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Original Article

The Effect of Environmental Exposures on the Diagnosis of Tuberculosis in Syrian Refugees

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Abstract

OBJECTIVE: Humanitarian crisis in the Middle East geography has brought refugees into being. The aim of this study is to investigate the relationship between refugees' tuberculosis diagnosis process and air pollution parameters and environmental exposures.

METHODS: A total of 229 patients with tuberculosis registered at Şanlıurfa Tuberculosis Dispensary during 2012-2018 were included. In this cross-sectional study, education levels, smoking status, warm-up style, and exposure to biomass, pesticides, dust storm, PM10, and sulfur dioxide were evaluated. Air parameters were received from https://www.havaizleme.gov.tr/. Bacteriological diagnosis was classified as smear-positive lung tuberculosis, smear-negative culture-positive lung tuberculosis, and other diagnostic methods. This study was approved by the Harran University Ethical Committee (10.12.2018; session: 12; decision no: 36).

RESULTS: Of the 229 patients diagnosed with tuberculosis, 53.3% were males and 46.7% were females. The average age was 31.15 ± 15.16. About 24.5% of refugees lived in camps, while 75.5% lived outside of the camps. The rate of smear (+) lung tuberculosis was 38% and smear (−) culture (+) lung tuberculosis was 14.4%.

Smoking ($P = .007$) in smear (+) cases and exposure to PM10 ($P = .036$) and sulfur dioxide ($P = .015$) in culture (+) cases were significant.

CONCLUSION: Smoking and air pollution are associated with delayed diagnosis of tuberculosis and severe forms of tuberculosis. We think that as a result of smoking cessation and reduction of air pollution, tuberculosis incidence in refugees can be reduced.

KEYWORDS: Air pollution, particulate matter, smoking, Syrian refugees, tuberculosis
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INTRODUCTION

Tuberculosis (TB) is still an important disease that requires timely diagnosis and treatment. Globally, in 2019, there were estimated 10.0 million TB cases and 1.4 million TB deaths.[1] According to the 2019 Organization for Economic Co-Operation and Development data, 2.8% of the population was foreign-born.[2] Socioeconomic parameters such as unemployment, poverty, low income, and rapid population growth are known to increase the incidence of TB.[3]

Air pollution is the elevation of pollutants that can be found in the atmosphere to the levels that adversely affect the health of people and living creatures and/or increase to the amounts that will cause material damage.[4] Air pollution indicator is particulate matter (PM). Particulate matter is measured in terms of micrograms per cubic meter (μg/m^3) and is named according to its size.[5] Air pollution is associated with poverty.[6] Now it is known that air pollution and other environmental factors play a role in the development of TB.

Wars and accompanying hunger, homelessness, and being a refugee cause a decline in health indicators including TB.[7] The concept of the refugee was published in 1951 in the United Nations Geneva Convention with the definition of "as a person who has a rightful fear that he/she will be persecuted because of his race, religion, nationality, membership of a certain social group or political thoughts, and therefore leaves his country and does not return or want to return because of his fear."[8] Tuberculosis-causing agent is *Mycobacterium tuberculosis*, a complex bacilli. Among persons living in the same environment, the bacillus is transmitted to healthy persons by inhalation of the bacilli into the lungs. The most infectious patients are those with laryngeal TB and cavity pulmonary TB.[9] For diagnosis, smear and staining with Ehrlich–Ziehl–Neelsen are performed. The transmission potential of patients who are smear negative is less than that of those who are smear positive.[10] In this study, we examined the relationship between bacteriological case definitions in Syrian Refugees and PM10 and sulfur dioxide (SO_2) from outdoor air pollution parameters in the context of TB.

MATERIAL AND METHODS

Study Design

This cross-sectional study included 229 refugee patients who applied to Şanlıurfa Tuberculosis Dispensary between 2012 and 2018 and were diagnosed with TB. Criteria for inclusion in the study were having been diagnosed with TB between

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2012 and 2018 and being a refugee. This study was approved by the Harran University Ethical Committee (10.12.2018; session: 12; decision no: 36).

Data Collection

Age, gender, education level, place of residence, smoking status, way of heating, exposure to biomass, pesticide, and dust storm, year of diagnosis, bacteriological diagnosis, treatment status, and organ involvement of patients were recorded. According to the organ involvement, TB classification was performed as lung TB, extrapulmonary TB, and both lung and extrapulmonary TB. Classification according to the treatment status included treatment, treatment completion, treatment lost to follow-up, transfer to another center, death, and ongoing treatment. Bacteriological diagnosis was classified as smear-positive lung TB, smear-negative culture-positive lung TB, and other diagnostic methods. Other diagnostic methods included adenosine deaminase enzyme level, TB polymerase chain reaction, smear-negative pulmonary TB, and so on.

Organ involvement, bacteriological diagnosis type, treatment results, and home addresses of the patients were listed. The patients were visited at their homes, and questions on smoking status, ways of heating, and exposure to pesticides, biomass, and dust storm were asked to those who volunteered to participate, and their answers were recorded. Interviews with Syrian refugees were conducted in the presence of a certified translator. Each visit lasted for an average of 25-30 minutes.

The average annual PM10 and SO_2levels in Şanlıurfa between 01.01.2012 and 31.12.2018, where patients were diagnosed, were retrieved from https://www.havaizleme.gov.tr/.

RESULTS

Of the 229 patients diagnosed with TB, 53.3% were males and 46.7% were females. The mean age was 31.15 ± 15.16. About 24.5% of the participants lived in camps, while 75.5% lived outside of the camps. While the number of diagnosed cases was 0.9% in 2012, it was 12.7% in 2018, and the highest rate was 27.1% in 2015 (Table 1).

In total, 56.3% of the individuals in the study group declared that they smoke, 30.1% of the participants had pesticide exposure, 24.0% had biomass exposure, and 91.3% had dust storm exposure. The most common form of heating was coal with 39.3% (Table 2).

MAIN POINTS

- Examining the relationship between refugees' air pollution parameters and their environmental exposure.
- Examining the relationship between smear-positive TB cases and PM10 and SO_2.
- Comparing tuberculosis (TB) in Turkish citizens and refugees.
- Demonstrating that cigarette smoke and air pollution are risk factors for TB.
- It is a study showing that TB incidence in refugees can be reduced by quitting smoking and reducing air pollution.

Table 1. Distrubution of Demographic Characteristics and Diagnosis Year of Patients With Tuberculosis

Features (n = 229)	n (%)
Age min-max=1-72 Mean ± SD, 31.15 ± 15.16	
Gender	
Female	122 (53.3)
Male	107 (46.7)
Residence	
City center	173 (75.5)
Camp	56 (24.5)
Diagnosis year	
2012	2 (0.9)
2013	15 (6.6)
2014	29 (12.7)
2015	62 (27.1)
2016	43 (18.8)
2017	49 (21.4)
2018	29 (12.7)

Pulmonary TB shows the most common organ involvement, with 71.2%. When TB treatment was examined, the results showed 42.4% treatment completion and a cure rate of 18.8%. The rate of death in TB follow-ups is 4.8%. Bacteriologically, smear (+) lung TB is 48.9% and smear (–) culture (+) lung TB is 34.9% (Table 3).

In one-way analysis, it was seen that there were no effects of pesticide exposure (F = 1.458, P = .235), heating (F = 0.084, P = .919), biomass exposure (F = 1.731, P = .179), and dust storm exposure (F = 1.615, P = .201) on bacteriological diagnosis. In smear (+) cases smoking (P = .007) , in culture (+) cases exposure to PM10 (P = .036) and SO2 (P = .015) were significant. With bacteriological diagnosis, the average values of parameters related to air pollution are presented in Table 4.

DISCUSSION

Our study evaluates refugees diagnosed with TB, certain sociodemographic characteristics, diagnostic processes, and exposures in their environment, and the relationship between PM10 and SO^2 and bacteriological diagnosis. With this aspect, this is a noteworthy study in the literature. We found the means of smoking in bacteriological smear (+) cases (P = .007) and of exposure to PM10 (P = .036) and to SO2 (P = .015) in smear (–) culture (+) cases to be significantly higher .

Smoking causes severe TB and/or deaths worldwide. Previous studies have shown that the smoke caused by smoking, which is one of the causes of indoor air pollution, has damaged alveolar macrophages, and as a result, the anterior defense system of the lungs has weakened.[11] In a meta-analysis conducted by Wang et al.[12] in 2020, contrary to our findings, they reported that smoking caused smear and culture negative in bacteriological diagnosis and delay in TB

Table 2. Distribution of Exposure of Patients with Tuberculosis to Some Environmental Substances

	n (%)
Smoking	
Yes	129 (56.3)
No	94 (41.0)
Passive smoker	4 (1.7)
Ex-smoker	2 (0.9)
Pesticide exposure	
Yes	69 (30.1)
No	160 (69.9)
Biomass exposure	
Yes	55 (24.0)
No	177 (76.0)
Dust storm exposure	
Yes	209 (91.3)
No	20 (8.7)
Heating type	
Wood	58 (25.3)
Coal	90 (39.3)
Wood and coal	8 (3.5)
Electric	69 (30.1)
Natural gas	2 (0.9)
Central heating	2 (0.9)

diagnosis.[12] In countries with high TB incidence and prevalence, there are studies reporting that TB outbreak can be controlled by smoking cessation.[13] There are similar studies in Turkey on the effects of effective control of smoking and

Table 3. Distribution of Patients with Tuberculosis to Clinical Characteristics

	n (%)
Location of TB	
Lung TB	163 (71.2)
Extrapulmonary TB	57 (24.9)
Both lung TB and extrapulmonary TB	9 (3.9)
Treatment outcome	
Cure	43 (18.8)
Completed treatment	97 (42.4)
Death	11 (4.8)
Treatment lost to follow-up	36 (15.7)
Transfer	16 (7.0)
Treatment is still continuing	26 (11.4)
Bacteriological diagnosis	
Smear (+) lung TB	112 (48.9)
Smear (–) culture (+) lung TB	80 (34.9)
Other diagnosis type	37 (16.2)

Table 4. Comparison of Bacteriological Diagnosis and Air Pollution Parameters

	Smear (+), n = 112	Smear (–) Culture (+), n = 80	Other Case Diagnosis Type, n = 37	F/*P*
Smoking	0.76 ± 0.557	0.53 ± 0.656	0.49 ± 0.507	**5.096/.007***
Pesticide exposure	0.25 ± 0.435	0.36 ± 0.484	0.32 ± 0.475	1.458/.235
Heating type	2.39 ± 1.276	2.46 ± 1.222	2.46 ± 1.325	0.084/.919
Biomass exposure	0.19 ± 0.392	0.30 ± 0.461	0.27 ± 0.450	1.731/.179
Dust storm exposure	0.95 ± 0.226	0.88 ± 0.333	0.89 ± 0.315	1.615/.201
PM10	52.45 ± 11.497	55.99 ± 12.455	50.16 ± 14.200	**3.384/.036***
SO^2	14.04 ± 7.068	17.07 ± 9.975	13.62 ± 3.530	**4.248/.015***

*Post hoc least significant difference.

indoor air quality to help prevent the risk of developing TB control.[14] In this study, 56.3% of patients had smoking habit, similar to the numbers reported in the literature. We found that there was a significant relationship between smoking and TB in patients with bacteriological smear (+) cases ($P = .007$).

PM10, one of the air pollution parameters, is suspended in the atmosphere. It reaches the lungs through the respiratory tract and plays a role in the etiopathogenesis of various diseases.[15] Another air pollutant is SO_2. Popovic et al.[16] reported that limited evidence of associations exists for PM10, SO_2 with TB.[16] Short-term exposure to low SO_2 in the environment, according to a different opinion on SO_2, is thought to have an acute protective effect against lung infections.[17] This view was suggested for patients who were followed up on in the TB outpatient clinic. In another study, Zhu et al.[18] found a significant relationship between exposure to PM10 and SO^2 and the frequency of lung TB.[18] In our study, we found a significant relationship between air pollution parameters and bacteriological diagnosis, in parallel with the literature. In smear (–) culture (+) cases, PM10 ($P = .036$) and SO_2 ($P = .015$) averages were significantly higher.

Pesticides show toxic effects in humans and weaken the immune system. Pesticide application causes respiratory diseases in acute and chronic periods.[19] As a result of exposure to pesticides, TB sensitivity increases.[20] In our study, 30.1% of the participants had pesticide exposure. There were no significant differences smear (+), smear (–) culture (+) and other case diagnosis type (Table 4).

In recent years, relatively many studies have linked biomass fuel fume exposure to various aspects of TB. It has been reported that there is a relationship between TB and exposure to biomass fuel fumes compared to fumes from other cleaner forms of fuel.[21] Another study reported that biomass fuel is

a risk factor for lung TB and emphasized the importance of reducing biomass fuel.[22] In this study, we found biomass exposure to be 24.0%. However, no statistically significant differences were found Smear (+), smear (–) culture(+) and other case diagnosis type (Table 4).

The southeastern region of Turkey is often affected by dust storms coming from the Middle East due to its geographical location. Cellular growth is impaired as a result of exposure to dust particles contained in dust storms. Dust storm exposure causes respiratory complaints and diseases in the acute and/or chronic period.[23] According to a study, young men coming from outside regions to geographical locations with dust storms were found to be at more risk of death than the local population.[24] Refugees have been exposed to periodic dust storms originating from the desert in Syria where they used to live and to dust stroms in Turkey where they migrated as these countries are in the same geography. In our study, 91.3% dust storm exposure was detected. However, there was no significant difference between the groups for TB bacteriological diagnosis. Patients were warned not to go out during dust storms and/or to wear a respiratory mask.

In conclusion, in our study in which we investigated the relationship between air pollution parameters and environmental exposures of refugees in the context of TB, that is, smear-positive TB cases, and air pollution parameters PM10 and SO_2, we observed that smear negative-culture positive more TB-positive cases. The main result of our study is that cigarette smoke and air pollution are risk factors for TB. Smoking and air pollution are associated with delayed diagnosis of TB and severe forms of TB. We think that as a result of smoking cessation and reduction of air pollution, TB incidence in refugees can be reduced.

Limitations

This study has several limitations. The scope of our study, which examines the relationship between the factors related to TB frequency, is refugees. One out of every four refugees is staying in camps. The living space conditions of refugees who stay in camps and outside of the camps differ. In addition, air pollution parameters are measured on a national air quality monitoring network, not on a home basis, and other pollutants such as PM2.5 and ozone are not measured in our region.

Ethics Committee Approval: This study was approved by the Harran University Ethical Committee (10.12.2018; session: 12; decision no: 36).

Informed Consent: Verbal informed consent was obtained from the patients who agreed to take part in the study.

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