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Respiratory Health Effects Caused by the Proximity to an Industrially Polluted Area of the Arieş River Basin, Transylvania, Romania

Camelia-Maria KANTOR[1]

[1] *Claflin University South Carolina, USA*

E-mail: ckantor@claflin.edu

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ABSTRACT

This study represents the efforts in identifying a possible connection between the close proximity of one village, Mihai Viteazu, Transylvania, Romania, to the former industrial platform of the Turda city and the causes of the population's respiratory health condition, study based on survey data. Consequently, 150 health face-to-face interviews were undertaken in Mihai Viteazu in August 2009 (out of which only 117 were relevant) and 50 from the control area, in search for indicators of significant respiratory symptoms due to exposure to chemical compounds and/or conditioned by periods of employment in one or more of the polluting industrial plants. The two main objectives were to first determine whether there was a significant difference between the health of the population living in the exposed area as compared to the control population represented by the Miceşti village, situated on the other side of the two towns, out of the exposed area's influence, and second, to identify whether those involved in industrial activities would be the most affected. The results concluded that close proximity to the industrial area and employment at the former plants can be associated with higher risk for chronic respiratory diseases, the exposed village registering a 57% of its surveyed population manifesting at least one sign of acute and/or chronic respiratory disease (tuberculosis, chronic bronchitis asthma, pulmonary emphysema) and/or higher incidence of irritant respiratory symptoms. From discussions, it also seems that the population is generally aware of the possible effects, but would still prefer being employed and working for the former plants, the industry representing for most of them employment stability and better living conditions.

1. INTRODUCTION

The first objective of the present study was to determine whether there was an excess of adverse respiratory and irritant health outcomes in the population who worked in or lived close to the industrial facilities as compared to the control area. Initially, two villages were chosen as exposed areas, Mihai Viteazu and Bogata, both being situated in close proximity of the industrial platform (cca. 4km, 2 km respectively). Bogata was however eliminated from the calculation because of a dominant variable, the existence of the pig and poultry farm in Bogata that would have given an incorrect interpretation, the farm being an important factor of pollution in the area. Therefore, the exposed village Mihai Viteazu, has been compared to the control village, Miceşti (15 km from the platform). Our two hypotheses are: one, industrial activities developed in Turda might be the main factors of the incidence of respiratory diseases and symptoms of increased sensitivity in the local population situated in close proximity to the site; and two, those involved in industrial activities would be the most affected. Therefore, age was identified as our constant dependent variable, while the independent variables were considered as being: sex, education, smoker/non smoker, occupation, hearth diseases, cough, phlegm, cough and phlegm, wheezing, short of breath, and

known respiratory diseases. In order to avoid that the sampling bias carries the potential for a larger error (convenience sampling had to be used because of the locals' reticence to completing surveys), the *"convenience sampling"* was also chosen based on a carefully planned selection of people living in every part of the village (every street was covered). Seen the nature of the survey questions and the local rural culture, the analysis would also take into consideration the locals' possible tendency of lying about their health.

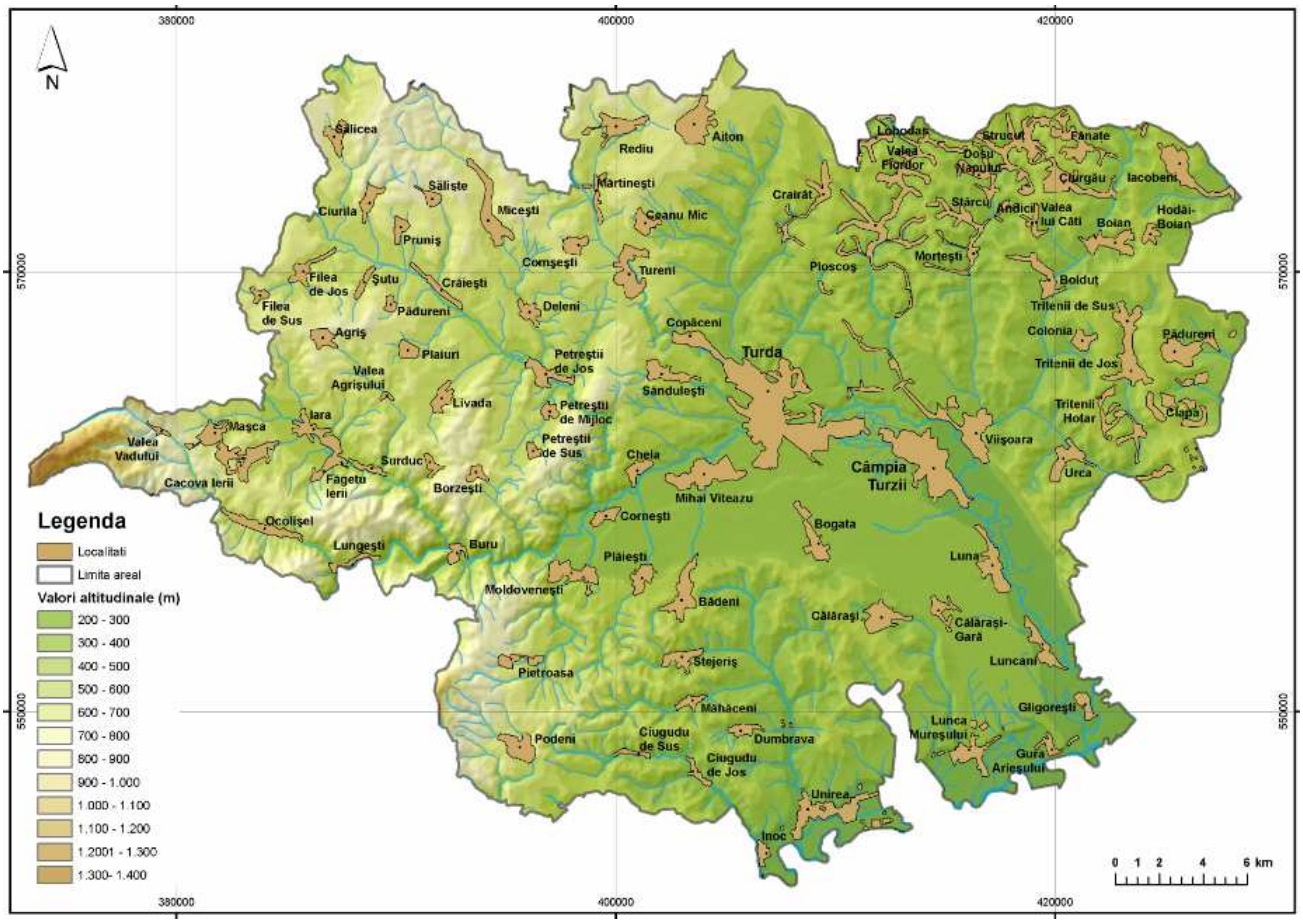

Fig. 1. GIS map of the surveyed area (two exposed and one control area).

1.1. Industrial pollutants

Favourable geographical position, natural resources and the fertile Aries basin insured the favourable conditions for the population living in the Aries River Basin area. Turda city played a critical role since the Daco-Romans by connecting the Apuseni Mountains area to the Apulum gold and salt mines on the Mureş River. The wide variety of rocks in the Aries basin, the methane gas in the Transylvanian Plain, the salt, as well as the favourable infrastructure and position in the hearth of Transylvania resulted in a more intense natural economic development in the area. Early twentieth century marks the emergence of large industrial units and the expanding the old capitalist units, Turda quickly becoming a prosperous industrial city. Therefore the following industry areas will be developed:

1.1.1. The extractive industry

The extractive industry is represented by mining for metals such as Jurassic limestone (Trascău Mountains), widely used in cement and lime production in Turda, gypsum and alabaster from Cheia, used to make plaster and certain handicrafts objects , quartz sands from Făgetu Ierii, for the manufacture of glass and silicon carbide and clay, gravel and sand from the river beds. Processing of many of the metallic resources also took place, in the industrial area of Turda: decorative alabaster, quartz feldspar and quartz flour (for the ceramic industry, glass and other building materials), crushed gypsum (for cement and plaster), scouring powder and prepared dolomite (for the ceramic industry, glass and steel building materials). Materials like cement, sand, lime and plaster were used to obtain tile adhesive and tiles, or plaster for finishing construction kits for grouting and other adhesives.

1.1.2. The Building materials industry

Building materials industry, defined as non-metallic mineral products industry used to be a main economic branch of the lower basin of Aries. Among its

sub-branches (binders, cement, lime and plaster, precast concrete, some insulating materials, abrasives, glass and ceramic fine and gross), binders industry was the best represented at the Turda cement factory producing appreciable quantities of cement clinkers, Portland cement, white Portland cement and lime. Another sub-branch, the ceramics and abrasives industry was characterized by quite complex manufacturing products that could be grouped in relation to the raw material used: fine pottery, refractory ceramic and materials abrasive also produced in units located in Turda. Later on there will be produced refractory bricks containing more than 93% silicon, with or without alumina (type silica), and mortar fire of the same type, and adding thereto a section of Turda Cement Company, where he works with fire brick aluminum oxide and silica content exceeding 50% by weight.

1.1.3. The chemical industry

Turda has a troubled history because of his *"Chimice"* plant, the former factory *"Solvay"* built in 1911 on the ruins of the former pulp mills. Initially the "Solvay" factory produced products were caustic soda, lime chloride and liquid chlorine (chlorine gas initially being destroyed by neutralization with lime) sold only in 1927. From 1921 until after the nationalization of the factory, "Solvay" Turda began to manufacture other types of chemicals, namely: liquid chlorine, hydrochloric acid, chemically pure sodium hypochlorite, ferric chloride and carbon tetrachloride. After 1950 the chemical plant *"Chimice"* diversified its production: chlorinated toluene, chloroform, monoclorbenzen, Detoxen, hexacloran, polyvinyl chloride, doubling its production capacity of its Electrolysis section, liquid chlorine, carbon tetrachloride, etc.

"Silica" was founded in 1949 as part of the building materials industry, the core activity being the production of bricks, later introducing (in 1984), a new highly polluting section producing silicon carbide. New products will be introduced in chemical plants since 1973 in Turda (potassium carbonate, potassium hydroxide, vinyl chloride, copolymer, Freon 12, anhydrous ferric chloride, Benzaldehyde, zinc chloride, fluoride and ammonium bifluoride, potassium persulphate). After 1977, different mixtures of pesticides are added to the production (Ridomil, turdazin, cuprozir) for use in agriculture to control pests, the production and export of copper oxychloride being highly intensified. During the year 1983 new products are added: type PVC emulsion 72-75, Ridomil turdazin, cupric chloride, copper hydroxide and Trilon B.

2. MATERIAL AND METHOD

2.1. Design

A cross-sectional survey was designed to determine the prevalence of respiratory and irritative symptoms in the population living near the exposed area as compared with the control area, the village Miceşti. Sampling of 250 people from both the exposed and non exposed areas took place from July to August 2009 (the total number includes Bogata as well). A number of 150 people were surveyed in Mihai Viteazu and other 50 from Miceşti, the control village. After dropping the inconsistent or incomplete surveys, only 117 surveys were used from Mihai Viteazu. Sample population selection was obtained quasi randomly, however only from more accessible sites (local institutions, local bar, private homes of people met on the street and convinced to accept taking the survey) because of people's reluctance to give personal information and/or to spend time answering the questions. However, special attention has been given to the coverage of the entire area of the village by covering sample population from each and every street, as well as to keeping a balance of males and females. Rural culture was an important obstacle in obtaining the information because of people's fear and shame in presenting themselves as sick or possibly sick. Culture has been identified as extremely important for the response bias, starting from the psychological types of surveys where people might be lying about their health. However, as it cannot be quantified, it cannot be used as a variable in our data analysis.

2.2. Defining the study population

Turda has a main industrial platform located on the right side of the Aries river, in the SW area of the city, ranging between DN1 rail input and Turda - Câmpia Turzii downstream, which hosts most of the polluting economic units. Dysfunctions that have occurred between the platform and its neighbouring areas were mainly caused by its location, prevailing winds carrying air pollutants toward the old downtown area and residential areas situated in its proximity. The other two areas of economic activities located in the immediate vicinity of the residential areas are the Oprişani Industrial Zone (fig. 2). Mihai Viteazu has been however chosen instead of the urban residential areas found in very close proximity to the site mainly because of the high number of workers commuting back and forth from the village toward the industrial platform. At one point, Mihai Viteazu was considered an *"industrial dormitory"* due to the high dynamics of its population. By analyzing the demographic data (figure 2) of the exposed area as compared to the control area, it is fairly evident that the population growth in Mihai Viteazu has been following the industrial evolution of the city, with continual growth from 1857 (manufacturing industry) to 1977 (technological industry), registering a serious decline from the years to follow as a consequence of high levels of pollution and industry gradual decline. In Miceşti, however, the population only grew from 1857 to 1966, to decrease steadily thereafter as a consequence of youth permanent migration toward the cities (Cluj and Turda).

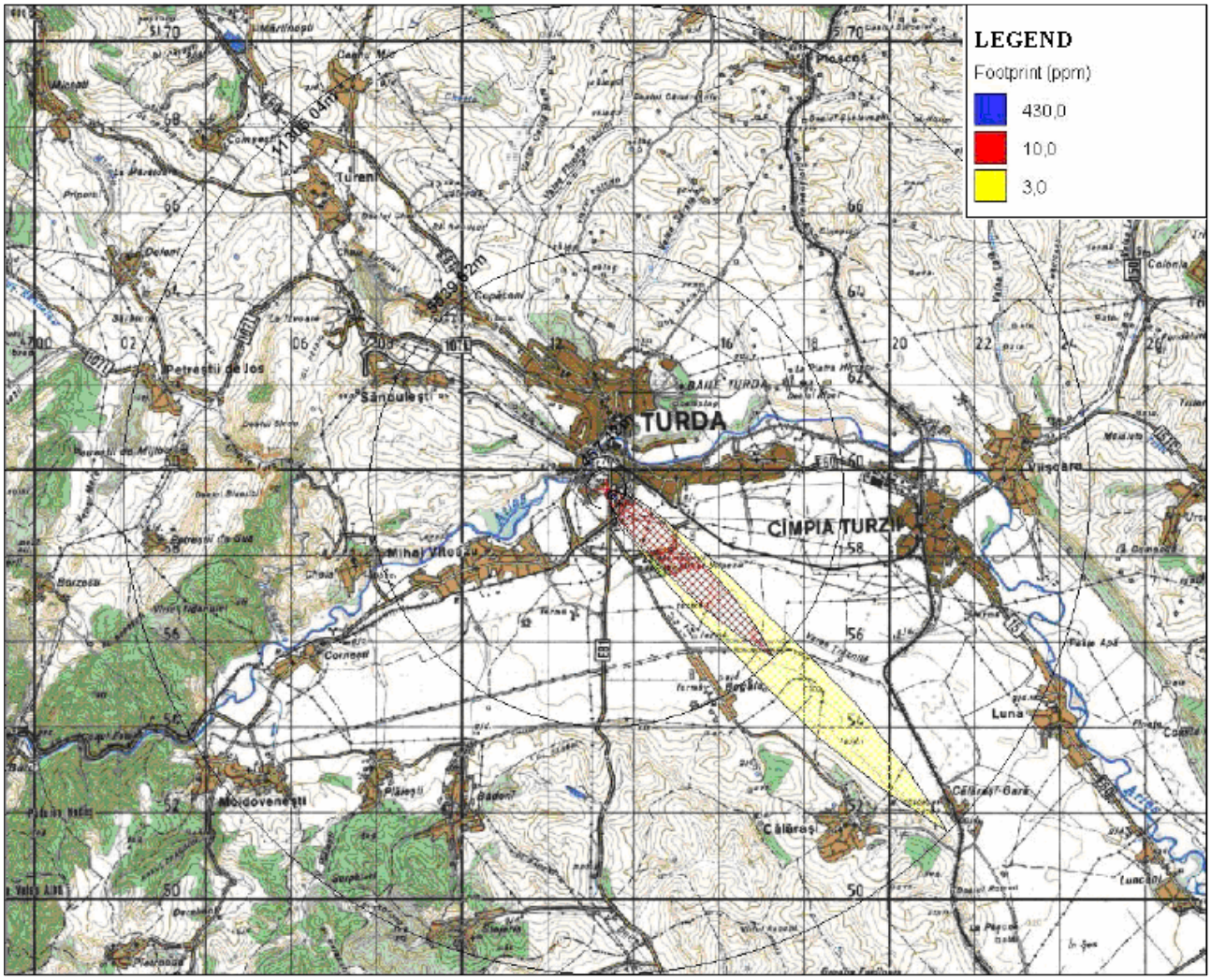

Fig. 2. Potentially affected areas [3].

While Mihai Viteazu has been providing the various industries with labour, commuting distance being reduced and public transportation being accessible to the rural population, Miceşti was losing its younger population while keeping its agricultural and apicultural orientation. Therefore, while the study population in Mihai Viteazu has been directly (through employment) or indirectly (through close proximity) influenced by the two cities and their economy, Miceşti remained relatively outside of the industrial area (with the exception of a few workers commuting to Turda).

Similarities were identified between the two compared villages. The surveyed population consisted of all residents aged in the range of 30 and 80 years of age living in the exposed/control areas. The average age was in the range of people born in between 1953-1973 (category two) in both villages, with small differences (0.8). In the control area there was an equal number of interviewed women and men (50%/50%), while in the exposed area 55.6 % was represented by women. The education levels are similar, respectively 54 vs. 60% of the population of both villages has at least a high school degree (education attainment has been improving due to the proximity to schools, career/vocational schools and universities.

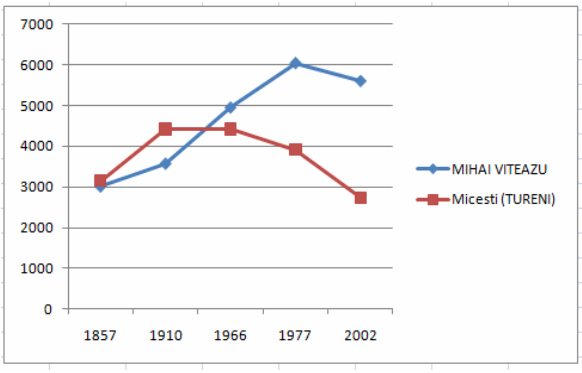

Fig. 3. Population growth from 1857 to 2002, data from the Statistical Yearbook of Romania / Statistical Data Center Cluj-Napoca.

There were 150 people surveyed from Mihai Viteazu, as well as 50 from Miceşti, the control village. Unfortunately, only 117 surveys from Mihai Viteazu

could be used for the interpretation of data, the others either missing important information or having inconsistent answers.

As far as smoking habits, the two surveyed villages were again similar, a 34.19% of smokers being identified in the exposed area as compared to a 20% from the control area (fig. 4 and fig. 5).

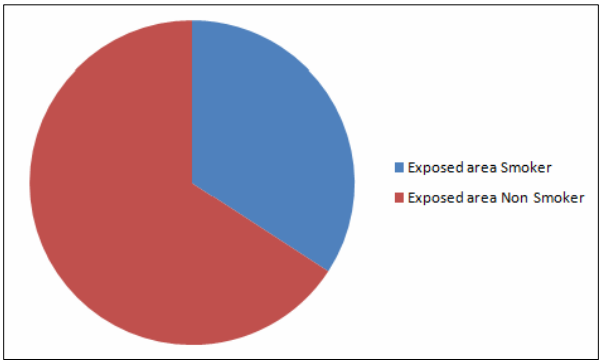

Fig. 4. Smoking habits distribution exposed area.

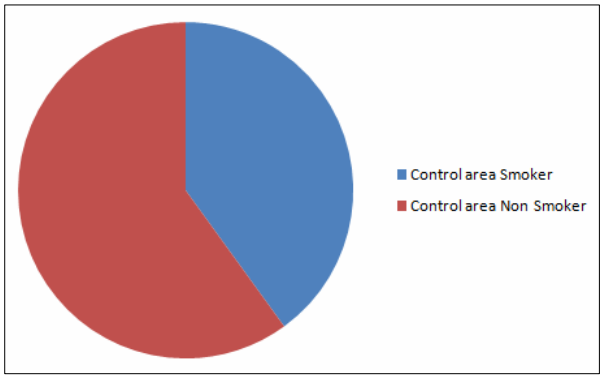

Fig. 5. Smoking habits distribution control area.

The subjects living in the exposed area reported a higher rate of occupation exposure to dust/fumes than the subjects living in the control area (63% vs 16%).

2.3. Questionnaire

A modified version of the *"Respiratory and Irritant Health Effects of a Population Living in a Petrochemical-Polluted Area in Taiwan"* [4] and of the American Thoracic Society Questionnaire (adult version) [1] was administered to all of the study subjects by the researcher herself and friends (all with a high level of education and trained prior to administering the survey). The survey was carried out in August 2009. It inquired about chronic respiratory symptoms such as coughing, phlegm production, wheezing, shortness of breath, and chronic bronchitis. The chronic respiratory symptoms concerned were defined as follows: chronic cough, coughing part of the day or the entire day for at least 3 months per year; phlegm production, phlegm production during a part of a day or for an entire day for at least 3 months per year; wheezing, a condition of causing a wheezy or whistling sound on inspiration at least occasionally, apart from that caused by a cold or acute upper respiratory infection; chronic bronchitis, a cough and/or phlegm on most days for 3 months or more out of a year; dyspnea, having to stop for breath when walking at one's own pace on level ground. The surveyed population was also asked about known hearth diseases that could cause heavy breathing, the data being considered as a variable. Known respiratory diseases and family diseases were also part of the questionnaire in order to identify the level of knowledge and people's awareness about their condition. Family diseases were inquired in order to identify a pattern that might be a separate cause for respiratory sensitiveness or diseases.

2.4. Statistics

The prevalence of respiratory symptoms according to place of residence were analyzed by using SPSS statistics software by examining the interdependence between the dependent variable age (representing also an account of the amount of time the subjects lived in the area and have been exposed to pollutants), and 11 independent variables (smoker/non smoker, occupation, hearth diseases, sex, education, cough, phlegm, cough and phlegm, wheezing, short of breath, and respiratory diseases). The adjusted odds ratios and their 95% confidence intervals were computed.

The effect of irritant gases (SO_2, NO_2, Cl_2, NH_3, oxidizing substances) and of the suspensions takes place at the respiratory system and can produce at high concentrations acute accidental poisoning with serious damage to the eyes and respiratory tract mucosa or alveolar-capillary membrane. At moderate concentrations it may cause a lung overload mechanism characterized by the mucociliary apparatus (initial mucus hypersecretion, followed by mucous gland hypertrophy and accompanied by reduced cell motility caliciforme ciliated cells) and impaired alveolar macrophages. Acute poisoning occurs only accidentally and is accompanied by damage to the anterior pole of the eye (conjunctivitis or chemical cheratoconjunctivita) and severe respiratory impairment (trachea-bronchial syndrome, bronchiolitis and lung toxicity with pulmonary edema).

With regard to pulmonary emphysema, it often occurs with chronic bronchitis, showing an increased incidence due to polluted urban environment. Emphysema is also correlated with smoking or occupational exposure to dust and toxic irritants and it occurs at a younger age with a tendency for faster progress. Increased frequency of asthma was not however reported. Asthma also occurs in conditions of air pollution and pollution outside the substances identified as allergens. Interpretation of these diseases is on account of irritating agents pollutants (sulphur dioxide, sulphuric acid, powder etc.). They are triggers of asthma in patients previously sensitized by spastic reflex response and action on bronchial muscle.

Table 1. SPSS results exposed area.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.615[a]	.378	.313	.631

a. Predictors: (Constant), Respdiseases, Smoker, Education, Sex, CPh, Cough, Phlegm, Hearth, Shbreath, Wheezing, Occupation

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25.411	11	2.310	5.800	.000[a]
	Residual	41.819	105	.398		
	Total	67.231	116			

a. Predictors: (Constant), Respdiseases, Smoker, Education, Sex, CPh, Cough, Phlegm, Hearth, Shbreath, Wheezing, Occupation

b. Dependent Variable: Age

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.515	.557		.925	.357
	Smoker	-.053	.127	-.033	-.419	.676
	Occupation	-.025	.175	-.017	-.144	.886
	Hearth	.121	.128	.079	.942	.348
	Sex	.016	.122	.010	.131	.896
	Education	.281	.044	.517	6.423	.000
	Cough	.040	.129	.026	.309	.758
	Phlegm	-.175	.133	-.110	-1.319	.190
	CPh	-.065	.146	-.037	-.443	.659
	Wheezing	-.127	.140	-.083	-.911	.364
	Shbreath	.213	.143	.138	1.490	.139
	Respdiseases	.250	.189	.163	1.322	.189

a. Dependent Variable: Age

Table 2. Variables in the equation.

VARIABLE	b	s.e. b	Beta	t	prob. t
Smoker	0.16286	0.3029	0.0819	0.538	0.5938
Heart	0.66682	0.4194	0.1991	1.590	0.1197
Sex	0.23931	0.1922	0.1505	1.245	0.2204
Education	0.39862	0.0742	0.6369	5.375	0.0000
Cough	-0.54854	0.4471	-0.2946	-1.227	0.2271
Phlegm	0.37294	0.6018	0.1876	0.620	0.5390
Cough Ph	-0.67868	0.8618	-0.3279	-0.788	0.4356
Wheezing	0.82432	0.5019	0.3597	1.643	0.1083
Short of breath	0.42125	0.3417	0.1589	1.233	0.2249
(Intercept)	-2.54072				
Increase in squared R for this step = 0.003130					
F = 0.2891 with D.F. 1 and 40 with Probability = 0.5938					

The survey results proved our hypothesis. Industrial activities in the Turda seemed to have been the main factors of the incidence of respiratory diseases and symptoms of increased sensitivity in the local population situated in close proximity to the site. A 57% incidence of acute and/or chronic respiratory diseases

was registered among the observed exposed rural population (especially acute or chronic bronchitis, characterized by increased bronchial infection, high incidence of regularly occurring cough), especially among former employees of the Chemical factories, cement, glass, and silica. Acute effects have been identified (after brief exposure), as well as the chronic effects (after long exposure) and late effects, depending on the time spent as employees of polluting enterprises or the years spent in areas affected by pollution. Late effects refer to those in which latent pathological phenomena might only occur after decades, such as the carcinogenic action of atmospheric pollutants.

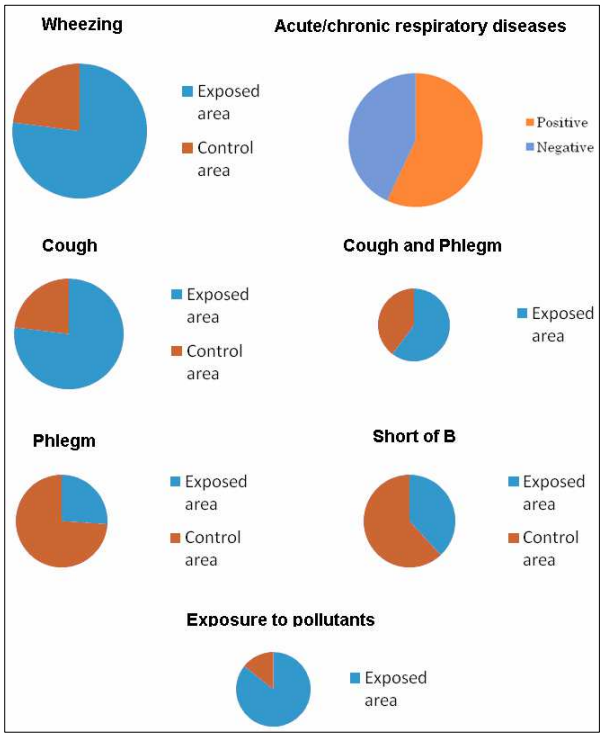

Fig. 6. Results exposed area.

The subjects living in the exposed area had a higher incidence of cough, cough and phlegm, and wheezing, but lower rates of phlegm and short of breath. The stability of the population, evidenced by length of residence (almost all respondents resided in current home more than 10 years), indicates that exposure has indeed been of long duration. Phlegm higher incidence in the control area might have been caused by the outdoor living and exposure to irritants causing allergies (pollen, grass, dust, animal fur etc).

The second hypothesis, that those involved in industrial activities would be the most affected has been proven by the high number of people exposed to dust/fumes/chemicals in the exposed area (0.886).

3. CONCLUSION

Based on survey data, the close proximity of Mihai Viteazu village, Transylvania, Romania to the former industrial platform of the Turda city might be one of the causes for the population's respiratory health diseases. However, one needs to be cautious when considering these data seen the high incidence of smokers in both villages (a 0.082 difference), as well as the culture element that might determine certain subjects to lie about their condition. Further research might consider a comparison of the existent data from the local health centres and hospitals, current survey and a repeated survey, as well as a comparison with the population living in the residential areas situated right on the industrial platform and directly influenced by the wind direction.

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