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Original Article

Analyzing the Relationship Between Air Pollution, Tobacco Use with Lung Diseases via Data Engineering Approach

Ozgun Pinarer
Department of Computer Engineering, Galatasaray University, Istanbul, Turkey

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Abstract

OBJECTIVE: The objective of this study is to present the concrete impact of air pollution and tobacco use on lung disease by using a data engineering approach and acquired datasets.

MATERIAL AND METHODS: To demonstrate the relationship between the air pollution and the tobacco use with the lung diseases, various relevant datasets are acquired. These datasets present not only Turkey but also worldwide situation. Datasets used in this study present the population, industrial growth, number of motor vehicles, forest area size, tobacco use rate, air pollution, number of death due to asthma, lung disease, tobacco use and air pollution. In total, 10 different datasets are gathered to prove our objective. To achieve our objective with the acquired materials, a data engineering approach is adopted. From a data engineering point of view, each dataset represents a variable for the calculation. With the data science engineering techniques used in this study, existing relations between these variables are clearly stated. Besides, with this information, a cause-consequence matching is achieved as well. In this study, covariance, correlation analyses are executed on the datasets. Moreover, multi-linear regression is performed for the forecasting.

RESULTS: Relations between the various datasets are explored and results are divided into 3 clusters based on the relations. Among the explored relations, the most significant relation is discovered between the tobacco use rate and its effects on death rates. This relation is measured around 93-94%, which can be considered as a high risk.

CONCLUSION: Results show the concrete impacts of deforestation on air pollution, increase in tobacco use especially in easy ages causes lung disease in worldwide. These results indicate a global warning about various senses: the importance of the forest area size to balance the air quality, regulations about the number of motor vehicles, and the tobacco selling to young people are highly required.

KEYWORDS: Data engineering, air pollution, tobacco usage, pneumonia, regression analysis
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INTRODUCTION

Air pollution is one of the most crucial environmental and health problems of our world. Air pollution can cause various respiratory distress for all living things that require oxygen. The atmosphere surrounding our world has its own chemical balance. The gases that make up the atmosphere are nitrogen (N_2, 78%), oxygen (O_2, 21%), argon (Ar, 0.9%), carbon dioxide (CO_2, 0.035%). In addition, neon (Ne), methane (CH_4), helium (He), hydrogen (H_2), and krypton (Kr) gases constitute the remaining 0.001%. The balance of these chemical gases among themselves can be forced to change by foreign particles or gases, resulting in air pollution.

The direct impact of air pollution on human health has been proven by clinical studies. The low age group, infants, and children are the most affected by air pollution. Since the respiratory systems of babies and children are still in development stages, air pollution can lead to a decrease in lung function, respiratory infection, and chronic lung diseases such as asthma in this age group. In addition, exposure to air pollution during pregnancy can lead to some diseases such as autism disorder.[1,2]

Besides, air pollution is known to cause cardiovascular diseases. If exposed to air pollution at high rates or for a long time, it may cause vascular stiffness, clot formation, and heart rhythm disorders. In addition, air pollution has been proven to cause lung cancer as a result of scientific research.[3]

Apart from air pollution, tobacco use has reached dangerous levels for human health. When the published death reports are examined, the death rates due to tobacco use or passive smoking surpass the death rate in traffic accidents.[4]

In Figure 1, the causes of death in Turkey for the year 2017 are given numeric rankings. According to these statistical data, tobacco use is at the second place and air pollution is at the fifth place that causes death.

Corresponding author: Ozgun Pinarer, e-mail: opinarer@gsu.edu.tr
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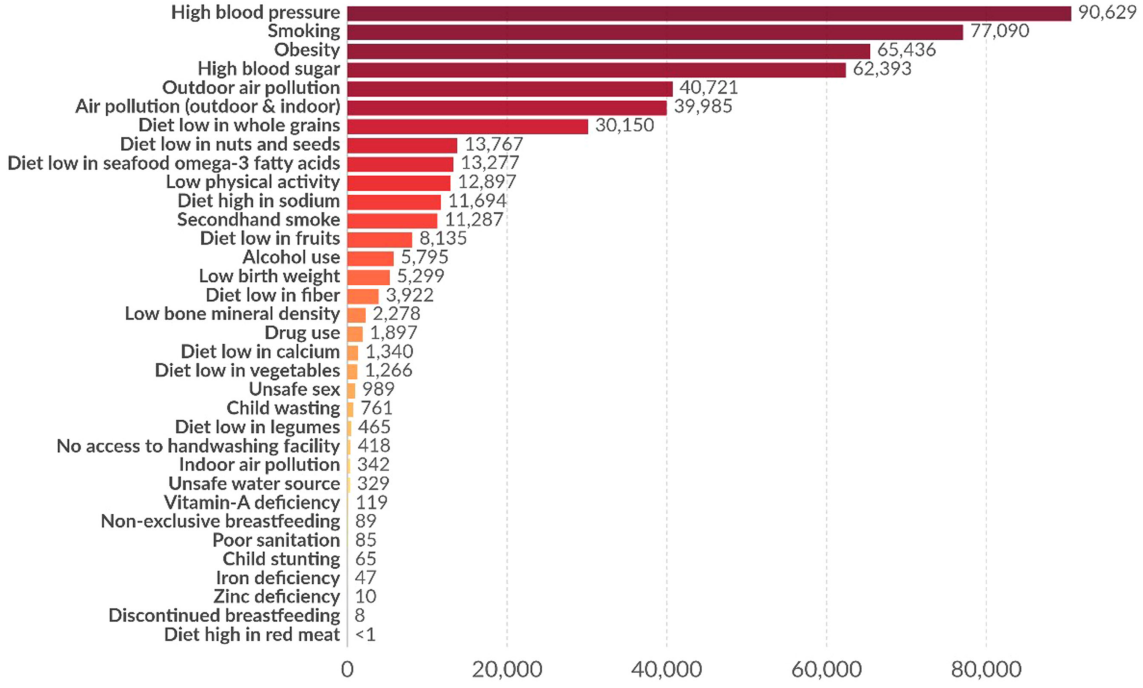


Figure 1. Causes of death in Turkey for the year 2017.[5]

In this study, the data engineering methods that have become the hottest research topics in computer engineering have been applied to acquired various datasets, and factors of death due to lung and respiratory diseases, and their effectiveness are investigated. On the basis of the death data related to the pulmonary and respiratory diseases obtained in the past, the effects of air pollution, tobacco use data, forest area data, motor vehicle, and industry growth data are gathered and their effects on each other are examined in methodology section and the results are introduced in results section.

MATERIAL AND METHODS

In this study, datasets obtained from different sources are collected and the existence of the relationship between these data is investigated by data analysis methods. The datasets used in the study are as follows (this numbering format is used when performing data analysis in the remainder of the article):

1. The population data of all countries and the number of people per km^2 between 1990 and 2017 (Dataset 1).[6]
2. Industrial growth data of all countries between 1990 and 2017 (Dataset 2).[7]
3. Number of motor vehicles of all countries between 1990 and 2017 (Dataset 3).[8]
4. Forest area sizes of all countries between 1990 and 2017 (Dataset 4).[9]
5. Tobacco and similar product use rates in all countries between 2000 and 2016 (Dataset 5).[10]
6. Particulate matter and ozone pollution data of all countries between 1990 and 2017 (Dataset 6).[11]
7. Number of deaths due to asthma in all countries between 2014 and 2016 (Dataset 7).[12]
8. The number of deaths due to lung disease and pneumonia in all countries in 2019 (Dataset 8).[12]
9. The number of deaths related to the use of tobacco and similar products in all countries between 2000 and 2016 (Dataset 9).[13]
10. Number of deaths due to particulate matter and ozone pollution of all countries between 1990 and 2017 (Dataset 10).[11]

MAIN POINTS

- Air pollution and tobacco use can lead to a decrease in lung function, respiratory infection, and chronic respiratory diseases such as asthma.
- Air pollution and the causes of death due to lung diseases throughout the world and Turkey, in particular, are analyzed.
- The factors of increase of death due to lung diseases are investigated and a mathematical model is built via data analysis techniques.
- Data engineering methods are applied on different datasets to find out the relationships between them and significant relations are determined.

Since the used datasets are open datasets and they do not indicate any personal information about the patients, ethics committee approval is not required for this study.

In the study, in Anaconda environment, Python programming language is preferred and numpy, pandas, sklearn, scipy libraries which are the most frequently used in data analysis are imported.

Relation Between Datasets

In order to obtain significant and concrete results within the study, 10 different datasets are examined. First, the existence of a direct relationship between these data is searched. To find out the relation between the datasets, the following data analysis methods are carried out respectively:

Table 1. Covariance and Correlation Analysis Results

1. Variable	Variable	Result of Covariance	Result of Correlation
Dataset 1	Dataset 6	+	0.32
Dataset 2	Dataset 6	+	0.81
Dataset 3	Dataset 6	+	0.89
Dataset 4	Dataset 6	–	–0.74
Dataset 2	Dataset 4	–	–0.62
Dataset 5	Dataset 8	+	0.93
Dataset 5	Dataset 9	+	0.94
Dataset 6	Dataset 10	+	0.88

1. Covariance Analysis.
2. Correlation Analysis.
3. Regression Analysis.

Outcome Measurements

In the literature, covariance and correlation methods are the early steps of data engineering to discover the data. Covariance analysis is used to determine the existence of relations between 2 data (+/–/N). Besides, correlation analysis is used as the severity of that relation [–1;+1]. The obtained results of the covariance and correlation analysis of the datasets are given in Table 1. The data of each country are analyzed among themselves, and their average is reflected in the table. Therefore, the results obtained do not belong to any country but are reflected worldwide.

Regression Analysis

Once covariance and correlation analysis are performed, the regression analysis is applied to the data groups whose relationships are detected. The independent variables and dependent variables in which linear regression and multiple regression analyzes are applied and determined in these analyzes are given in Table 2. According to this table, the increase in industrial growth and motor vehicles increase the amount of particulate matter in the air and ozone pollution together. The effects of both factors can be interpreted as balanced. Likewise, direct relationships were determined in deaths due to asthma, and it was determined that the increase in motor vehicles had a greater effect on deaths related to asthma. They play a concrete role in deaths due to lung diseases. With a similar approach, the effects on deaths due to particulate matter and ozone pollution are modeled mathematically and their effects are revealed.

Based on the subject matters of the gathered data, it is possible to divide these datasets into 3 subgroups. First subgroup is dedicated to respiratory and lung diseases and their reasons, second subgroup is allocated for tobacco use and its consequences, at last, third subgroup is committed to air pollution and its impact on death ratios. For each subgroups, reports, and analysis of global institutions or organizations are examined and relevant information is fetched. These numerical representations are used in our study in order to determine the concrete relations between the subject matters.

Table 2. Multiple Regression Analysis Results

1. Independent Variable (X_1)	2. Independent Variable (X_2)	Depended Variable (Y)	Multiple regression Equation
Dataset 2	Dataset 3	Dataset 6	$Y = 0.57 * X_1 + 0.69 * X_2 + 32.3$
Dataset 2	Dataset 3	Dataset 7	$Y = 0.26 * X_1 + 0.71 * X_2 + 67.32$
Dataset 2	Dataset 3	Dataset 8	$Y = 0.49 * X_1 + 0.83 * X_2 + 50.16$
Dataset 2	Dataset 3	Dataset 10	$Y = 0.68 * X_1 + 0.57 * X_2 + 16.3$

Group 1—Death Data Related to Lung Diseases: In order to show the importance of this study, the World Health Organization and the country's health institutions record their health data with great care and make sense of them as a result of data analysis studies. The health report published by the European Economic Cooperation and Development Organization in 2018 reveals the increase in the deaths related to lung diseases.

Studies in the literature indicated that respiratory diseases are responsible for 8% (400 000) of all deaths in EU countries in the year 2015. In Figure 2, for the years 2013-2015, the number of deaths due to lung diseases in EU and neighboring countries (Switzerland, Iceland, Serbia, Norway, Turkey) are given in the form of a weighted average of experienced age-based mortality rates per 100 000 people. In the mortality rates due to lung diseases, the number of men who die within the EU countries is 85% more than the number of women who died.

COPD (Chronic obstructive pulmonary disease) is another crucial disease, and in 2015, in the EU region, more than 180 000 people have died due to COPD which is equivalent to 40% of all respiratory disease deaths. Smoking, exposure to dust and chemical gases, and air pollution can trigger COPD as well.

In 2015, approximately 140 000 deaths occurred in EU countries due to pneumonia. This number constitutes more than 30% of the total number of death due to lung diseases. Figure 3 shows the comparison of mortality rates due to COPD and pneumonia in the EU and surrounding countries between 2013 and 2015.

Reports published by WHO and organizations such as the Turkish Thoracic Society reveal that respiratory diseases such as COPD are increasing day by day and are expected to reach serious levels in the near future.[14] According to the report published by the Turkish Thoracic Society COPD study group, the prevalence of COPD in Turkey is 19.2% In addition, COPD is the fourth most common disease in the world, according to WHO reports. It is expected to be the third disease for the current year. For instance, it is the fourth fatal disease in Turkey.[15]

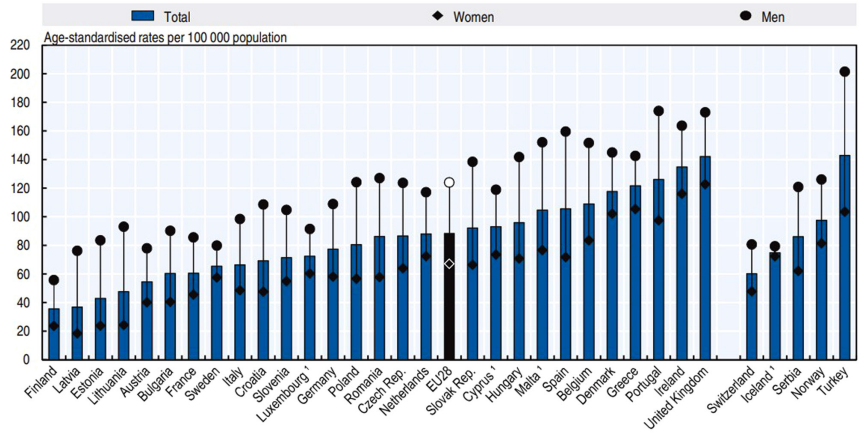


Figure 2. Comparison of mortality rates related to lung diseases in the EU and neighboring countries between 2013 and 2015.[12]

Group 2—Death Data Related to Tobacco Use: Smoking tobacco is one of the biggest health problems in the world. Day by day, unfortunately, the age to start smoking is decreasing and tobacco use is increasing. In Figure 4A, the proportion of people (aged 10 and over) who use tobacco every day is given in Turkey and 10 selected countries for the years 1990-2017. The ratio of the number of people using tobacco overpopulation in Turkey, according to these data was 20.3% in 2016. There is a huge decrease in this data considering that it was 32% in the year 1990. Especially in intercity public transport and in closed areas, the banning of tobacco consumption by law has a great effect on this issue. Nevertheless, tobacco use is the biggest problem that needs attention and threatens our health. Cardiovascular diseases are among the most common diseases. Tobacco use not only affects the lungs and breathing it also causes various vascular diseases such as coronary artery disease. The products put on the market as electronic cigarettes are similar to cigarettes, and these devices contain a number of chemicals and various foreign components other than nicotine.

Similarly, Figure 4B represents the proportion of people (aged 15 and over) who use tobacco in Turkey and 9 selected countries between 2000 and 2016.

During the 20th century, nearly 100 million people died due to the use of tobacco. According to the data of international health institutions, more than 8 million people died in 2017 due to tobacco consumption.

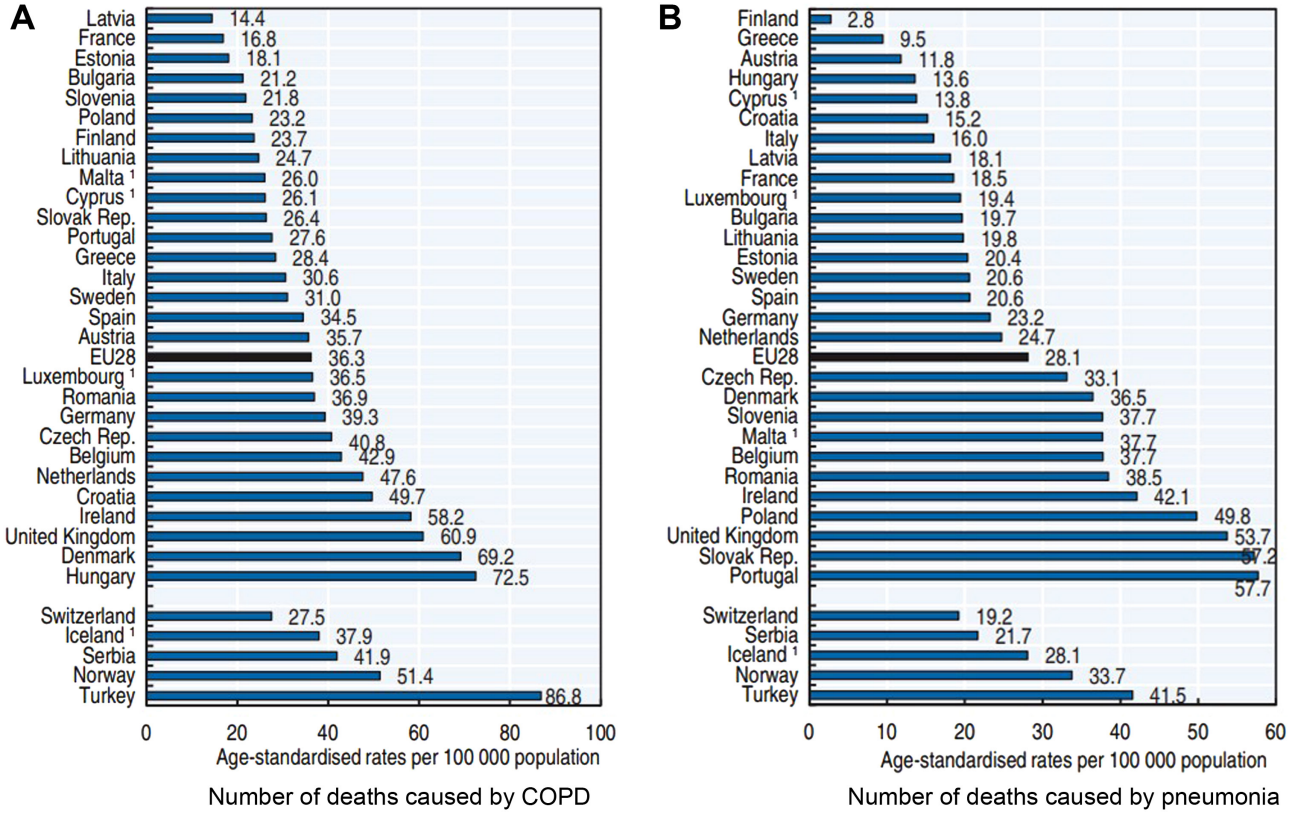
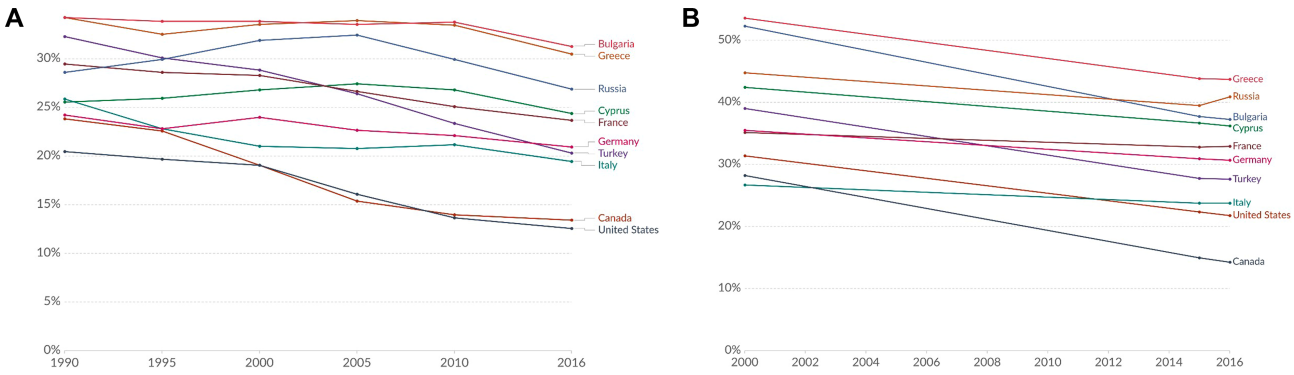


Figure 3. Comparison of mortality rates due to COPD and pneumonia in the EU and neighboring countries between 2013 and 2015.[12] (A) Number of deaths caused by COPD. (B) Number of deaths caused by pneumonia.



Proportion of people (aged 10 and over) who use tobacco every day is given for Turkey and for 10 selected countries for years 1990-2017 [10]

Proportion of people (aged 15 and over) who use tobacco in Turkey and 9 selected countries between the years 2000-2016 [16]

Figure 4. Tobacco usage statistics in Turkey and 9 selected countries. (A) The proportion of people (aged 10 and over) who use tobacco every day is given for Turkey and for 10 selected countries for the years 1990-2017.[10] (B) Proportion of people (aged 15 and over) who use tobacco in Turkey and 9 selected countries between the years 2000 and 2016.[16]

Besides the death of 7 million people consuming tobacco directly, the number of deaths due to passive smoking is quite high. It is estimated that 1.2 million people died early due to passive smoking.

Smoking is one of the primary reasons for lung disease especially lung cancer, as well as heart disease. When the death reports of 2017 are analyzed, 1 out of 7 deaths (13%) emerges as a result of direct smoking. This rate reaches 15% considering the result of passive smoking with 2% as well.[4]

Figure 5A represents death rates due to tobacco in Turkey and selected countries for the years 1990-2017 (rates per 100 000). Bulgaria and Russia have serious problems in this issue. In addition, Figure 5B represents the age distribution of deaths due to tobacco in Turkey for the years 1990-2017.

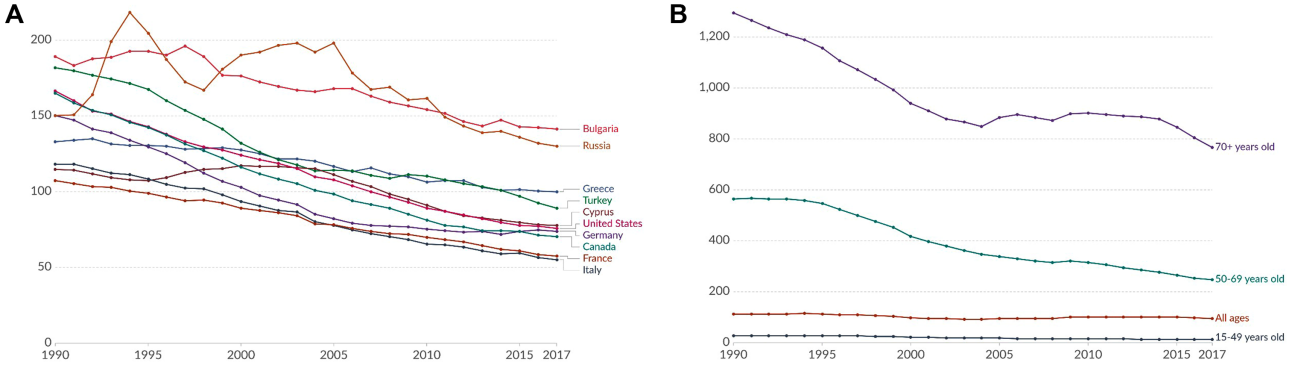
Group 3—Death Data Related to Air Pollution: There are many factors that cause air pollution: the increase in migration from the countryside to the city, rapid growth of the world population, factories opened with the growth of the industry, etc. As the migration from rural areas to cities has increased rapidly in recent years, energy consumption and fossil fuel use have also increased in cities. In addition, the number of motor vehicles is increasing day by day. All these factors have an effect on the increasing air pollution.

Air pollution can occur from natural disasters such as volcanic eruption and forest fires, as well as due to artificial reasons such as industry, traffic, and fossil waste use. As mentioned earlier, studies show that the increase in air pollution is the main cause of lung diseases and increase in deaths.[17] Both the World Health Organization and international health institutions draw attention to the importance of air pollution with their reports.[18,19]

When the issue of air pollution is examined, 3 main factors that cause pollution emerge are particulate matter, ozone pollution, and solid fuel use. Although nearly 200 factors have been reported in the literature, sulfur dioxide (SO2) and particulate matter measurement take place in its existing stations that are responsible for measuring air pollution rates. Apart from the measurement made in Turkey but with substantial effects of air pollution, carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb), and ozone (O_3) are the ratio of the gas to be aware of.

Factor Type 1 Particulate Matter (PM)

The substances suspended in the air and threatening human health are called particulate matter and are the first among the air pollutants. These particulate matter can contain heavy metallic chemicals such as lead and mercury, and due to their carcinogenic structure, they have a



Death rates due to tobacco in Turkey and selected countries for years 1990-2017 (rates per 100,000) [13]

Age distribution of deaths due to tobacco in Turkey for years 1990-2017 [13]

Figure 5. Tobacco-related mortality statistics in Turkey and 9 selected countries. (A) Death rates due to tobacco in Turkey and selected countries for the years 1990-2017 (rates per 100,000).[13] (B) Age distribution of deaths due to tobacco in Turkey for the years 1990-2017.[13]

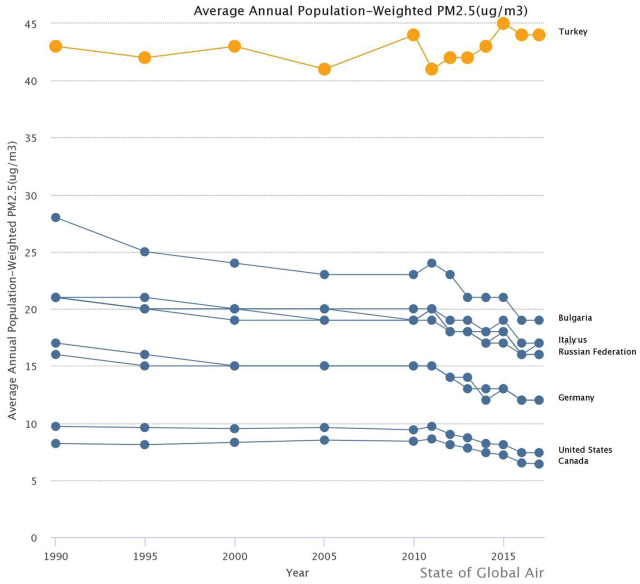


Figure 6. Particulate matter (PM2.5) concentrations of air in Turkey and 9 selected countries for the years 1990-2017 (x axis for years, y axis for μg/m³).[11]

very negative impact on human health. There are different categories according to the size of the particle, and its size and effect on human health are directly proportional. While the particulate matter is classified according to its size, 10 microns size called PM10 cannot enter the human body. However, substances under 10 microns (such as PM2.5) can reach the lungs and bronchi. Substances below 1 micron can be mixed with the blood through capillaries. Figure 6 represents particulate matter (PM2.5) concentrations of air in Turkey and 9 selected countries for the years 1990-2017.

Factor Type 2 Ozone (O_3) Pollution

Ozone is a reactive gas in the atmosphere. Since the liquid is not dissolved, it has negative effects on lung and human health. Especially in industrial areas, the balance of the atmosphere changes with the effect of gases released into the air, and ozone pollution is experienced.

Figure 7 represents the concentrations of ozone of air in Turkey and 7 selected countries for years the 1990-2017. Turkey ozone pollution (purple line) increased from 1990 to 2015. Greece and the USA are the closest countries to Turkey while ozone pollution in the EU is at a lower level.

Factor Type 3 Solid Fuel Pollution

In Turkey, although coal burning is replaced by natural gas heating, still there are regions that use coal burning for heating. Burning coal causes direct air pollution due to the high sulfur content in coal. Since coal is used as fuel especially in thermal power plants, air pollution created by these centers is quite high.[20]

Figure 8 represents the proportion of people using solid fuels in Turkey and selected countries for the years 1990-2017. The density of the solid fuel use in Turkey in the 90s was quite high compared to other countries through the expansion of natural gas usage over time could come to the level of other countries.

Interpretation of Results

In this study, various datasets are gathered, and the data engineering approach is adopted to detect the relations between these datasets. To search and discover a significant impact, datasets coming from different sources are used. Discovered relations can be clustered in 3 subgroups.

Cluster 1 Relation with Medium Impact

This cluster consists of the relation between the population of the countries and the air pollution of these countries. The relation is measured at 32%.

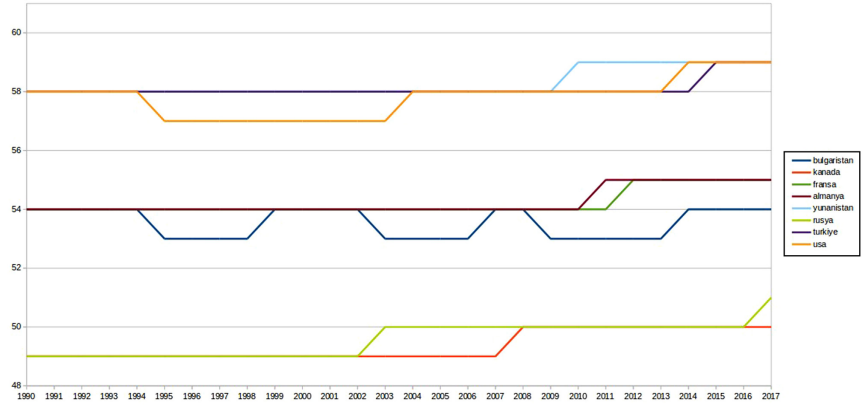


Figure 7. Concentrations of ozone of air in Turkey and 7 selected countries for the years 1990-2017 (x axis for years, y for ppb (μg/L)).[11]

Cluster 2 Relation with Strong Impact

This cluster is the core of the discovered relations. The impact of industrial growth and the number of registered motor vehicles on the air pollution are extremely high and risky for human health. This impact is measured between the interval (80-90)%. Besides, the most significant impact is explored from tobacco use rate and its effects on death rates due to tobacco use and lung diseases. This relation is measured around 93-94%, which can be considered as a high risk. Besides, the relation between air pollution and its impact on death rates is measured at 88%.

Cluster 3 Inverse Relation

On data engineering approach, the relations and the forecasts are not always positive (an increase on one side triggers another increase), in some cases, an increase may trigger a decrease on the other side. In our case, an increase in industrial growth for every country causes a decrease in forest area size for these countries. Besides, a decrease in forest area size affects air pollution, thus there exists a concrete transitive relation between these 3 datasets with an impact of around 60-75%.

DISCUSSION

Numerical reports of the institutions publish the latest numbers about the considered subject; however, the factors, reasons to cause these results are not proven enough. In our study, the gap is fulfilled and for the chosen datasets, each of them is examined and the main factors and their severity of impact on the results are determined. When the literature is reviewed, there are studies working on similar subjects; however, with our data engineering approach, our study compared to them is more technical and the results are more concrete.

There are many factors that affect human health and quality of life. Air pollution is one of the most important of these factors. The published health reports reveal a direct relationship between air pollution and lung diseases.[21] Similar studies model the air pollution rates that we may encounter in the following years and the changes in lung diseases related to this. Like these studies, Silva et al.[22,23] aim to prevent possible environmental disasters and high mortality rates that may occur in the coming years with the modeling developed within the project they carry out.[22,23]

Most of the studies in this area develop algorithms on large datasets and try to create consistent models in order to outcome meaningful results. In one of them, Chen et al.[19] investigate the factors affecting air pollution by applying big data processing methods on Chinese air pollution data.[24] In addition, Fotopolou et al.[25] developed a model on the relationship between the air pollution in big cities and country side and obtains concrete impacts on death numbers.[25]

Saygin et al.[26] and Solo et al.[27] examined the effects of air pollution and especially the increase in particulate matter rates on lung diseases and showed the relationship between the number of patients admitted to hospitals.

In addition, the effects of consuming tobacco use at a young age on human health and the effects of exposure to tobacco smoke in the working environment due to passive smoking have been examined in many studies.[28-30]

While there are many studies in the literature on Chinese air pollution and tobacco use, most studies reveal the relationship between air pollution and tobacco use data and mortality rates. This has been proven by a similar study conducted by us in which air pollution data of Turkey and neighboring countries are analyzed and the relationship between the pollution and the number of deaths is shown.[31] In the literature, although there are studies using limited local datasets, there are no studies using international datasets, especially datasets belonging to many fields that may affect each other. This study responds to this shortcoming in the literature.

With the performed study, it gives an opportunity to forecast for the near future. Besides, the government's policy about collecting data and sharing it worldwide is our main limitations that affect directly the analyzed performance.

CONCLUSION

In this study, air pollution and the causes of death due to lung diseases throughout the world and Turkey, in particular, are analyzed. The factors of increase of these data are investigated, and this study is carried out using data engineering techniques.

For data analysis, 10 different datasets are gathered and examined to detect the relations between them by using a

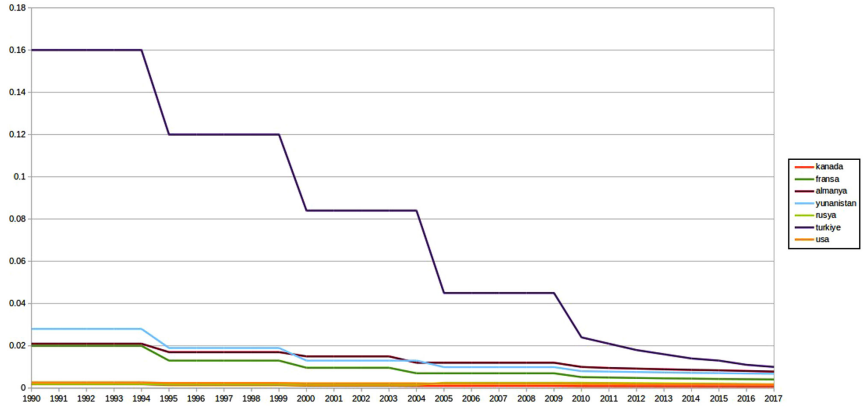


Figure 8. Proportion of people using solid fuels in Turkey and selected countries for the years 1990-2017.[11]

mathematical model with covariance, correlation, and regression methods. In this way, the relationships between the data have been revealed and the intensity of these relationships has been determined. Since the relationships between the collected datasets are analyzed, with the constructed model, a prediction for the near future can be done and relevant precautions can be discussed.

Ethics Committee Approval: This study does not require any Ethics Committee Approval.

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

Peer Review: Externally peer-reviewed.

Author Contributions: Supervision – O.P.; Design – O.P.; Concept– O.P.; Resources – O.P.; Materials – O.P.; Data Collection and/or Processing – O.P.; Analysis and/or Interpretation – O.P.; Literature Search – O.P.; Writing Manuscript – O.P.; Critical Review – O.P.

Conflicts of Interest: The author has no conflict of interest to declare.

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