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A STATISTICAL INVESTIGATION ON THE INCIDENCE OF TUBERCULOSIS ON FIVE FORMER COMMUNIST COUNTRIES (1995-2011)

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Abstract: *The object of this research paper is the analysis of tuberculosis (TB) through 17 yearly probes. The methodology of research consists mainly on statistical tests and models. The added value of this paper derives from the inclusion of economic terms together with social-lifestyle associated terms in order to determine which category is best associated with TB and thus should be paid more attention to. One of the conclusions of this research was that, as suspected, GDP/capita plays an important role in the incidence of TB, together with health expenditure/capita.*

Key words: *tuberculosis, incidence, statistic model.*

1. Introduction

Given the current macroeconomic context worldwide, characterized by worsening social and economic conditions, we strongly believe that TB incidence rate should be given more attention, as the consequences of this downturn could result in significant degradation of living conditions, high unemployment rates, low income, food deprivation, water deprivation, inappropriate living condition, drug abuse and thus a higher rate of TB incidence.

2. Material and Methods

Similar studies assessing tuberculosis incidence and prevalence have been performed by various specialists in the field, worldwide. Achcar, Martinez et al. concluded in a study investigating the prevalence of tuberculosis in New York City that the incidence of TB disease presented three trends between 1970-2000 based on the success of governmental programs and input: two declining trends-associated with good control programs, implementation of directly observed therapy, and an increasing trend associated with a systematic dismantling of public-health infrastructure of control programs [1].

A similar study was conducted by Guimarães, Lobo et al., examining data on the incidence and prevalence of TB, between 1990 and 2010 [2]. Regarding the incidence of tuberculosis the study revealed a downward trend in Brazil and the Americas and an upward notable trend in Africa, which was found to contribute to the global burden of disease. The author concluded that social deprivation, particularly in areas with poor housing,

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high unemployment rates, and low income, should increase awareness regarding TB incidence.

Oxlade and Murray investigated the mechanisms by which poverty increases the risk of TB [4]. The study revealed that almost all known TB risk factors were more common among the Indian poor, as those in the poorest strata frequently share multiple risk factors for active TB. Among the 49% of the poorest quintile who share low BMI and indoor air pollution, TB risk is increased compared to the same strata without either risk.

Our research is based on similar methodology employed in the above mentioned studies.

The aim of this paper is to investigate the relationship between tuberculosis incidence and a series of variables on a sample of five former Communist bloc countries: Bulgaria, the Czech Republic, Romania, Slovenia and Slovakia, during the period of 1995-2011, by using the apropriate methodology in the field, based on statistic models and previous similar studies.

The explanatory variables used in the empirical model include, but are not limited to: water pollution, CO_2 emissions, GDP/capita, literacy rate, health expenditure per capita, alcohol consumption per capita (liters), average calories/day/person.

The data gathering method employed annual samples from the World Bank and the World Health Organization websites [5, 6]. The research is based on a time period of 17 years.

3. Results and Discussions

Incidence of tuberculosis is the estimated number of new pulmonary, smear positive, and extra-pulmonary tuberculosis cases. The graphic below shows the incidence rate of TB in the 5 analyzed countries between 1995-2011.

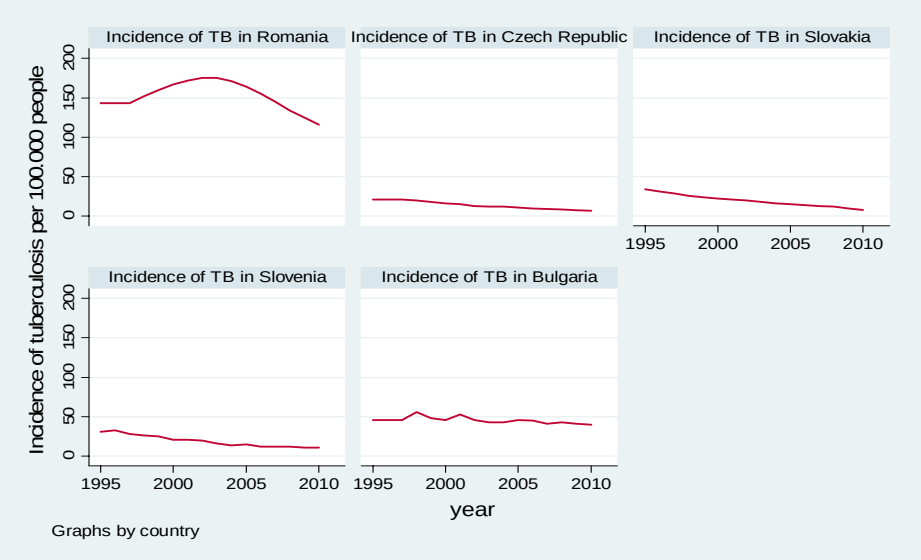

Fig.1. *Incidence of tuberculosis (1995-2011)*

All countries have values that range between 0-50 per 100.000 people, with the notable exception of Romania, who's TB incidence rate spiked over 150 cases

between 1998 and 2006, thus resulting in an upturn trend in that period and a downturn trend from 2006 to 2011, compared to the Czech Republic, Slovakia and Slovenia where there has been a constant decrease in TB incidence throughout the analyzed period of time.

A strong association between per capita GDP and TB incidence has been well established and thus we've included GDP/capita (USD) as a potential factor of interest. When developing this study we planned on including the literacy rate, the prevalence of under nourishment and the number of cigarettes smoked daily per person. Such data was unfortunately unavailable for the full analyzed period of time and we had to ignore its impact. We did include water pollution from the chemical industry (% of total BOD emissions), CO2 emissions from transport (million metric tons), pure alcohol consumption per capita (liters), the average number of calories available per day per person (Kcal), together with health expenditure (the sum of public and private) per capitain current U.S. dollars. This variable covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation.

Throughout our study we used cross-sectional time-series data that originate primarily from the World Bank and World Health Organization statistic databases [5, 6]. The results were computed using the Stata 11 software [3].

First, we ran a Hausman test in order to determine the regression method to be applied, fixed or random effects. The computed results revealed:

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  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
          =       17.50
Prob>chi2 =       0.00
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Hence we can conclude that the appropriate method of use is the fixed effects regression.

One important characteristic of panel data consists of the potential presence of heteroskedasticity. We addressed the issue by performing a modified Wald test.

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Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (5)  =     247.70
Prob>chi2 =     0.0000
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The computed results reject the null hypothesis of homoskedasticity and conclude heteroskedasticity. In order to address the problem of errors that are not independent and identically distributed, we use robust standard errors.

Another test we performed was the Pesaran CD test, a cross-sectional dependence test used to determine whether the residuals are correlated across entities.

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Pesaran's test of cross sectional independence =    -1.101, Pr = 0.2710

Average absolute value of the off-diagonal elements =    0.386
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The result sugest no cross-sectional dependence.

The computed results using fixed effects regression with robust errors are shown in the table below:

Table 1

Results of the fixed effects regression with robust standard errors

Variable	**Estimated coefficient level**	**p-value**
Waterpolution	-1.0085	0.228
CO_2 emissions from transport	0.9782	0.179
Ln ($_{GDP/capita}$)	-7.6405	0.152
Pure alcohol/capita (liters)	-1.0014	0.193
Calories/day/ person Kcal	0.0429	0.000
Healthexpenditure/capita (USD)	-0.0189	0.011
_const	10.9833	
N	62	
R^2	99.17%	
F(6,51)	11.01	
Prob>F	0.0000	

The total number of observations is 62. Based on the coefficient of determination we can conclude that 99.17% of the evolution of the TB incidence is explained by the predictors chosen in our model. The p value of F-statistic is 0.0000, thus resulting in a statistically significant joint effect of all explanatory variables on the TB incidence.

We notice that water pollution, alcohol consumption and CO_2 emission don't seem to have a potential influence upon the evolution of the TB incidence rate for the five analyzed countries, as the p values pertaining to the predictors themselves do not show a visible impact, being over the 0.1 threshold.

The slope for the explanatory health expenditure per capita is - 0.0189. This indicates that the incidence of TB rate could be expected to increase by 0.0189 cases per 100.000 people for each additional 1 USD decrease in the GDP/capita ratio. Similarly, for health expenditure per capita, a more subtle interpretation of the result compares two countries that have the same values for all of the other explanatory variables but who differ by 1 USD in their health expenditure per capita ratio. We would expect the country with the lower health expenditure per capita to have tuberculosis incidence rates that exceed those of the other country by 0.0189 people in 100.000.

Based on the p value for each explanatory variable, in the regression table above, we determined two statistically significant variables with potential impact over the TB incidence: the average number of calories per day and the health expenditure per capita.

Therefore, we reran the fixed effects regression with robust standard errors, based on the two explanatory variables that proved a potentially statistically significant impact upon the TB incidence, over the analyzed period of time. We also took into consideration, as a potentially influential factor, the GDP per capita natural logarithm as the p value associated with it was very close to 0.1.

The computed results are shown the table below:

Table 2

Results of the fixed effects regression with robust standard errors -3 variables

Variable	Estimated coefficient level	p-value
ln(GDP/cap)	-7.1753**	0.025
Calories/day/person	0.0203*	0.068
Health expenditure/capita(USD)	-0.0084***	0.023
_cons	56.0430	
N	75	
R^2	98.45%	
F(3,67)	34.72	
Prob>F	0.0000	

The dependent variable is the incidence of TB. The table shows the estimated coefficients and their significance level (*10%; **5%, ***1%).

The total number of observations increased to 75. Based on the computed results we can conclude that 98.45% of the incidence rate of TB is explained by the predictors chosen in our model. The p value of F-statistic is 0.0000, resulting in a discernible collective effect, as the coefficients of the explanatory variable do not simultaneously equal zero.

The slope for ln (GDP/capita) is -7.17. This indicates that the incidence rate of TB could be expected to increase by 7.17 for each additional unit growth in the ln (GDP/capita).

Similarly, the health expenditure per capita (USD) has a negative impact on the TB incidence rate.

4. Conclusions

A subtle interpretation of the results compares two countries that have the same values for all of the other explanatory variables but who differ by 1 USD per capita in their health expenditure. We would expect the country with the lower health expenditure per capita to have TB incidence rates that exceed those of the other country by 0.0084 people per 100000 people. As mentioned in the beginning, health expenditure per capita covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health, but does not include provisions for water and sanitation. This may not appear to be a significantly high number, but when considering a population of 21.3 million such as Romania's in 2011, this would be the equivalent of a 1.78 people increase in a year in the incidence of TB only from dropping health care costs. Similarly, for the Czech Republic, would result in a 0.88 people increase. Assuming that due to macroeconomic conditions all 5 analyzed countries would decrease their health expenditure by 1 USD per capita in a year, this could result in an a combined increase of 4 people suffering from TB in this region, and vice versa, should all countries increase their health expenditure by 1 USD per capita, this would result in a dropping TB incidence rate by 4 people/year only in this region. This calls for more prudent government cuts in healthcare.

The slope for average calories available per day per person is 0.02 resulting in a positive linear relationship between calories intake and the incidence of tuberculosis. The result seems surprising as normally TB is associated with a low

calorie intake rather than a high one, but we have to take into consideration the typical diet in the region which is high on carbohydrates. Based on the computed results we conclude that people in the 5 analyzed countries should concentrate on a healthier diet, with a low carbohydrates intake.

This research has been conducted on a two tier approach by attempting to analyze the incidence of tuberculosis from an economic and social perspective. There may be, of course, other variables to be included in a statistical model of TB analysis; therefore our approach cannot be considered a general one.

However, it drives a point when it comes to government budgetary policies and cuts and it proves the general assumption, confirmed also by the previously mentioned studies that there is astrong association between per capita GDP and TB incidence.

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