Original Article

Effect of human development index parameters on tuberculosis incidence in Turkish provinces

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Abstract

Introduction: A country's development level is measured with a quantitative parameter called the human development index (HDI). The present study researched the effects of HDI parameters (such as healthcare standards, income, and education level) on the incidence of tuberculosis.
Methodology: HDI data of 36 provinces of Turkey and the tuberculosis surveillance data were obtained from the Ministry of Development and the Ministry of Health, respectively. The associations between the incidence of tuberculosis and other HDI parameters were analyzed.
Results: Higher population density (n/km^2) (CI = 0.05 to 0.40) and higher relapse rate of tuberculosis (CI = 0.36 to 1.48) were identified to be independent predicting factors that increased the incidence of tuberculosis, whereas higher gross national product (CI = -0.06 to 0.00), the population that holds a green Medicare card (CI=-0.58 to -0.04), increased general practitioners per 100,000 people (CI=-0.66 to -0.01), female population (CI = -0.70 to -0.06), married population (CI = -1.34 to -0.03), were found to be significant negative predicting factors that were relevant to the incidence (protective against tuberculosis).
Conclusions: Tuberculosis is a disease that is affected by multiple factors, including the components of HDI. Improvement of income level, facilitation of access to health services via health insurance, urbanization with lower population density strategy, and provision of enough general practitioners may be useful in reducing the incidence of TB' in provinces of developing countries such as Turkey.

Key words: surveillance; tuberculosis incidence; human development index.

Introduction

Tuberculosis (TB) is an important health issue worldwide, observed specifically in underdeveloped countries [1]. The TB incidence rate is less than 10 cases per 100,000 population per year in high-income countries such as Western Europe, Canada, the United States, Japan, Australia, and New Zealand. In contrast, rates above 500 per 100,000 population are seen in underdeveloped countries such as Mozambique, South Africa, and Zimbabwe [1].

The development level of countries is measured with a quantitative parameter called the human development index (HDI) [2]. This index is obtained through the concurrent processing of data from a large number of categories, including demographics (population and age breakdown), education (literacy, elementary school, and university), healthcare (total number of doctors or nurses per 100,000 people, number of dispensaries, and number of TB laboratories), employment (unemployment rate), competitive and innovative capacity, financial capacity (annual income per capita), and quality of life. There are also modified formulations of HDI [3].

In the literature, there are few studies that compare the differences between the developmental levels and incidence of TB and other infectious diseases in various countries [1,4-6]. We did not find any existing study investigating the relationship between TB incidence and all detailed HDI parameters. Differences in the incidence of TB among countries may arise not only from developmental parameters, but also from geographical, socio-cultural, and legal differences, as well as variations in application of TB control programs between countries. Therefore, investigating the relationship between developmental levels and TB incidence between the cities within the same country will present more objective data than will investigating differences between countries. Experienced and trained

staff, microscopy and appropriate technical infrastructure, accessibility to drugs, and an adequate, well-functioning registry system are essential for TB control programs. The fulfilment of these principles is directly associated with economy, healthcare standards, and education levels, each of which is an HDI parameter.

The aim of the present study was to provide a comprehensive examination of the effects of HDI parameters and disease-specific surveillance data on the incidence of TB in different provinces of the same country.

Methodology

Data collection

The study utilized the online 2011 HDI of Turkey obtained from the Turkish Statistical Institute, Ministry of Development [7], and the TB surveillance data obtained from the Ministry of Health [8]. All data used in the study were national official online open data, which refers to the idea that certain data should be

freely available for use and re-use, as permitted by the Turkish Statistical Institute [9].

A total of 36 provinces were included in the study. The HDI levels of provinces were obtained from the socioeconomic development ranking of provinces and regions, published by the Turkish Ministry of Development in 2011 [7]. Modified Turkish HDI was prepared through the use of 61 variables for the years 2009 and 2010 in eight sub-categories, namely demographics, education, healthcare, employment, competitive and innovative capacity, financial capacity, accessibility, and quality of life.

Certain variables used in the socioeconomic development ranking and reported to be relevant to TB in studies conducted with TB patients (demographics, education, healthcare, and employment) were recorded for the 36 provinces. These variables consisted of population, population density, proportion of the population over 15 years of age, gross value added per capita (GVAC), unemployment rate, proportion of Green Card-holding population to provincial

Table 1. Developmental properties of the provinces.

Factors	N	Min	Max	Median	Mean	SD
Age between 0 and 4 years (%)	36	0.100	6.700	.900	1.600	1.900
Age between 5 and 14 years (%)	36	2.100	22.600	17.300	4.900	5.100
Age between 15 and 24 years (%)	36	5.000	62.500	19.400	20.700	12.100
Age between 25 and 34 years (%)	36	1.000	37.500	13.600	19.300	7.000
Age between 35 and 44 years (%)	36	0.100	22.000	14.800	12.500	5.300
Age between 45 and 54 years (%)	36	0.100	52.200	3.400	15.300	9.500
Age between 55 and 64 years (%)	36	2.100	26.600	11.700	12.800	6.100
Age over 65 years (%)	36	5.000	25.400	13.4155	13.700	5.900
Age over 15 years (%)	36	57.510	84.950	76.500	73.400	8.200
Population density (n/area-km^2)	36	11.000	2,622.000	64.700	172.200	430.200
Province population (n)	36	76,724.000	13,624,240.000	510,587.500	1,246,311.200	2,363,402.100
Married population proportion (%)	36	46.9100	69.770	64.500	62.600	5.900
Incidence of TB (n/100,000)	36	6.700	44.100	18.000	19.800	10.700
Human development index (HDI)	36	-1.730	4.520	0.1042	0.100	1.400
Gross national product (USD/person/year)	36	568.000	6,165.000	1,536.000	1,869.100	1,189.800
Immigration (n/1,000)	36	-46.670	16.580	-3.015	-4.300	12.200
Green Medicare card holders proportion (%)	36	2.700	57.500	11.100	20.300	18.100
Unemployment proportion (%)	36	4.700	17.400	11.300	11.600	2.900
Illiteracy proportion (%)	36	1.950	15.130	6.630	7.60	4.500
Only primary school (%)	36	13.910	35.460	26.100	26.400	6.500
University proportion (%)	36	4.710	17.430	8.100	8.500	2.900
Practitioner doctor (n)	36	55.000	5,845.000	287.000	633.200	1,090.800
Practitioner doctor per population (n/100,000)	36	42.300	71.710	54.000	55.000	7.500
Specialist doctor (n)	36	46.000	14,437.000	284.000	1,177.100	2,761.900
Specialist doctor per population (n/100,000)	36	34.720	174.610	60.400	68.100	28.400
Total doctor per population (n/100,000)	36	86.590	339.060	119.400	137.700	51.800
Nurses (n)	36	100.000	17,923.000	622.000	1,951.900	3,854.400
Nurses per population (n/100,000)	36	69.210	314.110	132.100	139.900	45.100
Dispensaries (n)	36	1.000	33.000	1.500	3.300	5.600
Hospital beds (n)	6	6.000	136.000	48.000	59.500	54.000
Hospital beds per population (n/100,000)	36	88.000	489.000	206.000	216.300	81.000

population, proportion of illiterate population, proportion of higher education or University graduated population, proportion of age over fifteen years population, number of hospital beds per 100,000 people, total number of doctors per 100,000 people, number of general practitioners per 100,000 people, and number of nurses per 100,000 people.

In addition to the HDI data, data pertaining to the incidence of TB utilized in the assessment of TB control were obtained from the 2011 report on TB in Turkey published by the tuberculosis department of the Turkish Ministry of Health [8]. These data included surveillance data such as provincial incidence of TB, population per tuberculosis dispensary, proportion of implemented directly observed treatment (DOTS), number of patient smears taken, number of smear-positives, success in treatment, failure in treatment, relapse rate, contact examinations per patient, and number of contact persons to whom medicinal prophylaxis was given per patient.

Statistical analysis

Statistical analyses were carried out using SPSS version 21. The Kolmogorov-Smirnov test was used to investigate whether the numerical data were normality distributed. Pearson's or Spearman's correlation test was used to identify the correlations between the incidence of TB and other normal or non-normal distributed data from the provinces. The determination of predicting factors for the incidence of TB was ensured through the use of the linear regression test, where correlated data stood as independent variables. A p value of less than or equal to 0.05 at a confidence interval of 95% was considered statistically significant.

Results

The total population of the 36 provinces included in this study was 43,560,619. The largest province (Istanbul) had a population of 12,900,000 whereas the smallest province (Tunceli) had a population of 79,000. The population density (number of population/area km^2) was between 11 and 2,622. The proportion of married people was 62.6%(Table 1).

The development index was between -1.73 (Mus) and 4.52 (Istanbul), with a mean value of 0.2±1.4 (Figure1). Annual income of person per capita was USD $1,869 (568–6,165). The unemployment rate was 11.6%, and the migration rate was between -46.67 and +16.58 per thousand. The proportion of green Medicare card holders was in the range of 2.7% and 57.5% (20.3% on average), whereas the illiterate population represented 7.6%, and graduates of elementary schools

represented 26.4% of the whole population. The total number of doctors per 100,000 people was between 86 and 339, and the number of general practitioners per 100,000 people was between 42 and 71 (Table 1).

The incidence of TB (Figure1) was between 6.7/100,000 (Kırsehir) and 44.1/100,000 (Istanbul); the

Figure 1. Relationship between human development index (HDI) and TB incidence linear and non-linear (exponental-S) curve estimation models.
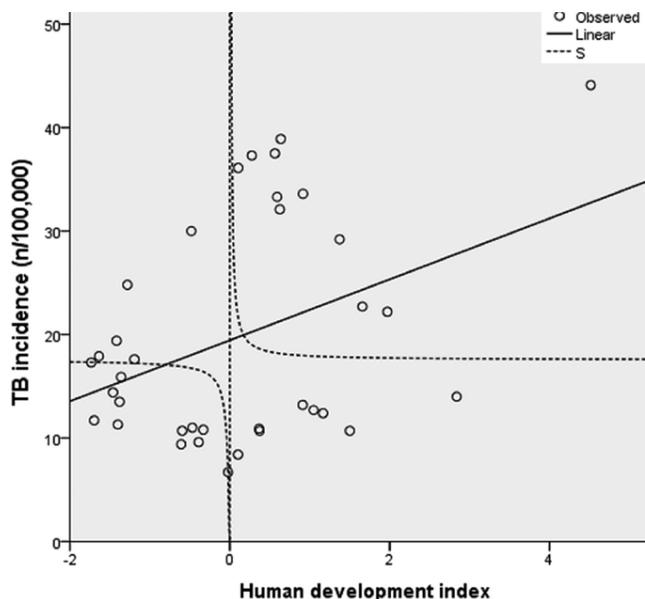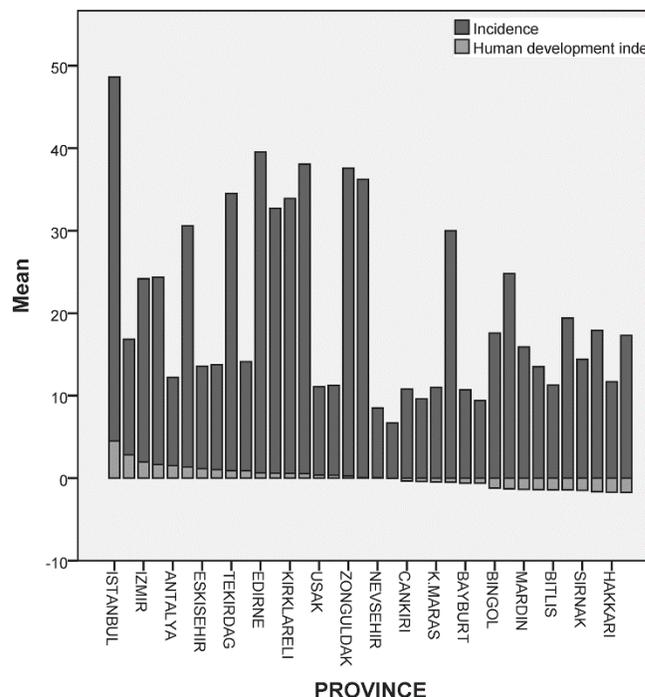

Figure 2. Provinces'human development index (HDI) levels and TB incidences: simple bar card representation

proportion of pulmonary TB was 58.6%±10.5, the proportion of new cases 92.8%±4.6, the number of prophylaxis-given persons per patient 0.1–3.8, and the DOTS proportion between 69% and 100% (Table2).

On examination of the correlation between the development index and TB incidence through curve estimation analysis (Figure2), only two models (linear [p=0.021] and non-linear exponential S model [p=0.033]) were observed to be significant, with a weak correlation (R-squared values were only 0.146 and 0.127, respectively). The linear model exhibited a positive correlation between the development index and incidence, while the S model led to the observation that incidence increased in inverse proportion to the development index, contrary to the linear model (Figure2). The equation for the linear model was calculated to be $[E(Y_t) = \beta_0 + \beta_1 t = 19.442 + 2.945t]$ and for the S model $[E(Y_t) = \exp(\beta_0 + \beta_1/t) = \exp(2.864 + 0.022/t)]$, where Y_t represents incidence and t represents the development index value. Therefore, the correlations between all components of the HDI and TB incidence were investigated separately.

Data correlating positively with the incidence of TB were identified to be the population of provinces (p = 0.025), gross national product (p = 0.018), proportion of the population over 15 years of age (p = 0.024), population density (population per area; n/km^2) (p =

0.004), number of dispensaries (p = 0.005), number of TB laboratories (p = 0.014), proportion of male population (p=0.002), number of examined TB contacts (p = 0.006), number of contact persons to whom medicinal prophylaxis was given per patient (p = 0.006), proportion of pulmonary TB cases (p < 0.001), and proportion of relapse rate (p = 0.001) (Table 3).

Data correlating negatively with the incidence of TB were identified to be the proportion of green Medicare card holders (p = 0.046), number of general practitioners per 100,000 people (p = 0.006), proportion of female population (p = 0.002), proportion of extra-pulmonary TB (p < 0.001), proportion of new TB cases (p = 0.001), and mortality among people with TB (p = 0.033) (Table 3). Other remaining data were not found to be correlated with TB incidence values of provinces.

Results of regression test

Upon analyzing the predicting effect of the current factors on the incidence through the linear regression backward method (Table 4), where incidence was a dependent variable, population density (n/km2) (CI = 0.05 to 0.40) and relapse rate (CI=0.36 to 1.48) were identified to be independent predicting factors that increased the incidence of TB. The variables of gross national product (CI = -0.06 to 0.00), female population (CI = -0.70 to -0.06), married population (CI = -1.34 to

Table 2. Characteristics of TB population in provinces.

Variables	N	Min	Max	Median	Mean	SD
DOTS proportion (%)	36	69.000	100.000	98.600	96.000	7.200
Male proportion (%)	36	37.500	79.300	60.000	58.700	9.400
Female proportion (%)	36	20.700	62.500	40.000	41.200	9.400
Pulmonary TB proportion (%)	36	37.500	76.600	60.000	58.600	10.500
Extra-pulmonary TB (%)	36	19.800	62.500	40.000	38.400	10.800
Examined contacts(n)	36	10.000	32,144.000	546.000	2,238.100	5,426.700
Examined contacts per patient	36	.200	16.200	6.400	7.400	3.800
Smear exam proportion (%)	36	0.000	100.000	90.200	86.600	17.200
Smear-positive proportion (%)	36	0.000	100.000	73.900	71.900	18.000
Culture study (%)	36	0.000	100.000	59.300	54.000	30.200
Culture-positive proportion (%)	36	0.000	100.000	76.700	72.700	22.400
Identification proportion (%)	36	0.000	100.000	80.00	64.600	35.000
Prophylaxis-given number	36	3.000	5,283.000	127.000	382.800	892.100
Prophylaxis given per patient (n)	36	.100	3.800	1.300	1.400	0.800
New cases (%)	36	84.300	100.000	92.900	92.800	4.600
Relapses (%)	36	0.000	13.800	6.200	6.100	4.100
Returning from failure treatment (%)	36	0.000	4.000	0.000	0.400	0.900
Returning from leave treatment (%)	36	0.000	7.000	0.000	0.700	1.300
Chronic (%)	36	0.000	1.000	0.000	0.000	0.100
Treatment success (%)	36	74.500	97.300	91.900	90.500	5.000
Failure (%)	36	0.000	3.200	0.000	0.400	0.700
Treatment leave (%)	36	0.000	8.600	1.600	1.800	2.000
Treatment continuation (%)	36	0.000	19.600	2.000	3.100	3.700
Death (%)	36	0.000	14.300	3.100	4.200	3.400

DOTS: directly observed treatment strategy.

-0.03), green Medicare card-given population (CI = -0.58 to -0.04), general practitioners per 100,000 people (CI = -0.66 to -0.01) were found to be significant negative predicting factors that were relevant to the incidence (model r-square = 0.764 and p = 0.011) (protective against TB).

Discussion

In the present study, we found that the population densities (n/km^2) of the provinces and the proportion of relapsed TB cases were independent predicting factors

that increased the incidence of TB, whereas gross national product, green Medicare card-holder population, number of general practitioners per 100,000 people, female population, and married population as variables were independent negative predicting (protective) factors for incidence of TB.

Trained personnel, microscopic diagnostics and technical infrastructure, continuity of accessibility to medicines, and adequate registration system constitute the main frame of TB control programs. Economic difficulties, lack of health infrastructure, laboratory

Table 3. Factors correlated with TB incidence.

Variables	Correlation	Sig. (2-tailed)
Development index	.382*	.021
Number of dispensaries	.460**	.005
Number of examined contacts	.453**	.006
Number of examined persons	.452**	.006
Gross national product (USD)	.392*	.018
Proportion of male population (%)	.506**	.002
Proportion of age>15 years population (%)	.376*	.024
Population density (person per area; n/km^2)	.473**	.004
Province population number	.373*	.025
Number of prophylaxis given	.447**	.006
Proportion of pulmonary TB cases (%)	.565**	.000
Proportion of relapse cases (%)	,546**	.001
Number of TB laboratories	.404*	.014
Proportion of TB deaths (%)	-.355*	.033
Practitioner doctors per population (n/100,000)	-.448**	.006
Proportion of extra-pulmonary TB cases (%)	-.608**	.000
Proportion of female population (%)	-.507**	.002
Proportion of population with Medicare card (%)	-.335*	.046
Proportion of new TB cases (%)	-.520**	.001

Table 4. Factors determining TB incidence of the provinces (linear regression analysis).

Factors	B (unstandard coefficient)	SE	Beta (standard coefficient)	t	P	95% CI
(Constant)	113,051	29,068		3,889	**,001**	53,30±172,80
Population density (n/km^2)	.023	.009	.905	2.643	**.014**	.00±.040
Gross national product (USD/year)	-.003	.001	-.293	-1.829	.079	-.00±.000
Proportion of green Medicare card holders	-.314	.132	-.531	-2.389	**.024**	-.58±-.044
Proportion of married population	-.688	.318	-.378	-2.165	**.040**	-1.34±-.035
Proportion of female population	-.383	.155	-.337	-2.478	**.020**	-.70±-.065
Practitioners per 100,000 population (n/100.000)	-.340	.159	-.237	-2.134	**.042**	-.66±-.012
Examined contacts per patient	-8.776E-05	.000	-.668	-1.921	.066	.00±.000
Proportion of extra-pulmonary TB proportion	-.273	.135	-.276	-2.018	.054	-.55±.005
Proportion of relapsed TB cases	.922	.272	.356	3.395	**.002**	.36±1.481

Dependent variable: TB incidence

Predictors: (Constant), P, population density (n/km^2), gross national product (income-USD/person/province), population number, proportion of immigration (n/1000), proportion of green Medicare card holders, proportion of age>15 years, proportion of married population, male proportion, female proportion, number of practitioners per population (n/100,000), relapsed proportion, proportion of pulmonary TB, proportion of extra-pulmonary TB, proportion of new TB cases, number of dispensaries, number of examined contact per patient, prophylaxis given per patient.

material shortages, lack of medicine, and lack of trained personnel, are factors that directly affect the viability and success of TB control programs.

In the present study, both linear and non-linear exponential (S) curve estimating models investigated the relationship between TB incidence and HDI levels of the provinces were found with weak significant correlations. In contrast to the positive correlated linear model, there was negative correlation between HDI and TB incidence in the S model. Furthermore, we found at least two factors with opposite effects on TB incidence for the same provinces. For example, Istanbul had the highest income level, which is expected to have a reducing effect on TB, but also it has the highest population density, which is expected to have a rising effect on TB infection. Therefore, to resolve this contradiction, we used components of HDI separately instead of HDI level alone for constructing a regression model to predict TB incidence.

Population density and crowding are two important factors related to the incidence of TB. In a study conducted in Brazil, population density, poor economic conditions, and household crowding were found to be correlated with higher incidence of TB [10]. In the present study, both higher population numbers of provinces and higher population density were found to be positively correlated with higher incidence of TB. However, in regression analysis, only population density was found to be an independent predicting factor that increased the incidence of TB. Increasing population density, which is identified as number of persons per area (km^2), may allow for the easy spread of TB infection. Reduction of population densities by implementing planned and orderly urbanization may be useful in reducing the incidence of TB.

Monetary income is another important factor related to TB. A study examining European countries indicated a negative prospective association between logged gross domestic product and TB rates [11]. Contrarily, a different study reported that the city of Porto Alegre exhibited a higher pulmonary TB incidence despite its higher gross national product compared with neighboring cities with a lower level of income [12]. Likewise, in the present study, the city of Istanbul was established to be the province both with the highest level of income and the highest incidence of TB. However, considering the present study regression model with all other factors, this was identified not to be a paradox, and the incidence of TB was found to decrease in proportion with the higher income level and to increase due to higher population densities and

certain other factors. Thus, raising income levels will be an important factor in reducing the incidence of TB.

In some studies, unemployment and migration were found to be facilitating factors for TB [13,14]. In the present study, neither proportion of unemployment, nor proportion of immigration was found to be correlated with the incidence of TB. The effect of those factors may be less important or may be masked by other properties such as low income level or crowded environments in those populations. Future studies are needed to investigate the role of unemployment and migration on incidence of TB.

The green Medicare card in Turkey aims at facilitating healthcare access for population groups with lower socioeconomic levels [15]. Therefore, this application may be regarded as an indirect indicator of access to healthcare services. The present study identified a lower incidence of TB in areas with a higher proportion of green Medicare card holders. The green Medicare card and other widespread use of applications that facilitate access to health services may be useful in reducing the incidence of TB.

The correct application of TB control programs and the improvement of standard of health services are important global strategies for management of TB. Number of hospitals, hospital beds, dispensaries, specialist doctors, practitioners, and nurses per population (n/100,000), number of examined contacts per patient, number of prophylaxis-given persons per patient, as well as the proportion of pulmonary TB, extra-pulmonary TB, new TB cases, and relapsed cases are important surveillance data associated with TB incidence and also indicate the health service quality of the provinces. The present study showed that number of laboratories, dispensaries, number of practitioner doctors per 100,000 people, number of examined contacts, and number of prophylaxis-given contact persons per patient were correlated with TB incidence. However, only the number of general practitioner doctors per 100,000 people was found to be a (protective) predicting factor for the incidence of TB. In Turkey, suspicion of infection with TB, prophylactic medicines for normal individuals in close contact with a patient with TB, and DOTS in TB treatment are mostly within the field of activity of general practitioners. We thought that these specific functions of practitioner doctors may be important for control of TB infection in Turkey. Our study suggested that providing a sufficient number of primary care physicians and general practitioners would be helpful inTB control.

The effect of gender on TB incidence is controversial. In a study assessing 14 countries with the use of World Health Organization (WHO) data, the female/male prevalence proportions were found to be lower than 0.5 in surveys undertaken in Southeast Asia and the Western Pacific region, while this figure was approximately 1 in the African region [16]. In a study conducted in San Francisco, the incidence of TB was found to be 2.1 times higher among men than among women, and this finding was attributed to transmission dynamics rather than shortcomings in the recording of cases [17]. A study undertaken in Hong Kong established that the difference between sexes was more distinct specifically in the group over 60 years of age, and the pulmonary form of TB was observed more commonly among men [18]. In the present study, being female was identified to be a factor that independently decreased the incidence of TB. This finding may be attributed to the reduced transmission dynamics in the female population, considering the fact that the female population is less active outside the home or in social and economic life when compared to the male population in Turkey.

There are conflicting results associated with marriage and TB incidence in the literature. A study covering a population of 1,323 people in Ethiopia found marriage to be a predicting factor that increased the risk of pulmonary TB [19]. Similarly, a population of human immunodeficiency virus (HIV)-positive patients yielded the finding that the incidence of TB was 1.7 times higher among single individuals than among married ones, whereas the incidence was 2.7 times higher among divorced individuals. Sex, age, marital status, education level, imprisonment status, smoking, and narcotic use were assessed for their effects on the development of TB among a patient population of 241 cases and 2,147 control subjects, and only HIV positivity was found to be independently associated with TB [20]. In fact, another study failed to establish any significant association between TB and marital status despite the distinct association between TB and alcohol abuse, smoking, and homelessness [21]. A study on 17,294 TB cases in Hong Kong determined that marital status and low household income were independently associated with the incidence of TB in multivariate analysis [22]. On the other hand, a study undertaken among a population of 55,384 in South Africa established that married individuals had a 50.0% lower risk of contracting TB when compared to single individuals [23]. In agreement with this study, the present study also observed the proportion of the married population to be an independent predictor that

decreased the incidence of TB. The fact that the married population exhibits such risk factors for TB as homelessness, depression, smoking, or alcohol or drug abuse to a lesser extent because their orderly lives and diets may contribute to the decreased incidence [24-28]. We believe that marriage contributes to reducing TB incidence via stabilization and regulation of lifestyle.

In the present study, the proportion of relapsed TB was identified to be an independent factor associated with increased incidence of TB. The fact that studies have also identified correlations between relapse proportion and factors such as male gender, low economic status, and co-morbidity that are responsible for increased incidence of TB [29] brings forth the notion that similar factors may increase both the incidence of TB and the relapse rate, simultaneously. Relapsed cases are reservoirs for new patients and lead to increased TB incidence. Relapsed cases must be reduced with proper monitoring and treatment.

Conclusions

Tuberculosis is a disease that is affected by multiple factors, including the components of HDI. Improvement of income level, facilitation of access to health services via health insurance, urbanization with a strategy of lower population, and provision of enough general practitioners may be useful in reducing the incidence of TB in provinces of developing countries such as Turkey. An in-depth examination of these factors may provide guidance for the development of international and national TB control strategies.

Authors' contributions
MT designed the study and wrote the paper. MD contributed important reagents and wrote the paper. SY contributed important reagents and analyzed data. HK performed research study. HSS performed research study. MO contributed important reagents and reviewed paper version. MI contributed important reagents and reviewed the paper. EG performed research study. CS contributed important reagents and wrote the paper.

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