

Effect of Human Development Index on Tuberculosis Incidence in Asia: An Ecological Study

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Abstract

Objective: Tuberculosis (TB) is a global health concern and is one of the main reasons responsible for the death of people by infectious diseases. We conducted this study to investigate the effect of human development index (HDI) on the incidence of TB in Asia. **Methods:** This ecological study was conducted in Asia to evaluate the correlation between the incidence of TB and HDI (life expectancy at birth, years of education mean and gross national income per capita). Data on TB from 2000 to 2016 were obtained from the World Bank Institution. The bivariate method and regression test were used to evaluate the correlation between incidence and mortality with HDI. Statistical analysis was conducted using Stata-14, and the significance level was considered 0.05. **Results:** In the recent years, the most occurrence of this disease in Eastern Asia is reported in Democratic Republic of Korea (513 persons/100,000), South-Eastern Asia in Philippines (520–590 persons/100,000), Cambodia (345–575 persons/100,000) and Timor-Leste (498 persons/100,000). A significant negative correlation was found between the incidence of TB and the HDI index in South Eastern ($R = -0.609$, $P < 0.05$) and South Central Asia ($R = -0.793$, $P < 0.05$). The results of regression analysis indicated that the increase in life expectancy at birth (LBE) ($B = -11.45$, $P < 0.05$) and MYS ($B = -9.6$, $P < 0.05$) caused a statistically significant decrease in the incidence of TB as well. **Conclusion:** The incidence of TB has a correlation with the human development index (HDI) in several Asian countries. Therefore, to reduce the incidence of the disease and prevent from it, the human development index should be considered as an effective factor in the occurrence of the disease, particularly in developing countries.

Keywords: Asia, human development index, incidence, tuberculosis

INTRODUCTION

Tuberculosis (TB) is one of the main causes of deaths from infectious diseases in the world. Drug-resistant forms of the bacteria are a major public health concern worldwide. During 2016, 10.4 million new cases of TB were occurred globally.^[1,2] In addition, 600,000 new cases of rifampicin-resistant TB infections were diagnosed during the same year, which 490,000 of them were multidrug-resistant infections (rifampicin is the most effective core drug against TB). Almost half (47%) of the incidents were observed in India, China and the Russian Federation.^[3] During 2016, 7.7 million deaths due to TB were reported, of which 4.4 million were people with HIV. TB is seen in all countries and every age groups, but most cases (90%) were reported in adults (2016), and almost two-thirds of the diagnosed patients lived in India, Indonesia,

China, Philippines, Pakistan, South Africa and Nigeria. Three regions of WHO, including Southeast Asia (45%), Africa (25%) and the West Pacific (17%) contain circa 87% of TB cases. The European and American regions contain 3% of the total cases, and the Eastern Mediterranean contains 7% of the cases.^[4] The annual occurrence of TB was different between the countries in 2016, 10 persons/100,000 population in most countries with high per capita income, up to 150–300 in more than 30 countries with a high occurrence of TB. In addition, more than 500 cases of TB were diagnosed in Democratic People's Republic of Korea, Lesotho,

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Mozambique, Philippines and South Africa.^[5] The most rapid decrease in the incidence of TB (4.6%) was observed in the European region between 2015 and 2016. In addition, there has been a 4% decrease in the incidence of the disease in countries with high-blood pressure issue including Ethiopia, Kenya, Lesotho, Namibia, the Russian Federation, Tanzania, Zambia and Zimbabwe since 2010.^[5]

There has been a progress in the care and prevention of TB, which means that the mortality rate (per 100,000 population every year) has decreased by 4.4% and incidence (new cases/100,000 population every year) has decreased by 1.9% annually.^[6]

Between 2000 and 2015, national and international efforts have been made to decrease the occurrence of TB based on the millennium development goals. The objective of sustainable development goals (SDGs) is to end the epidemic TB by it reducing its mortality up to 90% and the incidence up to 80% by 2030.^[7]

According to the goals of SDGs, the incidence of TB should have been decreased by 1.5% until 2015, 4%–5% by 2020 and 10% by 2025. As well, the mortality rate of TB disease should have been decrease from 17% in 2015 to 10% until 2020, and to 6.5% in 2025.^[3]

In the recent years, the reduction of poverty, as well as the progress in the nutrition and the increase in the budget of TB control program, have led to a successful control of the disease.^[8] HDI is an affecting factor on TB in different countries. Studies have shown that lower HDI index levels lead to greater incidence and spread of TB due to improper nutritional conditions, infectious diseases, smoking, lack of awareness and poverty.^[9,10] The objective of this study was to investigate the relationship between the incidence of TB and the human development index (HDI) in Asia.

METHODS

This ecological descriptive–analytical study was conducted from 2000 to 2016 based on the data from the World Bank on TB.

According to the World Health Organization, the incidence of TB was circa 100,000 in the present year. These data include comorbid HIV-positive and TB patients.^[5]

HDI

HDI is a complex of indices in three dimensions – life expectancy, educational level and management of resources for decent living. Today, the global community had notable improvements in all components of HDI. This improvement is different for each country, yet it has led to a reduction of inequities in health care services. Still, there is a major inequality between the northern and southern region in terms of income.^[11,12]

Statistical analysis

In this study, the method of two-dimensional correlation

was implemented to evaluate the association between the incidence and mortality rate of TB and HDI. In addition, the linear regression model was used to evaluate HDI in the incidence rate of TB. The significance level was considered 0.05. Data were analysed using STATA 14 Software version (Texas, USA).

RESULTS

Table 1 presents the incidence of TB between 2000 and 2016 in Asia. Studies showed that the highest incidence of TB is reported in Democratic Republic of Korea (513 in 100,000) in Eastern Asia, the Philippines (520–590/100,000) in South-Eastern Asia, Cambodia (345–575/100,000) and Timor-Leste (498/100,000). The highest incidence of TB in 2016 was related to Philippines in South-Eastern Asia with an incidence of 554 per 100,000 and the lowest incidence in Oman in Western Asia with an incidence of 9 per 100,000. [Figure 1].

The values for HDI and its dimensions are presented for each Asian country (based on HDI). These countries are classified based on the HDI index as very high, high, moderate and low HDIs [Table 2].

According to Figure 2, a negative correlation between the incidence of TB and the HDI index was seen in South-Eastern Asia ($R = -0.609$, $P < 0.05$) and South-Central Asia ($R = -0.793$, $P < 0.05$), which was statistically significant. In addition, a negative correlation was seen between TB and HDI index western Asia, but this correlation was not statistically significant ($R = -0.259$, $P > 0.05$) [Figure 2].

The Linear regression model showed that the increase in HDI ($B = -0.085$, $P > 0.05$) and gross national income (GNI) ($B = 0.006$, $P > 0.05$) caused a decrease in the incidence of TB, but this decrease was not statistically significant ($P > 0.05$). However, the results from regression analysis showed that the increase in LBE ($B = -11.45$, $P < 0.05$) and MYS ($B = -9.6$, $P < 0.05$) led to a decrease in the incidence of tuberculosis And this relationship was significant [Table 3].

DISCUSSION

Studying the incidence of TB requires long-term study plans and large populations (hundreds of thousands), which comes with at a high cost. The best method for estimating the incidence of TB is using the standard global health monitoring and surveillance systems because their reports are accurate. Because of this, these reports can be considered as a close proxy to the incidence rate. However, the monitoring system fails to measure the incidence of TB directly in many countries, because the number of treated patients remains unclear.^[13]

The incidence of TB varies in different countries. The lowest incidence is reported in high per capita income countries, including Western Europe, Canada, United States of America, Australia and New Zealand. In these countries, the incidence of TB is $< 10/100,000$ population.

Table 1: The incidence of tuberculosis in Asia in 2000-2016

Site	Incidence of TB (per 100,000 people) 2000-2016																
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Eastern Asia																	
China	109	105	102	98	95	92	89	86	83	82	77	76	74	70	68	66	64
Japan	36	32	30	28	27	24	23	22	22	21	20	20	19	1	18	16	16
Korea, Dem. People's Rep.	513	513	513	513	513	513	513	513	513	513	513	513	513	513	513	513	513
Korea, Rep.	49	84	78	82	77	94	92	91	88	94	95	99	94	89	85	79	77
Mongolia	162	182	196	198	227	228	247	224	214	210	205	191	183	189	192	197	183
South-Eastern Asia																	
Brunei	106	73	76	68	59	51	63	64	68	64	70	67	70	60	55	58	66
Cambodia	575	567	556	542	527	511	496	480	465	450	436	423	411	400	390	368	345
Indonesia	449	448	446	444	441	437	433	429	424	419	415	410	407	403	399	395	391
Lao PDR	330	317	305	293	282	270	260	249	240	230	221	213	204	197	189	182	175
Malaysia	75	72	68	73	68	69	71	70	73	72	76	80	86	91	92	88	92
Myanmar	411	411	410	408	406	403	400	396	392	388	384	380	376	373	369	365	361
Philippines	590	579	569	559	549	539	530	520	524	528	531	353	539	543	546	550	554
Singapore	51	44	42	43	38	35	33	33	37	35	35	36	50	46	46	45	51
Thailand	241	245	244	240	232	224	215	205	196	188	181	176	172	170	171	172	172
Timor-Leste	-	-	498	498	498	498	498	498	498	498	498	498	498	498	498	498	498
Viet Nam	197	192	189	185	181	176	172	168	164	159	155	151	147	144	140	137	133
South-Central Asia																	
Afghanistan	190	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189
Bangladesh	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221
Bhutan	249	220	224	206	193	192	171	182	171	197	225	208	188	176	172	153	178
India	289	288	287	285	282	279	274	268	261	254	247	241	234	228	223	217	211
Iran	22	22	21	20	18	16	16	16	16	17	17	18	18	18	16	16	14
Kazakhstan	166	183	194	199	197	186	172	163	156	151	145	134	121	107	93	79	67
Kyrgyzstan	244	246	243	235	224	210	195	179	165	153	145	141	140	141	142	144	145
Maldives	59	61	53	57	48	48	38	47	43	35	33	29	36	36	39	46	49
Nepal	163	163	163	163	163	163	164	164	164	164	163	162	161	159	158	156	154
Pakistan	275	275	275	276	276	276	276	276	276	276	276	276	276	275	270	270	268
Sri Lanka	66	66	66	66	66	66	66	66	66	66	66	66	66	66	65	65	65
Tajikistan	219	222	220	215	207	196	183	169	155	141	128	117	108	100	91	86	85
Turkmenistan	112	108	100	116	90	84	84	88	95	79	79	66	70	71	59	68	60
Uzbekistan	99	107	113	117	119	120	116	110	105	101	97	93	89	86	82	79	76
Western Asia																	
Armenia	54	57	59	64	69	92	75	72	71	68	61	55	53	60	57	47	44
Azerbaijan	80	75	78	57	80	88	83	79	108	133	104	125	86	78	76	71	66
Bahrain	36	31	30	39	34	36	33	33	31	32	23	20	20	18	16	14	12
Georgia	254	243	228	210	192	175	161	149	140	133	127	122	119	116	106	99	92
Iraq	50	50	49	49	48	48	48	48	47	46	46	45	45	45	43	43	43
Israel	10	9.6	8.6	8.5	8.1	6.5	5.8	6.6	5.2	5.5	5.3	6.3	7.6	4.5	5.2	4	3.5
Jordan	7.5	8.2	7.4	7.4	7.3	8	7.9	6.8	6.9	6.8	5.9	5.4	5.2	5.2	5.5	5.8	5.6
Kuwait	29	27	31	030	29	26	31	30	38	38	37	24	25	22	22	22	24
Lebanon	20	18	14	12	12	11	11	13	15	14	14	12	15	15	14	13	12
Oman	16	15	14	12	14	12	15	14	15	13	12	12	13	10	10	9	9
Qatar	54	53	50	46	41	43	39	39	47	45	37	33	40	30	23	25	23
Saudi Arabia	19	18	18	17	16	17	18	18	18	17	19	16	15	13	12	12	10
Syrian Arab Republic	39	37	35	35	32	29	26	27	23	24	22	22	18	17	23	19	21
Turkey	33	31	32	31	30	33	33	31	29	27	25	24	22	20	20	18	18
Yemen	116	110	102	95	87	80	73	66	60	55	52	50	48	48	48	48	48

TB: Tuberculosis

In the South American region, the incidence level of TB is reported to be < 50/100,000 population.^[14] Our study results indicated that the highest incidence of TB is seen in

the Democratic Republic of Korea (513/100,000) in East Asia, Philippines (520–590/100,000) in South-Eastern Asia, Cambodia (345–575/100,000) and Timor-Leste (498/100,000).

Table 2: Human development index and its components for Asian countries in 2015

Site	HDI	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita
Eastern Asia					
China	0.738	76.0	13.5	7.6	13,345
Japan	0.903	83.7	15.3	12.5	37,268
Korea, Democratic Republic of	-	70.5	12.0	-	-
Korea, Republic of	0.901	82.1	16.6	12.2	34,541
Mongolia	0.735	69.8	14.8	9.8	10,449
South-Eastern Asia					
Cambodia	0.563	68.8	10.9	4.7	3095
Indonesia	0.689	69.1	12.9	7.9	10,053
Lao PDR	0.586	66.6	10.2	5.2	5049
Malaysia	0.789	74.9	13.1	10.1	24,620
Myanmar	0.556	66.1	9.1	4.7	4943
Philippines	0.682	68.3	11.7	9.3	8395
Singapore	0.925	83.2	15.4	11.6	78,162
Thailand	0.740	74.6	13.6	7.9	14,519
Timor-Leste	0.605	68.5	12.5	4.4	5371
Viet Nam	0.683	75.9	12.6	8.0	5335
South-Central Asia					
Afghanistan	0.479	60.7	10.1	3.6	1871
Bangladesh	0.579	72.0	10.2	5.2	3341
Bhutan	0.607	69.9	12.5	3.1	7081
India	0.624	68.3	11.7	6.3	5663
Iran	0.774	75.6	14.8	8.8	16,395
Kazakhstan	0.794	69.6	15.0	11.7	22,093
Kyrgyzstan	0.664	70.8	13.0	10.8	3097
Nepal	0.558	70.0	12.2	4.1	2337
Pakistan	0.0550	66.4	8.1	5.1	5031
Sri Lanka	0.766	75.0	14.0	10.9	10,789
Tajikistan	0.627	69.6	11.3	10.4	2601
Turkmenistan	0.691	65.7	10.8	9.9	14,026
Uzbekistan	0.701	69.4	12.2	12.0	5748
Western Asia					
Armenia	0.743	74.9	12.7	11.3	8189
Azerbaijan	0.759	70.9	12.7	11.2	16,413
Bahrain	0.824	76.7	14.5	9.4	37,236
Georgia	0.769	75.0	13.9	12.2	8856
Iraq	0.649	69.6	10.1	6.6	11,608
Israel	0.899	82.6	16.0	12.8	31,215
Jordan	0.741	74.2	13.1	10.1	10,111
Kuwait	0.800	74.5	13.3	7.3	76,075
Lebanon	0.763	79.5	13.3	8.6	13,312
Oman	0.796	77.0	13.7	8.1	34,402
Qatar	0.856	78.3	13.4	9.8	129,916
Saudi Arabia	0.847	74.4	16.1	9.6	51,320
Syrian Arab Republic	0.536	69.7	9.0	5.1	2441
Turkey	0.767	75.5	14.6	7.9	18,705
Yemen	0.482	64.1	9.0	3.0	2300

HDI: Human development index, GNI: Gross national income

The incidence of TB was relatively stable from 1990 to 2001. Between 2011 and 2012, the reduction rate was 2%. To achieve the goals of millennium development goals (MGD), the reducing trend of TB should have continued until 2015. Using this goal, the incidence of TB has reduced in all six

regions of the World Health Organization.^[14] One of the most common ways to control TB is to identify the main risk factors for the disease. Recently, the biomedical and behavioural risk factors associated with TB are the main concerns. Pulmonary TB has a positive correlation with poverty and related factors

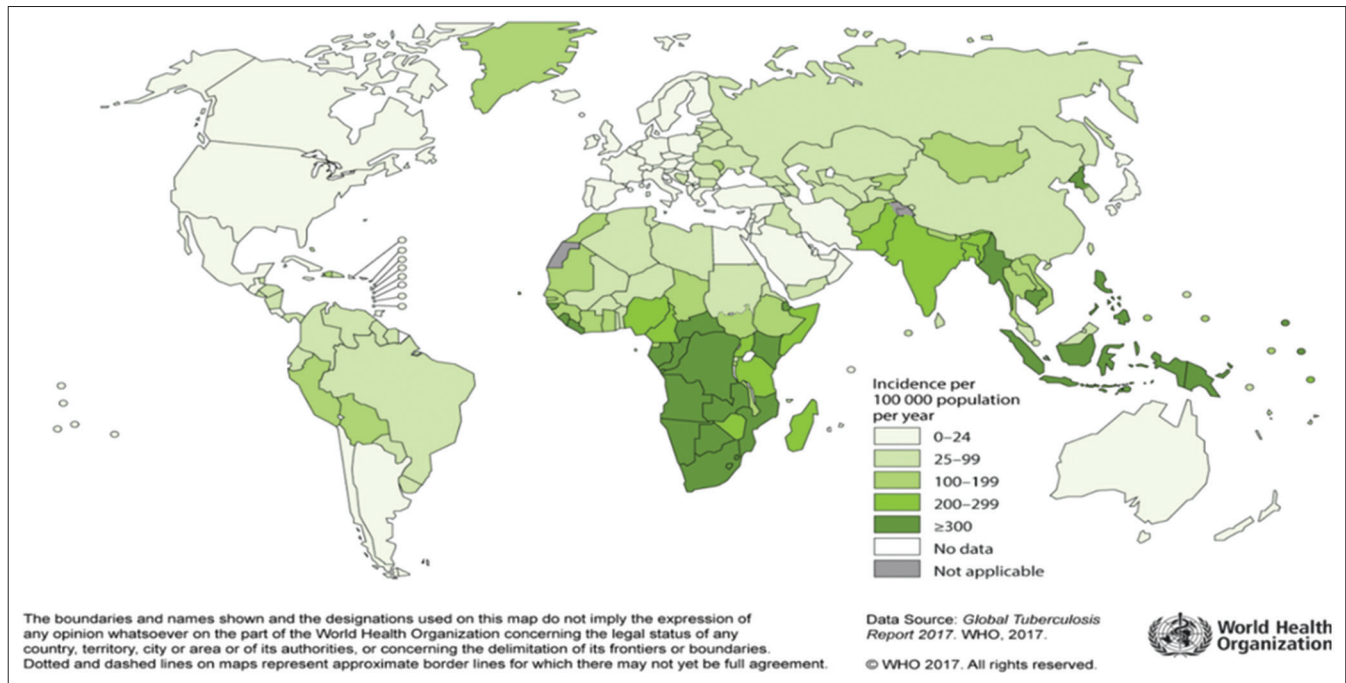


Figure 1: Estimation of tuberculosis incidence, 2016.

Table 3: Effects of human developmental indicators Components on the Incidence of tuberculosis in Asia

Variable	Incidence of TB		
	B	CI 95%	P
HDI	-0.085	-0.2-0.3	>0.05
Life expectancy at birth	-11.46	-23.9-1.01	<0.05
Expected years of schooling	8.75	-23.6-4.14	>0.05
Mean years of schooling	-9.6	-28.68-8.5	<0.05
GNI per capita	-0.006	-0.002--0.001	>0.05

HDI: Human development index, GNI: Gross national income, CI: Confidence interval, TB: Tuberculosis

including malnutrition and smoking. Therefore, the incidence of TB is affected by social factors in developing countries.^[15,16]

The results of our study showed that there is a significant negative correlation between the incidence of TB and the HDI index in South-Eastern Asia ($R = -0.609, P < 0.05$) and South-Central Asia ($R = -0.793, P < 0.05$). This shows that higher human development index in countries lead to a lower incidence of TB. This matter could be managed by improving the quality of life, correct diagnosis, and treatment of the disease, lack of malnutrition and decreasing poverty.

Investigating social determinants of health can be used to understand the incidence of TB.^[17] The Human Development Index (HDI) is a significant factor because it shows the relationship between the incidence of TB and economic dimensions. In addition, it is expressed regarding the quality of life in different countries.^[18-20] Studies in the Asia and Pacific regions showed that HDI is an effective predictor in the incidence of TB.^[21-23] Oxlade *et al.* used the incidence data of

165 countries and showed that the increase in life expectancy leads to a decrease in the incidence of TB by 7.8/100,000.^[24] Other studies reported that increasing HDI leads to the less probability of TB infection; therefore, it can be expected that the increase in HDI and quality of life, as well as improving the awareness and education can reduce the mortality and morbidity of the disease.^[20,25]

During our study, the results of regression analysis showed that the increase in LBE ($B = -11.45, P < 0.05$) and MYS ($B = -9.6, P < 0.05$) led to a statically significant reduction in the incidence of TB. In addition, the results of our study showed that the increase in GNI index led to reduction of the incidence of TB, but this reduction was not significant. The income per capita is another important factor in the incidence of TB. Studies have shown that there is a negative relationship between income and the incidence of TB in European countries.^[26]

Reviewing the literature has shown that the development of the health system affects the incidence of TB. Implementing the directly observed treatment, short course (DOTS) policy and the stop TB strategy is robustly dependent on the capacity of the health system, the availability of healthcare personnel and infrastructures of the health system.^[22,27] In regions with low HDI levels, the high occurrence of TB is reported due to lack of access to the healthcare system, timely diagnosis and incorrect treatment of the disease.^[28]

The results show that the occurrence of TB has a decreasing trend in the world. However, the goal of reducing the rate of the disease below epidemic state is being reached at a slow speed. Implementation of stop TB strategy is accelerated by the World

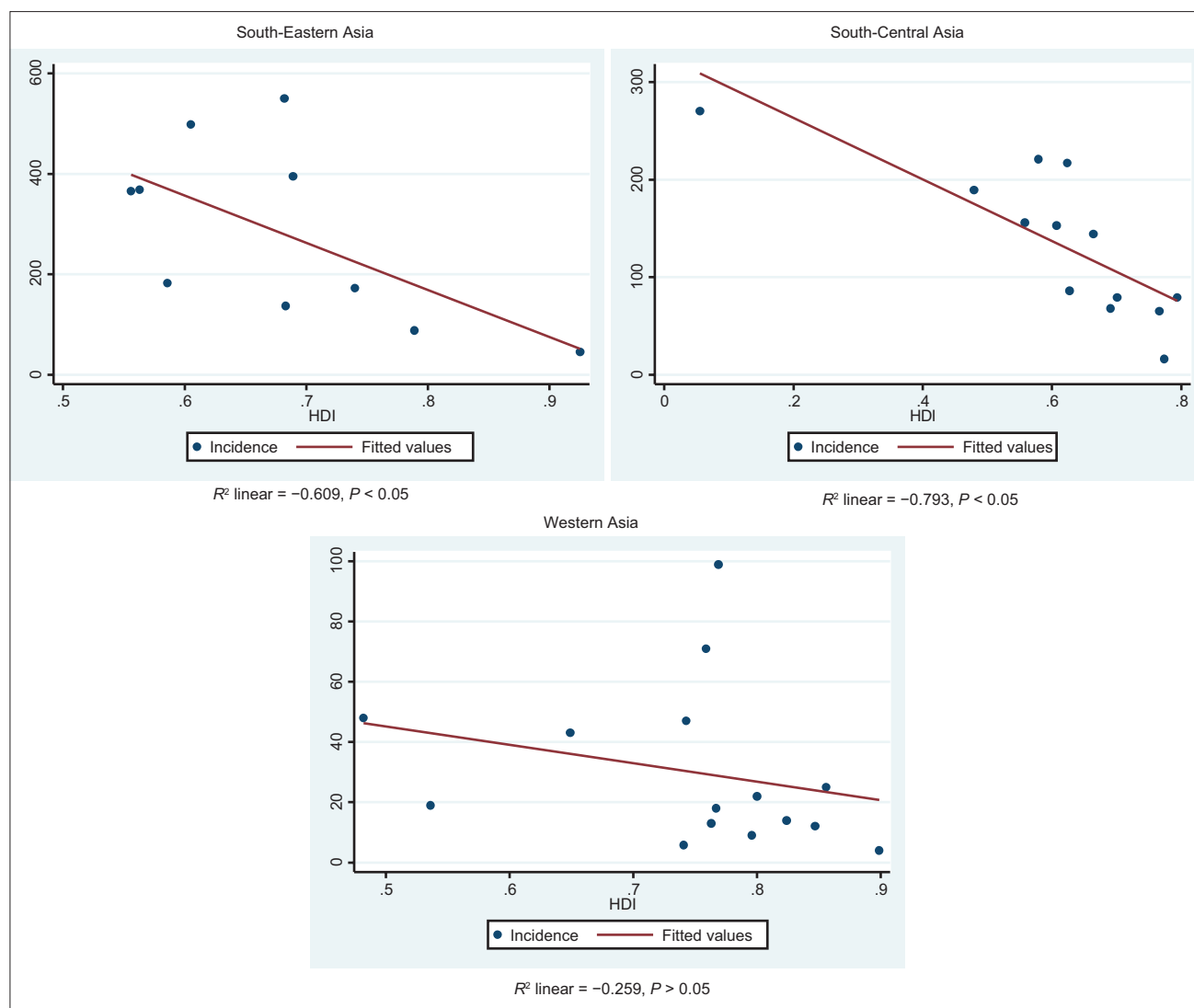


Figure 2: Correlation between the human development index and standardized incidence of prostate cancer in Western Asia, South-Central Asia and South-Eastern Asia in 2015.

Health Organization, especially regarding the comorbidity of TB and HIV and the efforts to fight them.^[3]

Therefore, to ensure the success of TB long-term control program, it is necessary to ensure that all components of the stop TB strategy are implemented precisely, with a specific attention to achieve more access to health care services for developing countries. Improving diagnostic and therapeutic efforts should be combined with prevention programs.

Eventually, newer and more effective vaccines can help the control programmes of TB. In addition, stronger coordination of health organizations to limit the impact of TB risk factors, including HIV/AIDS, smoking, malnutrition, alcohol, diabetes, bad living conditions and air pollution, can significantly reduce the incidence of TB in the world.

CONCLUSION

The incidence of TB is correlated with human development

index (HDI) in Asian countries. Therefore, to reduce the incidence of the disease and achieve the prevention goals, the human development index should be considered as an effective factor in the spread of the disease, particularly in developing countries. According to the results of the study, increasing the life expectancy at birth and the level of education, as well as the awareness of the community, can majorly reduce the incidence of TB.

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Conflicts of interest

There are no conflicts of interest.

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