Chapter 5
Exposure to Traffic-Related Air Pollutants as a Risk of Airway Obstruction

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Abstract Dynamic increases in the number of vehicles, particularly in large urban areas, cause a visible decline in the average speed of cars. Street networks are not able to efficiently handle generated traffic, which could result in increasing levels of air pollutant emissions and consequently in a greater incidence of people suffering from respiratory diseases. This study presents the effects of investigations on the influence of traffic-related air pollutants on inhabitants of two Polish cities living in the proximity of busy roads. As a control group rural area residents were taken. In 2005–2006 and 2008–2009 respiratory function tests were conducted on a group of 3,506 people (including residents of non-urban areas). The investigation has shown that people living near busy urban roads had a significant increase in the risk of bronchi obstruction.

Keywords Airway obstruction • Air pollution • Health • Municipal environment • Pulmonary function

5.1 Introduction

Direct proximity of busy main roads within urbanized areas is characterized by increased levels of air pollutants compared with urbanized areas remote from busy roads, and particularly with rural areas. As a result, the inhabitants living close to the busiest traffic arteries might be more exposed to the harmful influence of traffic than those living in other areas. Generally air pollutants have been recognized

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as increasing factors of chronic obstructive pulmonary disease (COPD) for over 50 years. That led to implementing air quality standards, which resulted in significant decreases in the levels of air pollutants from fossil fuels combustion, in particular dust and sulphur dioxide. However, a dynamic rise in road traffic density has led to increased levels of other pollutants, such as ozone, particulate matter with diameter below 10 μm (PM_{10}), or nitrogen oxides (MacNee and Donaldson 2000). These pollutants are currently the most serious problem of air quality in Europe (Martin et al. 2010).

Numerous epidemiological research results show that there is a relation between reported air pollution levels and harmful health effects, including a higher intensity of respiratory system ailments, and even a higher number of deaths caused by respiratory and cardio-vascular system diseases. Several publications report higher intensity of symptoms of pulmonary diseases among children and secondary school students living in the proximity of main roads with heavy traffic. An investigation made in Nottingham, UK (Venn et al. 2001), shows that, although there is no clear evidence to show that air pollutants lead to increased asthma incidence, a higher risk of respiratory problems can be noted among children. The risk is inversely proportional to the distance from busy traffic arteries and is the highest among the inhabitants who live within the distance of 90 m from busy main roads. Having reported the results of research done with a group of almost 1,000 children, based on odds ratio calculations, the authors show that for children living within 150 m of main roads, each 30 m closer to the road increases the risk of asthma symptoms (wheezing) by 1.08 and 1.16 for the age-groups 4 ÷ 11 and 11 ÷ 16 years, respectively.

Research results for the group of 1,129 children coming from different areas (with low or high level of SO_2 and PM_{10}) of Cracow, Poland (Jedrychowski and Flak 1998) show a strong relation between air pollution levels and some respiratory system symptoms (amount of secretion). Much more frequent cough and wheeze were reported among children who did not have allergy symptoms, who lived in areas with higher levels of air pollutants. In case of children diagnosed as having an allergy, coming to such conclusions seems more difficult, because asthma symptoms can result from numerous factors, including air pollution. A school-based, cross-sectional study in the San Francisco Bay Area (Kim et al. 2004), based on results of a group of 1,109 children, shows that there is a slight, although statistically significant, increase in bronchitis symptoms and asthma among children living in the areas with higher levels of traffic-related air pollutants. The research was carried out in urban areas with relatively clean air compared with the rest of the region, where local air pollutants originate mainly from road traffic. For particular pollutants (NO, NO_2, NO_x, $PM_{2.5}$, PM_{10}), the odds ratios were calculated with reference to the concentration increase by a value equal to the interquartile range of distribution of a particular pollutant concentration. Depending on the kind of pollutant, OR amounted to 1.02–1.06 for bronchitis and 1.01–1.08 for asthma.

One of the earliest results of research on the long-term influence of road traffic air pollutants on the progress of chronic obstructive pulmonary disease (Schikowski et al. 2005), carried out for 10 years in 4,757 women (living in the Ruhr Area in Germany), shows that an increase of average concentration of PM_{10} (interquartile range) by 7 μg/m^3 within 5 years causes a noticeable decrease of spirometric indicators. Forced expiratory volume during the first second of expiration (FEV_1) decreased by 5.1% (95% confidence level: 2.5–7.7%), while forced vital capacity (FVC) decreased by 3.7% (95% confidence level: 1.8–5.5%). At the same time, the authors point out that women who lived closer than 100 m to busy roads showed significantly lower spirometric parameters, and the risk of COPD incidence was 1.79 times higher (odds ratio with 95% confidence level: 1.06–3.02) compared with inhabitants of areas located further from main roads.

The results of research made close to a busy street in Gliwice, Poland (Grynkiewicz-Bylina et al. 2005) show that average daily PM_{10} concentrations in the street canyon are over 70% higher, and for polycyclic aromatic hydrocarbons over 60% higher, compared with the values of these pollutants within 100 m distance from the road. The author expects a 10% higher rate of respiratory system disease in the population exposed to higher levels of the PM_{10} of over 90 μg/m^3 in the road canyon.

Similar conclusions are drawn from the epidemiological studies conducted in the region of Pisa Cascina, Central Italy (Nuvolone et al. 2011). This study analyzed the epidemiological data and based on subjective assessments of residents (the questionnaire) and objective tests (spirometry and skin tests) shows that living at a distance of 100 m from the road is associated with an increased risk of wheeze, COPD and airways obstruction among men, and a higher risk of asthma attacks, shortness of breath, dyspnea, wheezing breath and positive skin tests among women.

According to data presented by Lubinski and Chcialowski (2003), concentrations of PM_{10} higher than 10 μg/m^3 lead to a 3% higher rate of death caused by respiratory system disease, but also to a 3% growth in the frequency of bronchial asthma attacks and to over 12% higher use of bronchodilators in case of patients suffering from asthma and chronic obstructive pulmonary disease (COPD). Likewise, an investigation conducted in east London (Peacock et al. 2011) clearly shows an impact on the respiratory system of PM_{10} pollution, black smoke, and NO_2 in patients with COPD. Dyspnea was particularly associated with the occurrence of PM_{10} among patients participating in the study.

Investigations conducted in selected US metropolitan areas (Schwartz et al. 1996) indicate that the daily percentage of deaths is related to changes in $PM_{2.5}$ concentrations, but not to those in PM_{10} concentration. The results show that each growth of 2-day average concentration of $PM_{2.5}$ by 10 μg/m^3 is related to 1.5% (95% confidence level: 1.1 ÷ 1.9%) growth of daily death rate. A further study by the authors carried out in six cities in the USA (Schwartz et al. 2002) shows that there is a linear relation between $PM_{2.5}$ concentration and death rate. Moreover, the authors show that there is no minimum value of a concentration of this pollutant that could be considered safe. The relation above given between the change in $PM_{2.5}$ concentration and mortality rate also holds for concentrations below the minimum permissible levels, according to the US Environmental Protection Agency. This indicator grows by 3% for each 10 μg/m^3 increase of solid particles coming from emissions from road transport.

A study of 8,111 adults in six cities of the US (Dockery et al. 1993) shows that the mortality level is highly dependent on tobacco smoking. After taking into account this and other risk factors, a statistically significant relation was observed between air pollution caused by respiratory dust and death rate. Interpretation of survival analysis showed that the mortality risk coefficient for deaths caused by lung cancer and respiratory and circulatory disease among inhabitants of the most polluted cities amounts to 1.26% (95% confidence level: 1.08 ÷ 1.47) compared with the cities characterized by the lowest level of air pollutants.

The results of long-term tests (lasting 8 years), carried out in Holland in a group of 5,000 persons aged 55 ÷ 69 (Hoek et al. 2002), based on the assessment of the correlation between road pollution level and mortality resulting from different causes, shows that the mortality risk coefficient among persons living along main roads amounts to 1.41 (95% confidence level: 0.94 ÷ 2.12) for all causes of death and 1.95 (95% confidence level: 1.09 ÷ 3.52) for the deaths caused by respiratory and circulatory system disease. The authors come to a conclusion that long-term exposure to traffic-related pollutants may shorten life expectancy, showing that the mortality caused by diseases not related to respiratory and circulatory system and tumors other than lung tumors are not related to air pollution levels – the risk coefficient amounted to 1.03 (95% confidence level: 0.54 ÷ 1.96).

In the present study, we report on the influence of traffic-related air pollutants on ventilation efficiency of inhabitants of large urban areas. The research was conducted among inhabitants of two Polish cities living along the main roads. The reason to conduct the study was that other studies on this subject, especially those from the US, cannot be directly applied to the corresponding situation in Polish urban areas, where the characteristics of exposure to traffic-related pollutants are different from those in other countries because of a different traffic structure, a higher average age of vehicles, different climatic and meteorological conditions, etc. Preliminary results of the Polish research concerning just one city have been presented elsewhere (Badyda and Lubinski 2009).

5.2 Methods

Pulmonary function tests were carried under two scientific projects, the first of which was conducted in the capital city of Warsaw, Poland, in 2005–2006 and the second one in the city of Gliwice, Poland, in 2008–2009. The investigations, performed by the Military Institute of Medicine and the Faculty of Environmental Engineering of Warsaw University of Technology, were carried out in the vicinity of selected busy roads as well as in the rural areas isolated from the direct impact of traffic-related air pollutants emissions. The results of the tests of the patients presently treated for chronic obstructive pulmonary disease (COPD) or bronchial asthma as well as those who did not cooperate with the doctor during the examination have been excluded from further analysis.

In Warsaw, 750 examinations were performed, including 333 women and 417 men. The tests involved 512 non-smokers and 238 smokers aged 14–90 (mean 50.9 ± 19.7 year). The control group consisted of the tests performed in 756 persons (423 women and 333 men), inhabitants of non-urban areas (29 towns located in various regions of Poland). 445 non-smokers and 311 smokers aged 18–85 (mean 47.8 ± 14.3) participated in the examination.

The Gliwice study encompassed 1,581 persons, including 854 women and 727 men. Among the examined individuals there were 875 non-smokers persons and 706 smokers aged 10–96 (mean 47.4 ± 18.3). In this investigation the control group covered 419 people (226 women and 193 men) from 6 selected spots situated near the city of Gliwice, characterized by a relatively low traffic.

5.2.1 Tests

All tests were conducted using an EasyOne spirometer in the period from May to September. The period of research resulted from the necessity to reduce the influence of pollutants from sources other than road traffic.

An outline of the research was as follows:

- presenting the aims of the test to the examined person and informing him that the test will not have any harmful impact on their health condition;
- subjective research – a questionnaire was carried out, taking into consideration anthropometric features, load of respiratory system disease, smoking habits, exposure to harmful factors in workplace and place of living, presence of symptoms that might show respiratory system disease, allergies, etc.;
- objective research – spirometric test carried out in the sitting position, at a specially prepared research place, after a few-minute time given to adapt to the new breathing conditions. Then several flow-volume curves were recorded, to gain repeatability of results in accordance with the American Thoracic Society. The test result included the following variables:
  - FVC (*Forced Vital Capacity*) – capacity of air, which is exhaled by a tested person during a forced exhalation after maximum slow inhalation;
  - FEV_1(*Forced Expiratory Volume during the First Second of Expiration*) – capacity of air, which is exhaled by a tested person within the first second of expiration;
  - PEF (*Peak Expiratory Flow*) – maximum velocity of flow measured during forced exhalation;
  - FEF_{50} (*Forced Expiratory Flow at 50% of FVC*) – velocity of air flow in middle phase of exhalation;
  - FEV_1%FVC – percentage indicator of FEV_1 capacity, in its relation to the present forced vital capacity (so called pseudo-Tiffeneau indicator).

According to the guidelines of the American Thoracic Society (1991, 1995) and the Polish Lung Disease Association, the trials were performed until at least three repeatable results were gained, i.e., the results for which the values of indicators for a particular measurement did not vary by more than 5%. The results were standardized according to the European Coal and Steel Community (Quanjer et al. 1993) guidelines. The subjects were divided into two groups, according to the burden of the smoking habit. The results were analyzed in accordance with this division, comparing them with those of the control group, after taking into account analogous division.

5.3 Risk Assessment of Airways Obstruction

Pulmonary function indicators enable to confirm or eliminate airway obstruction. As mentioned above, the first indicator demonstrating pulmonary disorders is a pseudo-Tiffeneau indicator ($FEV_1\%FVC$) lower than 70%. Persons with the result of $FEV_1\%FVC \geq 70\%$ are considered not to show symptoms of obstruction. Therefore each investigated person can be described by a dichotomous variable. Further in the study a person for which the value of this variable is ‘0’ will be considered healthy, while ‘1’ will refer to an ill person. The aim will be to determine a relation, similar to regression function, of a probability of obstruction appearance, with a group of independent variables such as age, gender, smoking habit burden and place of living. In this type of analysis it is not possible to apply multiple regression, therefore logistic regression is used.

Logistic regression describes the influence of independent variables on a dichotomous dependent variable. Let Y refer to the dependent variable with values: 0 – does not show symptoms of COPD ($FEV_1\%FVC \geq 70\%$), 1 – shows symptoms of COPD ($FEV_1\%FVC < 70\%$). The model of logistic regression for such a dichotomous variable has a form shown by Eq. 5.1:

$$P\left(Y = 1 \middle| x_1, x_2, \ldots, x_k\right) = \frac{e^{\left(a_0 + \sum_{i=1}^{k} a_i x_i\right)}}{1 + e^{\left(a_0 + \sum_{i=1}^{k} a_i x_i\right)}} \tag{5.1}$$

where

$P(Y=1|x_1,x_2,\ldots,x_k)$ – conditional probability that the Y variable will equal 1 for independent values $x_1, x_2, \ldots, x_k$; $a_{i,}$ $i=0,\ldots,k$ – regression coefficients; $x_1, x_2, \ldots, x_k$ – independent values.

Apart from assessing regression coefficients and their statistical significance, the odds ratios were calculated. The term ‘odds’ was defined as a ratio of probability of a phenomenon appearance (A), e.g. a disease, to the probability that it will not appear. The definition can be shown as in the Eq. 5.2:

$$S(A) = \frac{p(A)}{p\left(notA\right)} = \frac{p(A)}{1 - p(A)} \tag{5.2}$$

where

$S(A)$ – odds of a phenomenon appearance; $p(A)$ – probability of A phenomenon appearance; $p(notA)$ – probability of A phenomenon non-appearance.

Logistic models presented and discussed below were worked out on the basis of pulmonary function results and values of selected anthropometric indicators, smoking burden and place of living. The estimation of the models’ parameters was carried out separately for the investigated group as a whole, as well as taking into account the division into smokers and non-smokers. The presented logistic models include only the independent variables that showed significance (for $p < 0.05$). For each case, the mean square error estimator and the quasi-Newton method was used, and it must be mentioned that an application of any other available estimator or estimation method generally did not cause noticeable changes in the forms of models or values of regression coefficients. The ratio of product of properly classified cases to product of not properly classified ones significantly exceeded 1, which shows that the classification was much better than the one expected to occur by coincidence. Moreover, for each model the odds ratios were calculated for a single variation of analyzed parameters. They were presented in the tables with the estimation results.

5.3.1 Estimation for All Considered Cases

In the Warsaw study, a model calculated for all of the considered cases (all examined persons) is shown by Eq. 5.3:

$$P(X) = \frac{e^{-6.608+0.075\cdot AGE-0.528\cdot GEN+0.780\cdot SMK+1.014\cdot LIV}}{1+e^{-6.608+0.075\cdot AGE-0.528\cdot GEN+0.780\cdot SMK+1.014\cdot LIV}} \tag{5.3}$$

where

AGE – age of investigated person (years); GEN – gender – dichotomous variable: man ($GEN=0$), woman ($GEN=1$); SMK – smoking habit – dichotomous variable: non-smokers ($SMK=0$), smokers ($SMK=1$); LIV – place of living – dichotomous variable: control group (rural area inhabitants, $LIV=0$), investigated group (urban area inhabitants, $LIV=1$).

The model shows that the probability of a bronchial stricture appearance increases when the values of the variables ‘AGE’, ‘SMK’ and ‘LIV’ increase. For the latter two variables, the increase will be understood as the change of value from ‘0’ to ‘1’. In this case the probability of developing the disease rises among smokers and urban area inhabitants. Analogically, the probability decreases when ‘GEN’ variable increases, which shows a lower probability of disease appearance among women.

The results show that smoking increases the risk of the appearance of bronchial airflow disorders twofold, which is equivalent to developing COPD, while living along a busy main road (compared with rural areas) causes an increase of the risk nearly three times. Men are 1.7 times (0.59^{-1}) more at risk than women.

Logistic regression model was also made for the results of the study conducted in Gliwice. The subjective study of this investigation included some additional information that was not considered in the previously realized study in Warsaw. Some of these data, represented by the relevant independent values, were reflected in the logistic model. The model for all test cases is as follows:

$$P(X) = \frac{e^{-4.777+0.033\cdot TLV+0.481\cdot SMK+0.718\,LIV}}{1+e^{-4.777+0.033\cdot TLV+0.481\cdot SMK+0.718\,LIV}} \tag{5.4}$$

where TLV – length of residence in the specific location (years).

The results obtained in Gliwice indicate no significant differences in the occurrence of obstruction among men and women. The ‘AGE’ variable also showed to be irrelevant. However, significance ($p<0.0001$) was shown in the differences of the obstruction prevalence depending on the period of residence (in many cases, this variable may also reflect the age of examined individuals). As in the Warsaw study, the probability of obstruction increases among people living in the proximity of busy roads in comparison with the rural areas residents and is higher among smokers compared with non-smoking persons.

In both above listed logistic models, the quality factor test for chi-square fitting (χ^2) representing a variation between the presented model and the one with only one absolute term shows significance ($p<0.0001$) proving that independent variables in the model influence the possibility of disease

Table 5.1 Estimation of parameters of the logistic regression model of the entire investigated group of the Warsaw study

	Variable			
	AGE	GEN	SMK	LIV
Estimated parameter values	0.075	−0.528	0.780	1.014
Significance level	<0.05			
95% confidence interval for parameters	0.063 ÷ 0.087	−0.862 ÷ −0.193	0.412 ÷ 1.142	0.659 ÷ 1.369
Odds ratio for unit change of parameter	1.07	0.59	2.18	2.76
95% confidence interval for odds ratios	1.06 ÷ 1.09	0.42 ÷ 0.82	1.52 ÷ 3.13	1.93 ÷ 3.93

Table 5.2 Estimation of parameters of the logistic regression model of the entire investigated group of the Gliwice study

	Variable		
	TLV	SMK	LIV
Estimated parameter values	0.033	0.481	0.718
Significance level	<0.05		
95% confidence interval for parameters	0.020 ÷ 0.045	0.042 ÷ 0.920	0.086 ÷ 1.350
Odds ratio for unit change of parameter	1.03	1.62	2.05
95% confidence interval for odds ratios	1.02 ÷ 1.05	1.04 ÷ 2.51	1.09 ÷ 3.86

development. Values of the model parameter estimators are also statistically significant ($p < 0.05$). Tables 5.1 and 5.2 present selected values of the parameter estimators for both models calculated for the entire investigated groups, as well as odds ratios for single variations of particular parameter.

The above presented results allow to conclude that the risk of disturbance of air flow through the bronchi is significantly associated with smoking (more than 2 times higher in the Warsaw study and more than 1.6-fold higher in the Gliwice study), as well as with residence in the vicinity of busy roads. In comparison with the control groups (rural area residents), the risk of bronchial obstruction is almost 2.8-fold higher among inhabitants of Warsaw and more than 2 times higher amid residents of Gliwice.

5.3.2 Estimation for Non-smoking Group

In both studies, analogical models were created with the division for smokers and non-smokers, in order to analyze the influence of their place of living on probability of obstruction appearance. The models for non-smokers are shown in Eqs. 5.5 and 5.6, for the Warsaw and Gliwice studies, respectively:

$$P(X) = \frac{e^{-7.249+0.081\cdot AGE-0.764\cdot GEN+1.470\cdot LIV}}{1+e^{-7.249+0.081\cdot AGE-0.764\cdot GEN+1.470\cdot LIV}} \tag{5.5}$$

$$P(X) = \frac{e^{-6.863+0.025\cdot AGE+0.797\cdot GEN+1.150\cdot LIV+0.024\cdot TLV}}{1+e^{-6.863+0.025\cdot AGE+0.797\cdot GEN+1.150\cdot LIV+0.024\cdot TLV}} \tag{5.6}$$

According to these models, in both cases the probability of developing the disease among non-smokers increases with age (in the Gliwice study also with the duration of residence in a particular location) and it is higher in the urban area groups than in the control groups. Different observations in

Table 5.3 Estimation of parameters of the logistic regression model for the non-smoking group investigated in the Warsaw study

	Variable		
	AGE	GEN	LIV
Estimated parameter values	0.081	−0.764	1.470
Significance level	<0.05		
95% confidence interval for parameters	0.065 ÷ 0.098	−1.204 ÷ −0.324	0.945 ÷ 1.994
Odds ratio for unit change of parameter	1.08	0.47	4.35
95% confidence interval for odds ratios	1.07 ÷ 1.10	0.30 ÷ 0.72	2.57 ÷ 7.35

Table 5.4 Estimation of parameters of the logistic regression model for the non-smoking group investigated in the Gliwice study

	Variable			
	AGE	GEN	LIV	TLV
Estimated parameter values	0.025	0.797	1.150	0.024
Significance level	<0.05			
95% confidence interval for parameters	0.002 ÷ 0.049	0.039 ÷ 1.554	0.086 ÷ 2.215	0.004 ÷ 0.044
Odds ratio for unit change of parameter	1.03	2.22	3,16	1.03
95% confidence interval for odds ratios	1.00 ÷ 1.05	1.04 ÷ 4.73	1.09 ÷ 9.16	1.00 ÷ 1.05

both studies are related with gender: while in the Warsaw study a higher probability of obstruction among men was noted, in the Gliwice study women were more likely to be affected. Based on the collected data, this phenomenon is at the moment difficult to be explained. Similarly to the previous models, χ^2 value and values of the estimators of the model parameters were significant. The detailed values of models calculated for non-smoking persons are presented in Tables 5.3 and 5.4.

Among non-smokers, the risk of obstruction increases with age and in the Gliwice study, as it was mentioned above, an increased risk with each passing year of living near a busy road was indicated (a more detailed analysis shows that the risk of bronchi obstruction concerns only urban area inhabitants, while in the control group this parameter remains statistically insignificant). Non-smoking persons living in the proximity of busy roads are more exposed to obstruction appearance than those from rural areas (above 4 times higher risk in the Warsaw study and more than 3 times in the Gliwice study). It both cases it should be noted that the range of 95% confidence level is relatively high for both the estimated parameters and for a single variation of a parameter.

5.3.3 *Estimation for Smoking Group*

Logistic regression models calculated for the smoking group are presented in Eqs. 5.7 and 5.8, for the Warsaw and Gliwice studies respectively:

$$P(X) = \frac{e^{-6.858+0.075\cdot AGE+0.018\cdot BM}}{1+e^{-6.858+0.075\cdot AGE+0.018\cdot BM}} \tag{5.7}$$

$$P(X) = \frac{e^{-5.113+0.045\cdot AGE}}{1+e^{-5.113+0.045\cdot AGE}} \tag{5.8}$$

where *BM* – body mass of investigated person (kg).

Table 5.5 Estimation of parameters of the logistic regression model for the smoking group investigated in the Warsaw study

	Variable	
	AGE	BM
Estimated parameter values	0.071	0.017
Significance level	<0.05	
95% confidence interval for parameters	0.052 ÷ 0.091	0.001 ÷ 0.032
Odds ratio for unit change of parameter	1.07	1.02
95% confidence interval for odds ratios	1.05 ÷ 1.10	1.00 ÷ 1.03

Table 5.6 Estimation of parameters of the logistic regression model for the smoking group investigated in the Gliwice study

	Variable
	AGE
Estimated parameter values	0.045
Significance level	<0.05
95% confidence interval for parameters	0.024 ÷ 0.066
Odds ratio for unit change of parameter	1.05
95% confidence interval for odds ratios	1.02 ÷ 1.07

In the group of smokers, the influence of gender on the probability of disease appearance turned out to be irrelevant. However, in the Warsaw study, body mass had a slight but statistically significant ($p = 0.04$) positive effect. Other independent variables, including the variable describing place of living, were statistically insignificant. The values of the quality factor test for χ^2 fitting model was highly statistically significant. The detailed list of estimation results was presented in Tables 5.5 and 5.6.

The results calculated for smokers show that the influence of their place of living on the risk of the appearance of obstruction was irrelevant. This observation was confirmed by more detailed calculations (not shown), according to which the difference of average values of one of the most important pulmonary function indicators (FEV_1) between the urban and rural area inhabitants turned out to be statistically insignificant. In the Gliwice study, the differences in the FEF_{50} and FEV_1 %FVC average values were statistically irrelevant either. The gathered results show that the increased risk of the appearance of obstruction for smokers results mainly from the fact of smoking itself. Among independent variables, which showed to be significant in logistic regression models for the group of smokers, the only important factor was the age of the examined individuals. It seems that the factor associated with body weight, which was statistically significant in the Warsaw study, from the meritorious standpoint was not of particular importance concerning the risk of developing bronchi obstruction.

5.4 Conclusions

To summarize the above analysis, there exists a significant increase in the appearance of obstruction among non-smokers living in the vicinity of busy roads comparing with the control groups from rural areas. The results quoted in this study show a significant role of air pollutants in the development of diseases causing bronchial stricture (mainly COPD). Logistic regression models, which imply an increased probability of bronchoconstriction among smokers and among older people, also demonstrate an increased risk of obstruction with the degree of exposure to traffic-related air pollution impact – the likelihood of bronchi obstruction is higher in urban population groups living in the vicinity of roads with a high traffic volume compared with those of non-urban areas (nearly 3 times higher among Warsaw residents and more than 2 times higher among inhabitants of Gliwice in comparison with corresponding control groups).

Logistic models do not classify cases of disease in the expected way (the cases of lack of COPD symptoms are classified very well), which may suggest that there are other factors, which influence the appearance of obstruction and were not taken into consideration in the tests. A low level in classification of disease cases shows too small a patient sample. In the currently available database, the models could not precisely diagnose the influence of pathogenic factors or work out the expected high level of correct classification, similarly to those for healthy persons.

Despite these limitations, among the factors taken into account, the fact of living in proximity of busy urban roads increases the risk of the appearance of obstruction, particularly among non-smoking persons – in comparison with rural area residents the risk of bronchoconstriction is more that 4-times higher among inhabitants of Warsaw and above 3-times higher amid residents of Gliwice. In conclusion, the results based on the above presented models do not reflect the reality in satisfactory way, although they show a relevant and statistically significant influence of living in the proximity of busy roads on the increased risk of COPD appearance.

Further long-term studies should be performed on larger cohorts of subjects living near busy roads in cities, in areas isolated from the direct impact of traffic-related air pollutants, as well as in rural areas. Such studies may enable to determine the variations in the appearance of obstruction, pointing to the influence of various air pollutants on the incidence of respiratory system diseases.

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