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Correlation between air pollution in Lublin and the number of hospitalizations due to exacerbations of chronic lung and cardiovascular diseases

Abstract

Introduction. Air pollution exacerbates chronic lung and cardiovascular diseases. The greatest importance is assigned to dusts with a diameter of 2.5 μm (PM 2.5) and a diameter of 10 μm (PM 10) resulting from the combustion of solid fuels.

Aim. The aim of the study was to investigate the correlation between air pollution in Lublin in 2019 and the number of hospitalizations due to exacerbations of chronic lung and heart diseases.

Material and methods. The material was collected in Lublin from January 1st 2019 to December 31st 2019. The concentration of PM 2.5, PM 10 dust, air temperature and humidity were measured with the DM106A sensor. Data on the number of hospitalizations were obtained from the Independent Public Clinical Hospital No. 4 (SPSK 4) in Lublin. The material was statistically analyzed with the IBM SPSS Statistics package. The obtained results of the analysis were considered statistically significant at $p<0.05$.

Results. The average annual humidity was 59.1%, the concentration of PM 2.5 was 24.9 $\mu g/m^3$, and PM 10 was 33 $\mu g/m^3$. Dust concentrations increased at the beginning of heating season in October. They were high till the end of March. They fell in the spring. With increasing air humidity, there were more hospitalizations due to exacerbation of lung diseases. Men and women were more often admitted to hospital due to exacerbations of cardiovascular diseases than lung problems.

Conclusions. In low air temperatures during heating season dust concentrations increase but they do not affect the number of hospitalizations in Lublin. Air humidity is the factor correlated with admissions to hospital of both men and women with lung and heart diseases.

Keywords: particulate matter, air humidity, heart diseases, lung diseases.

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INTRODUCTION

Air pollution causes exacerbations of chronic lung diseases and cardiovascular diseases [1,2]. It is estimated that they cause 7 million premature deaths annually worldwide [3]. The greatest importance is assigned to dusts with a diameter of 2.5 μm (PM 2.5) and a diameter of 10 μm (PM 10) from the combustion of solid fuels [4]. There are concerns about the link between global climate change and the risk of human deaths [5]. Due to the emission of anthropogenic gaseous air pollutants, the average global temperature increase compared to pre-industrial times will soon reach 1.5°C [6]. Higher air temperatures, increased frequency of violent atmospheric phenomena, and the expansion of vector-borne disease zones raise concerns as to whether health systems in many countries will be able to provide medical services to those in need [7].

According to the data of the Central Statistical Office, in 2017, the average life expectancy for men living in Poland was 74.0 years and for women 81.8 years [7]. In our country 87,500 people had acute coronary syndrome in 2011 [7]. The prevalence of asthma in Poles has been increasing since the mid-1990s. The prevalence of asthma in 1995-2001 was assessed on the basis of a questionnaire among 6-7-year-olds in Poznan and estimated at 1.3%, in Cracow at 4%. In the 13-14-year-old group in Poznan at 2%, in Cracow 2.3%. In the years 2001-2002 the study was repeated and an increase in the incidence of asthma was found: in the group of 6-7-year-old children in Poznan 5.9%, in Cracow 5.8%, and in the group of older children in Poznan 5.2 %, in Cracow 6.8%. In the Lublin region, in children aged 8-13, the prevalence of asthma in 1995 was estimated 3.4%. In 2001, an increase to 9.6% was recorded. The frequency of asthma symptoms reported by respondents increased 3-4 times. In the years 1998-2001, under the patronage of the Polish Society of Allergology, the first nationwide epidemiological study of the frequency of asthma was carried out (PMSEAD – Polish Multicentre Study of Epidemiology of Allergic Diseases) [8]. The incidence of asthma in Poland was estimated at 8.6% in children and 5.4% in adults. It was found that prevalence rates are the highest in city centers and are three times higher than in rural areas. The latest data on the frequency of allergies and asthma in Poland come from the study 'Epidemiology of Allergic Diseases in Poland'. The study consisted of a questionnaire part and verification of diagnoses in outpatient clinics. Symptoms

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TABLE 1. Annual summary of measurements of concentrations of PM 2.5, PM 10, temperature and air humidity in 2019 and basic statistics.

	Days of observation	mean± SD	minimum	maximum	25th percentile	Median	75th percentile
Temaperature	365	9.1±7.4	-9.1	27.1	2.9	8.3	15.6
PM 2,5[μg/m^3]	365	24.9±22.5	1.0	139.0	8.0	15.0	40.8
PM 10[μg/m^3]	365	33.2±25.2	4.0	140.0	14.0	23.0	52.0
Relative humidity [%]	365	59.1±20	20.0	90.0	50.0	60.0	69.0

of bronchial asthma were declared by 7-20% of the population. Most of them in Wroclaw (28%). However, only 19% of respondents reporting symptoms of wheezing and whistling in the chest were diagnosed with bronchial asthma. Only 30% were diagnosed with asthma. This suggests that some cases of asthma are undiagnosed among urban and rural residents alike. Severe asthma places a burden on the patient, family and health system. This is due to the severity of the symptoms of the disease, treatment costs, impaired activity, quality of life, and limitations in fulfilling social roles and professional work. It is estimated that severe asthma affects 5-10% of the population suffering from bronchial asthma. A dynamic increase in the incidence of asthma is observed in Poland. This picture is in line with the worldwide rapid increase in the incidence of all forms of allergic diseases. Asthma is the most common chronic disease in children, adolescents and adults under 45. Asthma and respiratory diseases are one of the most common causes of hospitalization in this age group. The inhabitants of large cities suffer from asthma more often (3-4 times more often) than in rural areas [7].

Cardiovascular diseases are the leading cause of death in Poland [9].

Poland is a country in Europe on the north hemisphere in moderate climate. Autumn and winter (October-March) are considered heating season as temperatures often fall below 0°C.

AIM

The aim of the study was to investigate the correlation between air pollution in Lublin in 2019 and the number of hospitalizations due to exacerbations of chronic lung and heart diseases.

MATERIAL AND METHODS

Data was collected from January 1, 2019 to December 31, 2019 in Lublin. The concentration of PM 2.5, PM 10, temperature and relative air humidity were measured at a fixed time of 6:00 a.m. The 1.5 m above the ground in a point sheltered from direct sunlight in Lublin, Bronowice district, using an air sensor model: DM106A (China). Data on the number of hospitalizations of patients with exacerbations of bronchial asthma as well as chronic obstructive pulmonary disease (COPD) and ischemic heart disease, including acute cardiac syndrome (ACS), ST-elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI), were obtained with the consent of the management of the Independent Public Clinical Hospital No. 4 (SPSK 4) in Lublin at 8 Jaczewski Street.

The collected research material was statistically processed using the IBM SPSS Statistics (v. 25) statistical package. Quantitative variables are described by means of the mean, standard deviation, median, first quartile, third quartile, as well as minimum and maximum values. For categorical variables,

TABLE 2. Statistics on the number of patients hospitalized in SPSK4 in Lublin from January to December 2019 due to exacerbations of heart and lung diseases.

Month	Heart diseases		Lung diseases		Total
	N	%	N	%	N
January	170	77.3	50	22.7	220
February	212	82.2	46	17.8	258
March	186	81.2	43	18.8	229
April	179	77.2	53	22.8	232
May	224	84.2	42	15.8	266
June	178	78.8	48	21.2	226
July	222	79.9	56	20.1	278
August	200	79.7	51	20.3	251
September	172	75.8	55	24.2	117
October	223	75.6	72	24.4	295
November	130	69.5	57	30.5	287
December	76	58.0	55	42.0	131
	2172	77.6	628	22.4	2800

the size and percentage of the categories are given. The normality of the data distributions was checked using the Shapiro-Wilk test.

In order to determine the correlation between quantitative variables, the Pearson linear correlation coefficient was used, which is used to test the linear relationship between two features, provided that the distribution of the studied features is a normal distribution. The chi-square test was used to determine the relationship between the variables measured on the qualitative scale. The obtained results of the analysis were considered statistically significant at $p<0.05$. The results are presented to the nearest thousandths.

RESULTS

Table 1 shows the annual summary of measurements of concentrations of PM 2.5, PM 10, temperature and air humidity in 2019 and basic statistics. Increases in PM 2.5 and PM 10 concentrations were observed in January and February 2019. They fell in March and April - with the end of the heating season, and rose sharply on October 18, and then fluctuated in November and December 2019. A negative correlation ($p<0.001$) was found between the temperature and the concentrations of both types of dust. There was a positive correlation between relative air humidity and PM 2.5 ($R=0.366$) and PM 10 ($R=0.355$). Table 2 presents the statistics on the number of patients hospitalized in SPSK4 in Lublin from January to December 2019 due to exacerbations of heart and lung diseases. The correlation between air temperature and the number of hospitalization from lung diseases (LD) was negative ($R=-0.044$), between LD and PM 2.5 was not significant ($R=0.222$), for PM 10 as well ($R=0.198$). There was a positive correlation between r elative air humidity and the number of hospitalizations due to exacerbation of LD ($R=0.583$; $p<0.05$). The increase in humidity in the fall months was accompanied by an increase in hospitalizations due to LD. There were no statistically significant relationships ($p>0.05$) between the number of admissions to hospital due to heart diseases and air temperature ($R=-0.064$), PM 2.5 ($R=0.383$), PM 10 ($R=-0.289$) nor relative air humidity ($R=-0.345$). In the analysed period, both women and men were significantly more often hospitalized for exacerbations of heart disease than for lung disease.

DISCUSSION

According to Wojtyniak and Goryński, the estimated health effects related to short-term exposure to high concentrations of suspended dust particles with a diameter of 2.5 micrometers (PM 2.5) are much lower than those observed as a result of long-term exposure to lower concentrations. The estimated number of premature deaths resulting from short-term exposure to PM 2.5 in 12 agglomerations and 14 largest Polish cities in 2005-2017 is 4,000 per year. The observed concentration levels of PM 2.5 above 80 μ/m^3 (equivalent to a daily concentration of 100 μ/m^3 PM 10 – the threshold value informing the public about the risk of exceeding the alarm level for PM 10 dust) indicate an average 25% share of premature and relatively rare situations with such high concentrations. However, short-term exposure to air dust pollution cannot be underestimated, because in areas where low emissions have a significant share in air quality, this share may be twice as high. In cases of smog episodes lasting more than a few days, an increase in the number of deaths per month should be expected at the level of over 2,000 additional cases nationwide [7].

According to the definition provided by the Chief Inspectorate for Environmental Protection (Chief Inspectorate of Environmental Protection), aerosol (winter) smog is an atmospheric phenomenon arising from the primary emission of dust and gaseous pollutants into the air and the formation of secondary dust as a result of chemical reactions occurring in the atmosphere, in weather conditions favoring the accumulation of such as wind silence, strong thermal inversion, haze, average daily air temperature below 5°C. The nomenclature of air quality assessment used by the Chief Inspectorate of Environmental Protection often includes the definition of smog as an episode of a situation of elevated concentrations of PM10 for one or several days with an observed over 50% excess of the daily permissible level for PM 10 (50 $\mu g/m^3$), i.e. the limit level an episode of 75 $\mu g/m^3$ [10,11].

In the study, the WHO standards for air pollution were not exceeded [12-15]. There are no large industrial plants in Lublin, and pollution in the heating season results from the burning of solid fuels in home furnaces.

Slama et al. also studied the correlation between the level of air pollution in several large cities in Poland and admissions to hospital. In their study only a weak correlation was found between the increase in air pollution and the number of hospitalizations due to cardiovascular diseases [16]. Our results also did not show any significant correlation between concentrations of PM 2.5, PM 10 and numbers of admissions to SPSK4 due to exacerbation of heard or LD.

Konduracka et al. studied the relationship between air pollution and the frequency of heart attacks among the inhabitants of Cracow in 2012-2015. The authors in all age groups found a positive correlation between a short-term increase in PM 2.5 concentrations in the air and an increase in the number of hospitalizations due to heart attacks. For PM 10, such a relationship was observed only with a decrease in air temperature [17]. It is clear that when temperature drops, people use more solid fuels for heating. Cracow and Katowice have the worst air quality of all Polish cities. Moreover, Cracow is located in a valley with weak winds so any PM stays there in air for longer periods than in other regions of the country. Katowice and the adjacent agglomeration have a lot of industry releasing gaseous air pollutant and PMs. Lublin, however, is located on a highland, has little industry and is surrounded by agricultural region with clean air.

Cichowicz et al. analyzed the variability of air pollution levels (including PM 2.5, PM 10) in Greater Poland in 2009-2015 and observed a similar variability as in our study – the dust concentration increased during the heating season [18].

Dyląg et al. analyzed the influence of air pollution in Cracow on the incidence of infections in children. They found that the annual mean concentrations of PM 10, PM 2.5 and nitrogen oxides exceeded the permissible values in Poland. Moreover, they showed a positive correlation between their levels and the number of viral respiratory infections in children during the winter period. There was no relationship between the incidence of disease and the air temperature [19].

In the current situation, it is estimated that the number of COVID-19 cases increases by 100% when the concentration of dust pollution increases by 20%. Increased air humidity also favors longer survival of viruses in water drops from nasal or mouth secretions carried by air currents during sneezing and coughing [20,21]. Sciomer et al. note that particulate air pollution worsens the course of COVID 19 infections [22].

Researchers from Milan found a positive correlation between the concentration of PMs in the air, temperature and the number of COVID 19 infections in Italy in early 2020. They found a negative correlation between air humidity and the number of infections [23].

The analysis of Fattorini et al. showed that the concentrations of air pollutants (NO2, O3, PM 2.5, PM 10) in the northern part of Italy over the past 4 years have exceeded the permissible limits for a long time. Long-term air pollution positively correlates with the high number of COVID19 infections in the northern provinces of Italy, and with an increased incidence of severe respiratory and circulatory complications in the course of the disease [24]. The dusts are pro-inflammatory and raise the concentration of C-reactive protein in the blood serum [25,26].

CONCLUSIONS

In low air temperatures during heating season dust concentrations increase but they do not affect the number of hospitalizations in Lublin. Air humidity is the factor correlated with admissions to hospital of both men and women with lung and heart diseases.

REFERENCES

1. Grzywa-Celińska A, Krusiński A, Milanowski J. 'Smoging kills' – Effects of air pollution on human respiratory system. Ann Agric Environ Med. 2020;27(1):1-5.
2. Pope CA 3rd, Burnett RT, Thurston GD, et al. Cardiovascular mortality and long-term exposure to particulate air pollution: epidemiological evidence of general pathophysiological pathways of disease. Circulation. 2004;109(1):71-7.
3. Orru H, Ebi KL, Forsberg B. The Interplay of climate change and air pollution on health. Curr Environ Health Rep. 2017;4(4):504-13.
4. Kim KH, Kabir E, Kabir S. A review on the human health impact of airborne particulate matter. Environ Int. 2015;74:136-43.
5. Gasparrini A, Guo Y, Hashizume M, Kinney PL, et al. Temporal variation in heat-mortality associations: A multicountry study. Environ Health Perspect. 2015;123(11):1200-7.
6. Capon A, Corvalan C. Climate change and health: global issue, local responses. Public Health Res Pract. 2018;28(4):2841823.
7. Wojtyniak B, Goryński P. Sytuacja zdrowotna ludności Polski i jej uwarunkowania. Warszawa: Narodowy Instytut Zdrowia Publicznego – Państwowy Zakład Higieny; 2018.
8. Liebhart J, Dobek R, Małolepszy J, Wojtyniak B, et al. The prevalence of Allergic Diseases in Poland – the results of the PMSEAD Study in relation to gender differences. Adv Clin Exp Med. 2014;23(5):757-62.
9. Jankowski P. Zasady profilaktyki chorób układu krążenia w 2018 roku. Kardiol Inwazyjna. 2017;5(12):42-8.
10. Główny Inspektorat Ochrony Środowiska [http://powietrze.gios.gov.pl/]
11. Główny Inspektorat Ochrony Środowiska: Analiza wybranych epizodów wysokich stężeń pyłu PM10 z lat 2013-2016. Etap II Epizody z lat 2015-2016. Warszawa: Główny Inspektorat Ochrony Środowiska; 2017.
12. World Health Organization. Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: global update 2005: summary of risk assessment. Geneva: World Health Organization; 2006.
13. World Health Organization. Health risks of air pollution in Europe – HRA PIE project. Recommendations for concentration–response functions for cost – benefit analysis of particulate matter, ozone and nitrogen dioxide. WHO Regional Office for Europe. World Health Organization; 2013.
14. World Health Organization. Review of evidence on health aspects of air pollution – RE VIHAA P Project. Technical Report; 2013.
15. World Health Organization Regional Office for Europe. Review of evidence on health aspects of air pollution – REVIHAAP project: final technical report. World Health Organization; 2013.
16. Slama A, Śliwczyński A, Woźnica J, et al. Impact of air pollution on hospital admissions with a focus on respiratory diseases: a time-series multi-city analysis. Environ Sci Pollut Res Int. 2019;26(17):16998-7009.
17. Konduracka E, Niewiara Ł, Guzik B, et al. Effect of short-term fluctuations in outdoor air pollution on the number of hospital admissions due to acute myocardial infarction among inhabitants of Kraków, Poland. Pol Arch Intern Med. 2019;129(2):88-96.
18. Cichowicz R, Wielgosiński G, Fetter W. Dispersion of atmospheric air pollution in summer and winter season. Environ Monit Assess. 2017;189(12):605.
19. Dyląg KA, Wroński B, Przybyszewska K, Dumnicka P. Air pollution is associated with incidence of viral croup among children living in Kraków area, Poland. Folia Med Cracov. 2018;58(1):69-79.
20. Andree BPJ. Incidence of COVID-19 and Connections with Air Pollution. Exposure: Evidence from the Netherlands. Policy Research Working Paper 9221.World Bank Group; 2020.
21. Sharma AK, Balyan P. Air pollution and COVID-19: Is the connect worth its weight? Indian J Public Health. 2020;64(Supplement):S132-S134.
22. Sciomer S, Moscucci F, Magrì D, et al. SARS-CoV-2 spread in Northern Italy: what about the pollution role? Environ Monit Assess. 2020;192(6):325.
23. Zoran MA, Savastru RS, Savastru DM, Tautan MN. Assessing the relationship between surface levels of PM2.5 and PM10 particulate matter impact on COVID-19 in Milan, Italy. Sci Total Environ. 2020;738:139825.
24. Fattorini D, Regoli F. Role of the chronic air pollution levels in the Covid-19 outbreak risk in Italy. Environ Pollut. 2020;264:114732.
25. Hennig F, Fuks K, Moebus S, et al. Nixdorf Recall Study Investigative Group. Association between source-specific particulate matter air pollution and hs-CRP: local traffic and industrial emissions. Environ Health Perspect. 2014;122(7):703-10.
26. Li Y, Rittenhouse-Olson K, Scheider WL, Mu L. Effect of particulate matter air pollution on C-reactive protein: a review of epidemiologic studies. Rev Environ Health. 2012;27(2-3):133-49.

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