce public health decision-makers to revise the TB prevention policy with regards to the burden of the disease at the national. Prediction model for tuberculosis incidence is needed in Cameroon like in other countries which may be used as a decision supportive tool for planning health interventions and allocating health resources [9].

5. Conclusion

The temporal pattern of TB notifications in the city of Yaoundé showed to be associated to two meteorological parameters: mean ambient temperature and relative mean humidity. The highest peak was in the month of June during the rainy season. Data from this work may contribute to the National Tuberculosis Control Program to model tuberculosis

variation from recorded tuberculosis notifications since years in order to find an indicator for better intervention strategies for disease control.

List of abbreviations

Exp [B]: Exponentiation of the B coefficient
SPSS: Statistical Package for Social Sciences
TB: Tuberculosis

Declarations

Ethics Approval and Consent to Participate

This study was approved by the National Ethics Committee of Cameroon and written informed consent was obtained from all participants and/or their parents/legal guardians for children before enrollment.

Consent for Publication

Not applicable.

Availability of Data and Materials

The data from the current study is available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

VPB Conceived and designed the study. ST, ALW, EMT and LKS participated in field work.

VPB, JPAA and JCT supervised laboratory analysis. ST analyzed the data. ST, ALW, VPB, JPAA, JCT, EMT and LKS contributed to the writing of the manuscript and approved the final version of the manuscript

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