

## Spatial association of socio-economic status and prevalence of Tuberculosis in Nepal, 2019

Vijay Sharma<sup>1</sup>, Wongs Laohasiriwong<sup>2\*</sup>, Roshan Kumar Mahato<sup>3</sup>, Kittipong Sornlorm<sup>4</sup>

<sup>1</sup>MPH (International Health), Faculty of Public Health, Khon Kaen University, Khon Kaen, Thailand

<sup>2</sup>Dean, Faculty of Public Health, Khon Kaen University, Khon Kaen, Thailand

<sup>3</sup>Assistant Professor, Faculty of Public Health, Khon Kaen University, Khon Kaen, Thailand

<sup>4</sup>Lecturer, Faculty of Public Health, Khon Kaen University, Khon Kaen, Thailand

\*Corresponding author: Prof. Dr. Wongs Laohasiriwong, [wongsa@kku.ac.th](mailto:wongsa@kku.ac.th)

### ABSTRACT

**Background:** Tuberculosis (TB) is a communicable disease which is one of the major causes of poor health and the leading cause of death around the world. Nepal is a developing country which is still fighting against poverty and many communicable diseases including TB. Although many studies have explored the TB and its associated factors, there are very rare studies addressing the spatial association of TB with associated factors.

**Objectives:** This study aims to find out the spatial association of socio-economic status and prevalence of tuberculosis in Nepal in the year 2019.

**Methods:** This cross-sectional study was carried out by utilizing the data set available from National Tuberculosis Control Center Nepal in the year 2019 and other associated factors from different sources. A Moran's *I* and Local Indicators of Spatial Association (LISA) were used to identify the spatial autocorrelation between TB and associated factors in Nepal.

**Results:** The results indicated the spatial autocorrelation between TB and socio-economic factors in Nepal. Statistically significant factors were; Night Time Light, Land Surface Temperature Day, Land Surface Temperature Night, Population Density, Urban Area, Wall with Cement Stone, Roof with Reinforced Cement Concrete, and Fuel Liquefied Petroleum Gas with Moran's *I* value of 0.303, 0.428, 0.430, 0.271, 0.265, 0.433, 0.435 and 0.282.

In the year 2019, the LISA analysis identified the significant positive spatial local autocorrelation of Night Time Light with 8 high-high and 8 low-low districts, Land Surface Temperature Day with 12 high-high and 5 low-low districts, Land Surface Temperature Night with 12 high-high and 5 low-low districts, Population Density with 7 high-high and 8 low-low districts, Urban Area with 7 high-high and 8 low-low districts, Wall with Cement Stone with 11 high-high and 8 low-low districts, Roof with Reinforced Cement Concrete with 10 high-high and 8 low-low districts, like wise Fuel Liquefied Petroleum Gas with 9 high-high and 8 low-low districts respectively.

**Conclusion:** There were significant spatial associations between prevalence of tuberculosis and socio-economic status in Nepal in the year 2019, which should be addressed by new policy recommendations to detect the tuberculosis cases and possible associated factors to minimize the burden of TB in significant way.

**Keywords:** Spatial association, Prevalence, Socio-economic status, Tuberculosis

## 1. Introduction

Tuberculosis (TB) is a communicable disease caused by the bacillus *Mycobacterium Tuberculosis*, which is one of the prime causes of ill health and claims numbers of lives worldwide [1]. *Mycobacterium tuberculosis* can infect almost any part of the body [2]. TB was declared as emergency in 1993 [3]. TB was the leading cause of death worldwide before Coronavirus disease 19 was pandemic [1]. Approximately a quarter of world's population is estimated to be infected with *M. tuberculosis* [1]. The WHO South East Asia Region consists of 43% burden of TB incidence [4]. According to WHO, lives of around 85% of TB infected people can be saved with proper guidelines of treatment protocol.

Nepal is a landlocked country surrounded by India and China where 17.4% of the populations are multidimensionally poor [5]. In the year 2019, approximately 10 million people were infected with TB globally, where Nepal contributed for 0.35% of global population and 0.45% contribution for TB cases [6].

Approximately 42000 people were reported to be infected with TB in the year 2019 in Nepal with the incidence rate of 151 per 100,000 population [6]. To our knowledge there are very limited studies related to spatial study in Nepal, despite many articles and publications regarding TB. Hence, this study is intended to find out

prevalence of TB and its spatial associations with socio-economic factors in Nepal in the year 2019.

## 2. Methods

### 2.1 Study area

This study has been carried out in Nepal, the landlocked country between India and China in South Asia. The total area of Nepal is 147,516 sq.km with 143,351 sq.km land and 3,830 sq.km water. Nepal comprises 7 provinces and 77 districts with 753 local levels including metropolitan city, sub metropolitan city, municipality and rural municipality with their own executive body. Nepal shares the borders with India in east, west and south and China in the north.

The geographic coordinates of administrative areas were collected from Nepal Administrative Boundary (WGS 1984) (<https://download.hermes.com.np/nepal-administrative-boundary-wgs>).

### 2.2 Study design and population

This cross-sectional analytical spatial study used the data available from different sources, whereas, total numbers of TB infected population in Nepal in the year 2019 was obtained from National Tuberculosis Control Program, Nepal which was secondary data available on website. Likewise, Night Time Light data, Google earth engine, Ministry of Health and Population of Nepal, The Humanitarian Data Exchange and Highway

Management Information System (HMIS) UNIT were accessed to obtain the required data for this study.

### **2.3 Dependent and independent variables**

The dependent variable in this study was prevalence of TB in Nepal in the year 2019, similarly, the independent variables were NTL, population density, urban area, rainfall pattern, land surface temperature day, land surface temperature night, non-public (private) health facility per 10000 population, types of roads, types of houses, types of house wall, types of roofs and types of cooking fuels.

### **2.4 Statistical analysis**

This study used the Quantum GIS program to describe the spatial distribution patterns of prevalence of TB in all 77 districts of Nepal in the year 2019. After gathering the available data, we uploaded the data on QGIS program and we made the shape file of the country for further utilization on GeoDa program, we can also find out the different clusters of tuberculosis with the help of QGIS as well.

With the help of Geo Da program we can assess the clusters of tuberculosis on the basis of univariate and bivariate analysis. Univariate analysis provides the clusters of particular factors, where, bivariate analysis investigates the association between cause and effect. In both analysis in Geo Da we can find the Moran's I value which lies between -1 to +1, it

provides spatial autocorrelation of the variables.

Distribution patterns of the tuberculosis was determined based on the localized detection of prevalent spatial patterns. To describe the spatial distribution patterns of tuberculosis prevalence rate, QGIS version 3.20.3 (Odense) [7], Geo Da version 1.18.0.16 [8] were used to determine the measure of spatial autocorrelation analysis for an exploratory spatial data analysis,. QGIS was applied to integrate all data before being transferred to Geo Da for LISA.

A global spatial autocorrelation analysis using Moran's index (Moran's I) was performed to assess the spatial clustering of TB prevalence in Nepal. Local spatial autocorrelation was used to detect high- and low- risk areas for the TB prevalence. A Moran's I value  $> 0$  indicates that the TB prevalence of district (i) and its neighbouring districts differs significantly from that of other districts. District (i) is the center of the area with the higher/ lower TB prevalence, and is defined as a high-high/ low-low area for TB prevalence, respectively. In contrast, the TB prevalence between districts shows a discrete distribution at Moran's  $I < 0$  and a random distribution at Moran's  $I = 0$ .

In the study, the dark red shows an indication of spatial clusters when having a high

frequency of geographic factor with a high frequency of tuberculosis prevalence rate in the identified district with three neighbouring districts (high surrounded by high or Hot-spot or High-High). The dark blue location indicates spatial clusters when a low frequency of geographic factor with a low frequency of tuberculosis in the identified district with three neighbouring districts (low surrounded by low or Cold-spot or Low- Low). In contrast, the light red and light blue are the indications of spatial outliers (respectively, high surrounded by low or High-Low, and low surrounded by high or Low-High) [9,10]. The statistical significance level is 0.05. The simulation was 999 permutations to evaluate the sensitivity of the results.

### 2.5 Ethical clearance

Ethical permission for the study was obtained from the Ethics Committee in Human Research of Khon Kaen University, Khon Kaen, Thailand (HE652129).

### 3. Results

#### 3.1 Spatial distribution characteristics of the prevalence of tuberculosis in Nepal, 2019.

In the year 2019 we observed that the clusters were basically concentrated in the Terai regions of Nepal where eight districts were observed with high prevalence of TB. The districts were including Bhaktapur, Makawanpur, Chitawan, Nawalpur, Palpa, Dang, Pyuthan and Kanchanpur (Fig1).

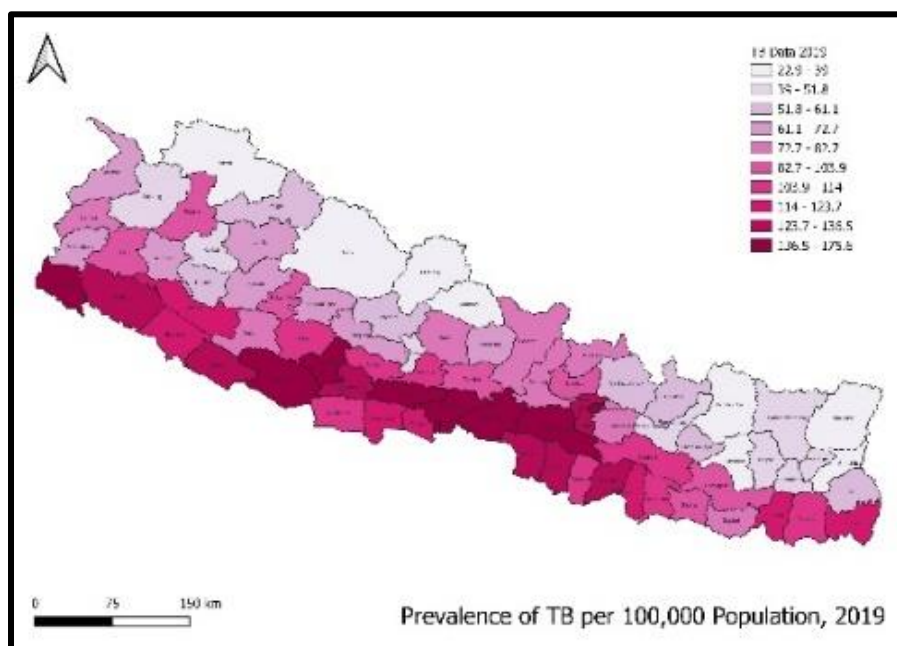


Figure1: Prevalence of TB in Nepal in the year 2019.

### 3.2 Univariate Analysis of Tuberculosis per 100,000 Population in year 2019.

In 2019, with positive spatial autocorrelation, Moran's I value 0.548, p-value <0.05, high-high was observed in Kathmandu, Lalitpur,

Makawanpur, Rautahat, Bara, Parsa, Chitawan, Tanahu, Nawalpur, Parasi, Kapilvastu and low-low in Taplejung, Panchthar, Terhathum, Sankhuwasabha, Bhojpur, Solukhumbu, Okhaldhunga, Mugu (Fig 2).

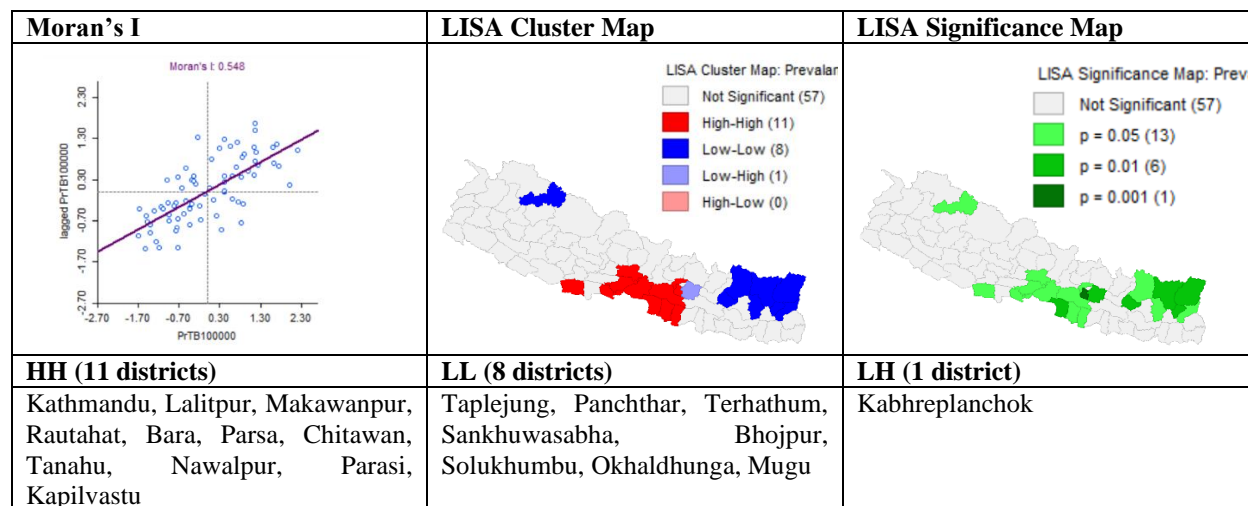


Figure 2: Univariate Analysis of Tuberculosis per 100,000 Population in year 2019.

### 3.3 Socio-economic factors associated with prevalence of tuberculosis.

### 3.4 Bivariate Analysis of Tuberculosis with NTL in year 2019

In year 2019, with positive spatial autocorrelation, Moran's I 0.303 and p-value

<0.05, high-high were Kathmandu, Lalitpur, Rautahat, Bara, Parsa, Chitawan, Parasi, Kapilvastu where low-low were Taplejung, Panchthar, Terhathum, Sankhuwasabha, Bhojpur, Solukhumbu, Okhaldhunga, Mugu on bivariate analysis of TB with NTL (Fig 3).

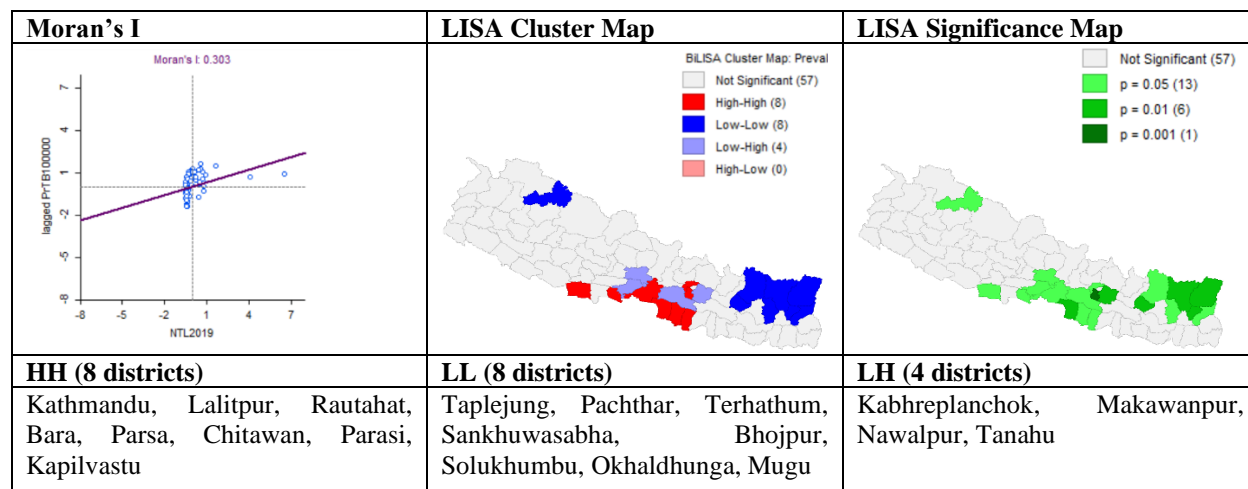


Figure 3: Bivariate Analysis of Tuberculosis with NTL in year 2019

In year 2019, with positive spatial autocorrelation, Moran's I 0.271 and p-value <0.05, where, high-high were Kathmandu, Lalitpur, Rautahat, Bara, Parsa, Parasi, Kapilvastu and low-low were Taplejung,

Panchthar, Terhathum, Sankhuwasabha, Bhojpur, Solukhumbu, Okhaldhunga, Mugu on bivariate analysis TB with population density (Fig 4).

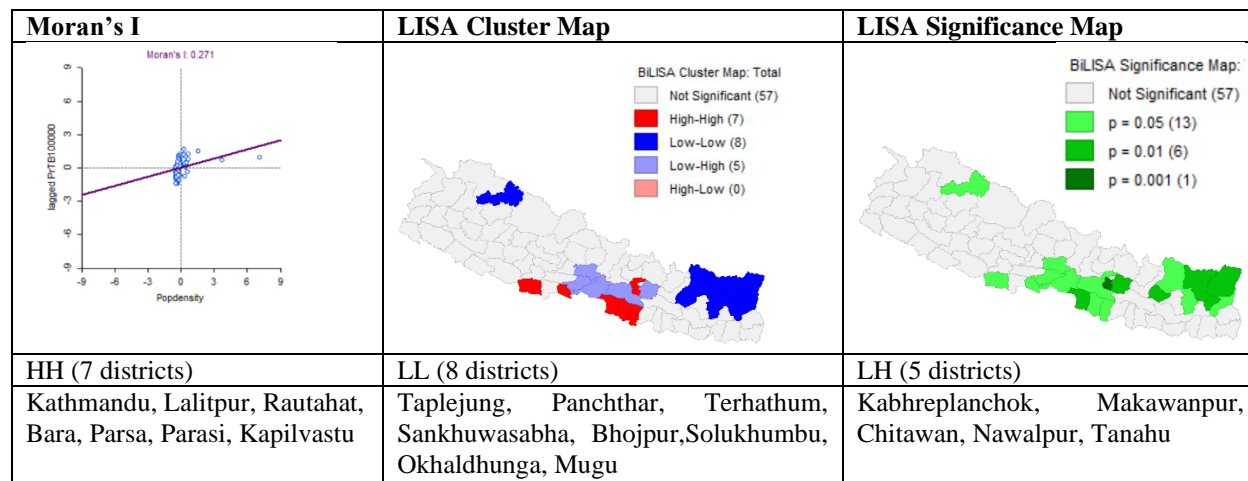


Figure 4: Bivariate Analysis of Tuberculosis with Population Density in year 2019

In year 2019, there was positive spatial autocorrelation with Moran's I 0.265 and p-value <0.05, high-high districts were Kathmandu, Lalitpur, Rautahat, Bara, Parsa, Chitawan, Parasi and low-low districts were

Taplejung, Panchthar, Terhathum, Sankhuwasabha, Bhojpur, Solukhumbu, Okhaldhunga, Mugu on bivariate analysis of TB with urban area (Fig 5).

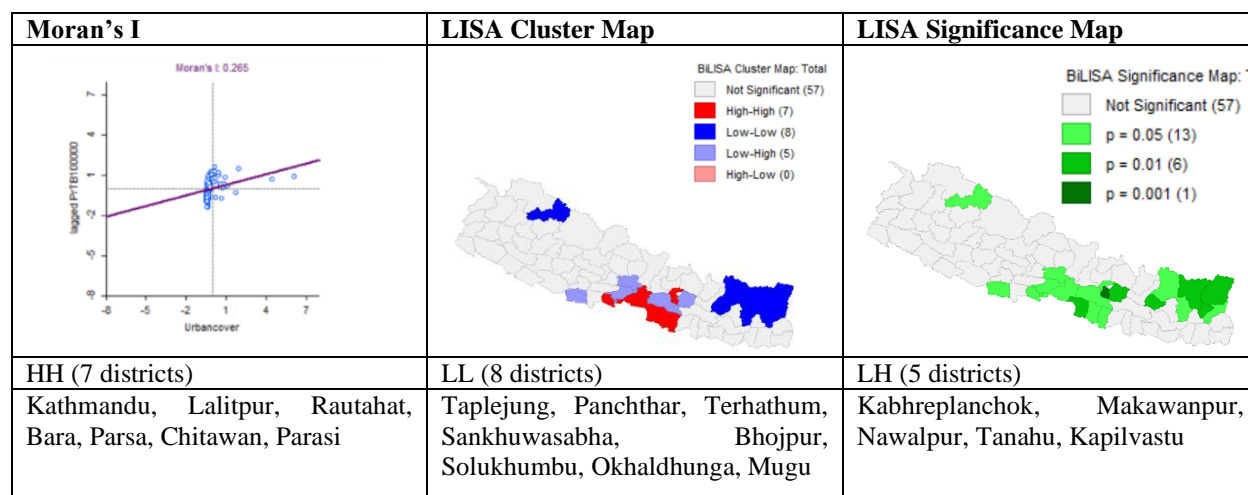


Figure 5: Bivariate Analysis of Tuberculosis with Urban Area in year 2019

#### 4. Discussions

This current study mainly aimed to explore the clusters of tuberculosis in all 77 districts of Nepal and associated factors based on socio-economic status using the spatial analysis. We have gathered the data of TB in the year 2019 and associated factors as well.

Our current study revealed a total of eight districts with higher concentration of TB including Bhaktapur, Makawanpur, Chitawan, Nawalpur, Palpa, Dang, Pyuthan and Kanchanpur.

In our study prevalence of TB was significantly associated with NTL with significant Moran's I value. Since NTL is one of the indicators that can be presented as a proxy for numbers of variables, including density, urbanization, SES and economic growth [11]. According to a study conducted in Asia and the Pacific, prevalence of TB was observed in those countries with lower SES including other index [12]. Similarly, one study carried out in USA also revealed that low SES had significant effect to increase the numbers of TB cases [13]. Different types of SES have their own specific pattern to affect the individuals with TB [14].

As TB is a communicable disease, there is a high chance of transmission of this disease among the persons if there is dense of people.

Among large number of persons there is high possibility of disease to be spread rapidly. Population density was observed to be significantly associated with the incidence of TB in a study carried out in Turkey [15]. Likewise, higher density of people and higher density of cases were significantly associated in study which was carried out in Brazil [16]. A study in China revealed that densely populated districts had high incidence of TB [17]. Similarly, trend of TB was found to be increasing with the increasing trend of population density in a study carried out in Taiwan [18]. Urbanization is another factor which is significantly associated with transmission of many communicable diseases including TB. Generally, we assume that due to lack of proper housing, sanitation and other many factors TB can get transmitted in fast trend in urban area. A study carried out in Thailand revealed that urban area are vulnerable to transmission of TB [19]. Likewise, one study in Malaysia revealed that majority of TB cases were occurred in urban areas [20]. TB was found to be a major public health problem in a study carried out in South India [21].

From around the world, it is observed that global warming and other climate related changes have many adverse effects on human health. Infectious diseases including TB are

directly or indirectly associated with environmental behaviours including rain fall patterns as well. In our study rain fall pattern was significantly associated with prevalence of TB. Similarly, risk of TB was found to highly associated with average of annual rain in a study carried out in Iran [22]. Likewise, rainfall had significant association with TB risks in a study performed in Malaysia [23].

There is diversity in climate of Nepal as there are three ecological zones ranging from mountains in north to plain terai in south. Hence, at the same time we can observe different types of climatic variance in Nepal. We assume that many diseases, specifically communicable diseases including TB are attributed to the weather. Land surface temperature at day and night were associated with risk of TB in our current study. There was positive correlation between TB incidence and average yearly rainfall in a study conducted in China [24]. Similarly, another study in China revealed that changes in temperature was significantly associated with admission of TB cases [25]. Winter indoor crowding was found to be associated with risk of TB transmission in a China based study [26]. Another study conducted in USA also had observed that the minimum temperature was one of the factors with strongest contributions for the distribution of TB [27]. Similarly, temperature and

humidity were observed as supporting factors for the endemics of TB in a study that was performed in Bangladesh [28]. Numbers of TB cases were significantly increased with extreme heat and cold in a study carried out in Japan [29]. Health facility is another factor which is directly or indirectly connected with occurrence and treatment of any disease either it is a communicable disease or non-communicable disease. Non-public health facility which is run under private initiation was found to be associated with prevalence of TB in our study. Generally, we believe that if there is provision of proper case detection with the help of health facility, then it will be easy to manage the cases. Hence, proper health service makes easy to detect and manage the cases. Inadequate diagnostic centres and lack of trained persons were found to be associated factors for lower case detection of TB in a study conducted in Ghana [30]. Similarly, in a study conducted in Pakistan revealed that health service from private sector had immense role for case notification of TB [31].

Another factor associated with TB is type of roads in Nepal. Roads are means of transportation, however, at the mean time they are the sources of many pollutants including dangerous particles those can attribute for occurrence of TB. Basically, dusty roads are believed to be sources of pollution. In our study

asphalt road had positive spatial autocorrelation and earthen road had negative spatial autocorrelation with TB. One study conducted in Taiwan revealed that poor air quality was associated with the risk of TB [32]. House is another important factor which plays vital role in terms of developing the diseases including TB. On average, in Nepal there are two types of houses including owned house and rented house. We believe that rented houses are more congested as compared to own houses because in rented house we have to manage many things within a limited area, hence, there is more chance of developing communicable disease including TB. According to a study, rental flats with lower floors were found to be associated with tuberculosis [33]. Likewise, better houses owners were in the high risk of developing the TB as they did not have to travel more and being exposed in the same environment for long which was supposed to be supporting factor [14]. Materials used to make the wall of house also can play the role to develop different diseases. Basically, ventilation of house depends upon the types of house walls. According to a study conducted in India, wall material was found to be associated with the risk of tuberculosis [34]. Furthermore, types of materials used to make the roof of the houses are other factors which can also be associated with the development of

many communicable diseases including tuberculosis. On the basis of types of roofs materials, we can assume the condition of air circulation which can attribute for the tuberculosis. In general, we assume that proper air circulation helps to minimize the risk of respiratory disease including TB. Roofing materials were associated with risk of TB in a study conducted in India [34].

Among the many associated factors for the development of TB, cooking fuels are another important factor. Being a developing country, a large number of Nepalese people are dependent upon those cooking fuels which create more smoke which are against our health. Because of unhealthy smokes produced by local cooking fuels including firewood, cow dung, straw and other dry grasses there is adverse effect on the health of people specially in respiratory system including TB. According to a study conducted in India, solid cooking fuel was found to be significantly associated with the occurrence of TB [21]. According to a study conducted in India, it was found that types of cooking fuels had association with risk of tuberculosis [34].

## **5. Conclusion**

There were significant spatial associations between prevalence of tuberculosis and socio-economic status in Nepal in the year 2019, which should be addressed by new policy recommendations to detect the tuberculosis cases

and possible associated factors to minimize the burden of TB in significant way. Likewise, studies based on spatial analysis should be carried out along with other studies as well.

### Conflict of Interest

No conflict of Interest

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