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Spatial and non-spatial determinants of successful tuberculosis treatment outcomes: An implication of Geographical Information Systems in health policy-making in a developing country

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Abstract This retrospective study aimed to address whether or to what extent spatial and non-spatial factors with a focus on a healthcare delivery system would influence successful tuberculosis (TB) treatment outcomes in Urmia, Iran. In this cross-sectional study, data of 452 new TB cases were extracted from Urmia TB Management Center during a 5-year period. Using the Geographical Information System (GIS), health centers and study subjects' locations were geocoded on digital maps. To identify the statistically significant geographical clusters, Average Nearest Neighbor (ANN) index was used. Logistic regression analysis was employed to determine the association of spatial and non-spatial variables on the occurrence

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of adverse treatment outcomes. The spatial clusters of TB cases were concentrated in older, impoverished and outskirts areas. Although there was a tendency toward higher odds of adverse treatment outcomes among urban TB cases, this finding after adjusting for distance from a given TB healthcare center did not reach statistically significant. This article highlights effects of spatial and non-spatial determinants on the TB adverse treatment outcomes, particularly in what way the policies of healthcare services are made. Accordingly, non-spatial determinants in terms of low socioeconomic factors need more attention by public health policy makers, and then more focus should be placed on the health delivery system, in particular men's health.

1. Introduction

Globally, multidrug-resistant tuberculosis (MDR-TB), mainly because of prior failed or default treatment outcomes, is a serious problem in the fight against TB disease [1—4]. According to the World Health Organization (WHO) report in 2013, annually on average, 3.6% of new TB patients were diagnosed with MDR-TB and at least half a million people were diagnosed with MDR-TB worldwide, of whom the majority live in low- to middle-income countries (LMICs) [5]. As a major challenge to the control of MDR-TB, Directly Observed Treatment-Short Course (DOTS) was recommended by WHO to overcome failed and default treatment outcomes [6]. Nevertheless, in almost all LMICs that adopted the DOTS project, MDR-TB followed by high rates of adverse treatment outcomes is a common issue [7,8].

In spite of the evidence indicating the contribution of non-spatial characteristics, including age, gender, low education achievement, domicile and social class to determine the outcome of TB treatment [9,10], the spatial factor in terms of physical accessibility to a healthcare center during the drug treatment course has been less considered. Moreover, reasons for failed or default treatment outcome are multifaceted and involve a combination of spatial and non-spatial factors, along with how health policy was formulated to deliver healthcare services [11—14].

Iran as a middle-income country, located in the Eastern Mediterranean region with an average incidence rate of TB (all TB forms 0—24 per 100,000 population), has experienced increased incidence rates of TB drug resistance during recent years [15]. One step in order to determine the distribution of TB cases is visualizing the statistics by employing the application of the Geographical Information System (GIS) in the public health discipline; however, this was hardly considered an option in Iran, and its usage is limited [16]. Accordingly, there are a few studies on spatial patterns of TB and their related treatment outcomes that have focused on non-spatial factors. These studies have shown a link between ethnicity, previous unsuccessful treatment, age and sex with anti-TB drug resistance [15,17]; however, information on the effect of spatial and non-spatial determinants on TB treatment outcomes is scarce. Therefore, this retrospective study aimed to address whether or to what extent spatial and non-spatial factors with a focus on a healthcare delivery system would affect successful TB treatment outcomes in Urmia, Iran.

2. Methods

2.1. Study area and population

This cross-sectional study was conducted in Urmia, the capital of West Azerbaijan Province (WAP), which is located along the border of Turkey and the Lake of Urmia that extends to the East. The Urmia landmass is 5,125 square kilometers (km^2), with a density of 85.2 inhabitants per km^2. According to the 2006 census in Iran, the Urmia population was 875,000 (30% of total WAP population), with 69% urban residents and a male to female ratio of 51% [18]. According to the Human Development Index (HDI), the WAP is one of the most deprived regions in Iran [19]. The Urmia population is served by 18 urban and 33 rural health centers (on average, given that urban and rural health centers serve 48,000—60,000 and 6,000—8,000 inhabitants, respectively). The municipality includes four districts (Fig. 1), of which the district with the higher socioeconomic status is located in the central area (district number of 4), while others with lower socioeconomic status are concentrated in the northwest and northeast regions (district numbers 2 and 3). The population density per km^2 for