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Air Pollution and Socio-Economic Determinants of Chronic Obstructive Pulmonary Disease in Albania

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ABSTRACT: Introduction. Chronic obstructive pulmonary disease (COPD) has become a global issue. The Global Burden of Disease Study reports a prevalence of 251 million cases of COPD in 2016, while it is estimated that 3.17 million deaths were caused by the disease during that period. In this paper we conduct an ecological study, to analyze the effects of socio-economic factors and air pollution on the COPD prevalence at the population level in Albania. Methods. Group-level data from 61 municipalities in Albania was used to assess the relationship between environmental exposures, living conditions, and socioeconomic factors with the prevalence of chronic obstructive pulmonary disease. Results. The regression analysis shows that for every percent increase in the concentration of PM2.5 in Albanian cities, a 32% increase in the prevalence of COPD was observed. Similarly, there was an increase in COPD prevalence associated with the increase of the urban population and the number of vehicles registered per city. It is worth mentioning that no statistically significant relationship was observed between the prevalence of COPD, smoking levels, and the Poverty Index. Conclusions. Within the limitations of an ecological analysis, these findings support an association between the prevalence of chronic obstructive pulmonary disease and environmental exposures, socioeconomic factors, and living conditions. However, there is a call to more individual-level analysis and more in-depth research to further investigate the extent of this association in Albania.

KEYWORDS: COPD prevalence, environmental, socioeconomic, PM2.5, smoking, Albania.

Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive life-threatening lung disease that causes obstructed airflow from the lung and predisposes to exacerbations and serious illness [1].

As a chronic inflammatory lung disease that affects various age-groups, it has become major global issue.

The Global Burden of Disease Study reports a prevalence of 251 million cases of COPD in 2016 [2].

Meanwhile, it is estimated that 3.17 million deaths were caused by the disease during that period, which corresponds to 5% of all deaths in the world that year [2].

In the context of Albania, the World Health Organization (WHO) Report of Lung Disease Deaths states that in 2018, the number of deaths caused by lung disease reached nearly 2.70% of total deaths that year.

The age adjusted death rate is 13.54 per 100,000 of population, which puts Albania in #157th rank worldwide [3].

According to WHO data, Albania has a prevalence of 0.3% of Chronic Obstructive Pulmonary Disease [3].

In addition to population morbidity, the costs of COPD to health services and society are substantial. Consultation rates in primary care are high and exacerbations of COPD are one of the most common causes of hospital admission.

In developed countries, exacerbations of COPD account for the greatest burden on the health care system [3].

In the European Union, the total direct costs of respiratory disease are estimated to be about 6% of the total health care budget, with COPD accounting for 56% (€38.6 billion) of this cost [4].

That is why assessing the factors that influence the prevalence of COPD is considered of high importance.

Many studies have associated COPD with socio-economic factors such as lifestyle and work-related exposures.

These studies suggest that some of the main socio-economic factors that play a key role in the development and worsening of COPD, include air pollution, tobacco smoking as well as economic status.

Typically, investigations to determine the socio-economic factors of COPD are conducted by assessing individual level data from hospitals and health centers.

In this paper an ecological study is performed to analyze the effects of socio-economic factors and air pollution on the COPD prevalence at the population level in Albania.
Methods

Overview

This study is an ecological analysis using population level data.

A cross-sectional regression among the 61 municipalities of Albania is conducted.

All the data used in this regression analysis, including the poverty indicators, belong to the year 2018.

Only the demographic data consists of projections and estimates because they were obtained from the 2011 population census.

Once compiled using Excel.exe from Microsoft Office, the data was then imported into the statistical software STATA, through which we were able to run our regression model and the necessary statistical tests.

Data used in this cross-sectional regression was gathered from multiple publicly available sources mainly in governmental websites such as the Ministry of Tourism and Environment, Ministry of Health and Social Protection as well as Ministry of Finance of Albania.

In addition, socio-demographic data was obtained from the population census of 2011 from INSTAT, the Albanian Institute of Statistics which is an independent institution under the authority of Council of Ministers.

Study Design

Since we are exploring the effects that various socio-demographic factors have in the prevalence of chronic obstructive pulmonary disease in Albania, the dependent variable in this regression model is the prevalence of COPD.

The prevalence for each one of the municipalities of Albania was calculated based on the existing cases of people diagnosed with COPD.

This regression model consists of 5 independent variables.

Based on the literature review, each one of the selected variables, indicates an existing relationship with the prevalence of COPD.

These variables were modeled and adopted for each on the 61 municipalities of Albania.

The metadata is illustrated in Table 1.

To interpret and explain the coefficients as a percentage change rather than a change in units, the natural log of each one of the variables was taken using STATA.

Our regression model is shown below:

\[
\text{COPD\_prevalence} = \beta_0 + \beta_1 \text{PM2.5\_concentration} + \beta_2 \text{smoking\_levels} + \beta_3 \text{nr\_vehicles} + \beta_4 \text{poverty\_index} + \beta_5 \text{urban\_population} + \varepsilon
\]

The literature review suggests that each one of the selected variables has a strong positive relationship with the prevalence of COPD.

A 95% confidence level was used to assess this relationship between variables.

Table 1. Metadata.

| Name of variable     | Explanation                                      |
|----------------------|--------------------------------------------------|
| COPD\_prevalence     | Prevalence of chronic obstructive pulmonary disease |
| PM2.5\_concentration | Concentration of particulate matter 2.5 in air    |
| smoking\_levels      | Rate of smoking tobacco                          |
| nr\_vehicles         | Number of vehicles registered                    |
| poverty\_index       | Poverty Index                                    |
| urban\_population    | Number of people living in urban areas           |

Note: Explanation of variables used in the regression model of this study.

Results

According to the regression model, there was indeed a positive relationship between the independent variables and the dependent variable.

However, not all the relationships were statistically significant at a 95% confidence interval.

The results of the regression are illustrated in Table 2.

Table 2. Regression analysis results.

| Variable          | Coef. | Std. Err. | P>|t| |
|-------------------|-------|-----------|-----|
| PM2.5\_concentration | 0.32* | 0.24      | 0.004 |
| urban\_population  | 0.36* | 0.37      | 0.007 |
| poverty\_index     | 0.17  | 0.27      | 0.530 |
| smoking\_levels    | 0.21  | 0.26      | 0.429 |
| nr\_vehicles       | 0.85* | 0.08      | 0.000 |

Note: Dependent variable is Log (COPD) *Denotes statistical significance at 95% confidence interval.

According to the results of the regression model, 1% increase in the concentration level of PM2.5 in the atmosphere, is associated with a 32% increase in the prevalence of COPD.

Literature review suggests PM2.5 is one of the leading factors of the development of chronic obstructive pulmonary disease.

The p-value of the PM2.5 variable in our regression model, indicates that the estimated coefficient is statistically significant.

The PM2.5 variable is not the only factor affecting the dependent variable.

The number of vehicles and the number of people living in urban areas are two variables in this regression model, whose p-values also denote statistical significance.
According to this model, a 1% increase in the number of vehicles registered in a municipality, is associated with an 85% increase in the prevalence of COPD.

This means that municipalities with higher number of vehicles, have also the highest prevalence of chronic obstructive pulmonary disease.

In addition, the regression model suggests that a 1% increase in the urban population is associated with a 36% increase in the prevalence of COPD.

Using the same rationale, municipalities with the highest percentage of urban population have also the highest prevalence of COPD.

The estimated coefficient of the smoking variable indicates a positive relationship with the dependent variable, but it does not denote statistical significance at the 95% confidence level.

This means that the publicly available data in Albania shows that indeed there is a relationship between smoking tobacco and higher prevalence of COPD but there are many other factors that need to be assessed to explain the p-value associated with this variable.

The 5th variable that was used in this regression model was the poverty index variable.

According to the regression results, 1% increase in the poverty index was associated with 17% decrease in the prevalence of chronic obstructive pulmonary disease.

Even though the regression model shows a relationship between the poverty index and the prevalence of COPD, the p-value does not indicate statistical significance.

**Five Assumptions of Gauss-Markov Theorem**

The estimated regression model has an R-squared of 0.84, which means that about 84% of the variation in the dependent variable is explained by variation in the independent variables present in our regression model.

In order for the OLS to be BLUE the five assumptions of Gauss-Markov theorem need to be satisfied.

MR1-The regression model was linear in parameters.

All the variables were in the natural log form.

Also, plotting the data in a scatter plot shows the linear nature of the regression model.

MR2-There was random sampling.

While compiling the data none of the 61 municipalities were omitted regardless weather they looked like outliers or not.

MR3-We tested for multicollinearity and made sure that there was no perfect collinearity between the variables.

Through the statistical software STATA a VIF test was run and the results indicated a slight relationship between variables with a mean VIF of 1.51.

Then, to double check the results and to specifically identify which one of the variables were correlated with one another, a correlation test was conducted and the results are shown below, in Table 3.

![Table 3. Correlation between variables.](image)

| Variable          | COPD_prevl | PM2.5_conc | urban_pop | poverty_index | smoking_level | nr_vehicles |
|-------------------|------------|------------|-----------|---------------|---------------|-------------|
| COPD_prevl        | 1.0000     |            |           |               |               |             |
| PM2.5_conc        | 0.1972     | 1.0000     |           |               |               |             |
| urban_pop         | 0.0431     | 0.6442     | 1.0000    |               |               |             |
| poverty_index     | -0.0373    | -0.0632    | 0.0107    | 1.0000        |               |             |
| smoking_level     | 0.0151     | -0.5485    | 0.4988    | -0.0248       | 1.0000        |             |
| nr_vehicles       | 0.6988     | 0.1782     | 0.2371    | 0.0082        | -0.0162       | 1.0000      |

Note: Results from a correlation test conducted to test for Multicollinearity.
If |x|<0.5 variables are not correlated. A slight relationship between PM2.5_conc and urban_pop; COPD_prevl and nr_vehicles can be observed.

MR4-The zero conditional mean assumption was not violated.

By including all these variables, we are assuming that there are no other variables in the error term that might affect the dependent variable.

MR5-A Breusch Pagan test was performed to test for heteroscedasticity.

The results did not indicate any form of heteroscedasticity.

To double check the results, we scatter plotted the fitted values with the residuals and indeed the regression model is homoscedastic.

Since none of the 5 assumptions of multiple regressions were violated, we could say that the regression model is mostly accurate, and the coefficients are unbiased as well as efficient.
Discussion

For the most part, the findings of our ecological analysis were very consistent with previous studies done in regard to individual-level association between socioeconomic factors and COPD.

In addition, the expected relationship between the variables matched the hypothesis, except for the poverty index variable, which showed a negative relationship with the prevalence of COPD.

The literature suggests that there is a very strong positive relationship between the prevalence of chronic obstructive pulmonary disease and various socioeconomic factors, including the environment, living conditions and behavioral factors.

However, the regression results suggest that the main determining factors of COPD in Albania are environmental factors and not so much the behavioral ones.

This comes because of only 3 variables showing statistical significance: the concentration of PM2.5, the number of urban population and the number of vehicles.

The other two variables did not show any statistical significance.

Many studies suggest that air pollution, especially PM2.5, is a determining factor of the development and worsening of COPD morbidity.

The term fine particles, or particulate matter 2.5 (PM2.5), refers to tiny particles or droplets in the air that are two-and-one-half microns or less in width [5].

They are considered the most dangerous form of air pollution because they can travel deeply into the respiratory tract, reaching the lungs [6].

Studies have suggested that long term exposure to fine particulate matter may be associated with increased rates of chronic bronchitis, reduced lung function and increased mortality from lung cancer and heart disease.

A study conducted in the Chinese population, concluded that prolonged chronic exposure to PM2.5 resulted in decreased lung function, emphysematous lesions, and airway inflammation [14].

Most importantly, long-term PM2.5 exposure exacerbated cigarette smoke-induced changes in COPD [12].

According to the regression conducted in our study, the relationship between the prevalence of COPD and the PM2.5 levels is as strong and determinant as the literature suggests.

This means that in cities with higher concentration of air pollutants, there is a higher prevalence of COPD.

In addition, cities with higher concentration of air pollutants are the ones with the highest population density, and as a consequence with the highest number of cars.

This could explain the reason why these three variables showed statistical significance in our regression.

Looking at table 3, it is clearly shown that there is a slight positive relationship between these three variables.

However, this relationship is not strong enough to show multicollinearity, and based on the correlation test that we conducted these results are acceptable.

According to previous studies, smoking is another determining factor of COPD morbidity.

Tobacco use is considered as a risk factor for six of the eight leading causes of deaths in the world including respiratory and cardiovascular diseases, stroke and several malignant diseases [7].

The most effective available treatment for COPD is smoking cessation.

Evidence shows that the rate of progression of COPD can be reduced when patients at risk of developing the disease stop smoking, while lifelong smokers have a 50% probability of developing COPD during their lifetime [8].

More significantly, there is also evidence that the risk of developing COPD falls by about half with smoking cessation [13].

The prevalence of smoking in Albania is slightly higher compared to other western societies.

Data from Tobacco Atlas show that almost 40.9% of men, and 6.1% of women consume tobacco daily in Albania and in 2016, 25.24% of death in men and 9.1% of death in women were caused by tobacco consumption [9].

Because smoking rates are slightly higher than the European standard, we anticipated a strong and positive relationship between the smoking variable and the prevalence of COPD.

Our ecological study demonstrated that, indeed there was a positive relationship between smoking and the prevalence of COPD in Albania, but this relationship was not statistically significant.

This could be since the regression is based on population level data, which means that the margin of error could be a little bit higher compared to an individual-based approach.
The smoking rate is an estimate that was calculated based of individual-level exposure to cigarettes. As an estimate it does not fully represent the whole population characteristics in regard to smoking.

Even though the regression results show a positive relationship between smoking and the prevalence of COPD, this relationship is not statistically significant because it is challenging to portray a legitimate causal relationship in an ecological study.

The Poverty Index is another important factor that according to the literature, is strongly connected to the COPD morbidity.

The Human Poverty Index (HPI) was introduced in 1997 in the Human Development Report by the United Nations and is an indication of the poverty of community in a country, which assesses three elements of deprivation-longevity, knowledge, and a decent standard of living [10].

Although, smoking remains the single most important cause of obstruction, a high prevalence of restriction associated with poverty could explain the high ‘COPD’ mortality in poor countries [11].

However, our regression results demonstrated that there was a negative rather than a positive relationship between these two variables.

This means that the poorer the city the lower the prevalence of COPD.

This is certainly a result that we did not anticipate, nor the literature suggested.

Usually, living conditions are an important factor associated with COPD prevalence, mainly because people living in poverty tend to not have access to proper hospital services, which causes the advancement of the disease.

This could not be similar for Albania since there is universal care, and patients which show early symptoms of COPD are treated in primary and secondary care setting.

Regardless of wealth, people receive the same medical treatment and because of that the Poverty Index could not be a determining factor for COPD prevalence in Albania.

Another reason why this relationship resulted negative, could be the way the poverty index was estimated for each one of the 61 municipalities, which might not have truly represented the poverty levels of these municipalities.

In comparison to the three population-based indicators, which resulted statistically significant in our ecological analysis, the smoking rate and the Poverty Index provide a population-based measure estimated from individually assessed smoking rates, longevity, knowledge, and a decent standard of living.

This might be the main reason why the smoking variable and the Poverty Index did not show a statistically significant relationship with the prevalence of COPD in Albania.

**Conclusions**

In this paper an ecological study was conducted to analyze the effects of socio-economic factors and pollution on the COPD prevalence at the population level in Albania.

More specifically, we assess whether the concentration of PM2.5, smoking levels, the Poverty Index, number of urban population and the number of vehicles in the city have an effect in the prevalence of COPD in Albania.

The literature review shows a clear causal relationship between these variables and the prevalence of chronic obstructive pulmonary disease, especially in regard to individual-level exposure.

The regression model conducted in this study portrays similar results, where 4 out of 5 variables showed a positive relationship with the prevalence of COPD, and 3 out of the 4 variables that were connected positively showed statistical significance.

According to this ecological study, the main causal factors of chronic obstructive pulmonary disease are environmental factors.

As such, environmental exposures need to be taken into consideration when studying the prevalence of chronic obstructive pulmonary disease.

Even though there are many studies around the world that suggest a strong relationship between socioeconomic factors, environmental exposures and the prevalence of COPD, this is not the case with Albania.

The main issue remains the lack of individual based publicly available data.

Therefore, there is a great need for more individual-level analysis and research to show the extent to which environmental exposures, living conditions and socioeconomic factors affect the prevalence of chronic obstructive pulmonary disease in Albania.

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Conflict of interests

None to declare.

References

1. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS medicine, 2006, 3(11):e442.
2. Vos T, Allen C, Arora M, Barber RM, Bhutta ZA, Brown A, Carter A, Casey DC, Charlson FJ, Chen AZ, Coggeshall M. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. The lancet, 2016, 388(10053):1545-602.
3. WHO. Lung Disease in Albania. World Life Expectancy. 2018. [online] Available at: https://www.worldlifeexpectancy.com/albania-lung-disease [Accessed 03.11.2020].
4. WHO. Prevalence of chronic obstructive pulmonary disease. European health information at your fingertips. 2021. [online] Available at: https://gateway.euro.who.int/en/indicators/hfa_403-2510-prevalence-of-chronic-obstructive-pulmonary-disease/visualizations/#id=19388 [Accessed 03.11.2020].
5. Department of Health New York State. Fine Particles (PM 2.5) 2018 [online] Available at: https://health.ny.gov/environmental/indoors/air/pm_q_a.htm [Accessed 03.11.2020].
6. Zhao J, Li M, Wang Z, Chen J, Zhao J, Xu Y, Wei X, Wang J, Xie J. Role of PM 2.5 in the development and progression of COPD and its mechanisms. Respiratory research, 2019, 20(1):1-3.
7. WHO. Tobacco. World Health Organization Response. World Health Organization; 2021. [online] Available at: https://www.who.int/health-topics/tobacco#tab=tab_1 [Accessed 03.11.2020].
8. Lundback B, Lindberg A, Lindstrom M, Rönmark E, Jonsson AC, Jönsson E, Larsson LG, Andersson S, Sandström T, Larsson K. Not 15 but 50% of smokers develop COPD? Report from the Obstructive Lung Disease in Northern Sweden Studies. Respiratory Medicine, 2003, 97:115-122.
9. Tobacco Atlas. 2020. [online] Available at: https://tobaccoatlas.org/. [Accessed 03.11.2020].
10. Human Development Reports. The 2020 Global Multidimensional Poverty Index (MPI) | Human Development Reports. 2020 [online] Available at: http://hdr.undp.org/en/2020-MPI. [Accessed 03.11.2020].
11. Bumey P, Jithoo A, Kato B. Chronic obstructive pulmonary disease mortality and prevalence: the associations with smoking and poverty-a BOLD analysis. Thorax, 2014, 69:465-473.
12. World Health Organization. Health effects of particulate matter. In: Editors (Eds): Policy implications for countries in Eastern Europe, World Health Organization Regional Office for Europe, 2013, Copenhagen, 6-7.
13. Laniado-Laborín R. Smoking and chronic obstructive pulmonary disease (COPD). Parallel epidemics of the 21 century. Int J Environ Res Public Health, 2009, 6(1):209-224.
14. Lu, F., Xu, D., Cheng, Y., Dong, S., Guo, C., Jiang, X., & Zheng, X. Systematic review and meta-analysis of the adverse health effects of ambient PM 2.5 and PM 10 pollution in the Chinese population. Environmental research, 2015, 136:196-204.

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