Epidemiology of Selected Diseases Related to Air Pollution in Krakow

Agnieszka Petryk

1 Department of Regional Economics, Cracow University of Economics, ul. Rakowicka 27, 31-510 Kraków, Poland, e-mail: agnieszka.petryk@uek.krakow.pl

ABSTRACT

Excessive concentrations of smog toxicants constitute a critical factor influencing the health quality of inhabitants of urban agglomerations. The exposure to elevated concentrations of suspended particulate matter, sulfur dioxide (SO\(_2\)), nitrogen dioxide (NO\(_2\)) and carbon monoxide (CO) is associated with an increase of adverse health effects. Prolonged exposure to air pollution, especially from low emission, may be linked not only to a greater risk of developing cancer of the respiratory system, or cardiovascular morbidity but also to the increased frequency of admissions to hospitals and emergency units as well as medical consultations in surgeries and outpatient clinics. The issue was investigated using the city of Cracow as an example. Attempts were made to find the connection between air pollution in the city of Cracow and the frequency of hospitalization and medical consultations of patients (registered in the city) due to lung and bronchial malignancy and cardiac dysrhythmia taking into account the data from the years 2010–2016 submitted by the Malopolska Regional Branch of the National Health Fund.

Keywords: air pollution, smog, low emission, morbidity

INTRODUCTION

Air pollutants monitoring, conducted in terms of assessing their harmfulness to human health in accordance with the EU and national regulations, includes the emission of 11 substances [Holnicki et al. 2014]. The study analyzes four selected substances which are especially prevalent in the Krakow agglomeration: suspended particulate matter (PM\(_{10}\), PM\(_{2.5}\)), sulfur dioxide (SO\(_2\)), nitrogen dioxide (NO\(_2\)) and carbon monoxide (CO). Particular attention is paid to the threats arising from the emission of suspended particulate matter due to the fact that its concentration levels show the highest values among the four aforementioned toxicants and for this reason they arise public interest. For the conducted analyses, the basic thesis is that air polluted with low emission products poses a potential threat to the health of users and city dwellers. The low-emission sources such as urban transport and other transport pollution, the heating system of detached houses based on the combustion of coal and municipal waste, or local boiler rooms, rather than cogeneration plants, steel plants or other industrial plants, are the main source of air pollution in urban agglomerations [Bagieński and Jaskulska 2016; Report 2010; Petryk 2017a; Petryk 2017b]. This is related to the fact that the emission of pollutants from large industrial, heating, energy and transport sources is subject to numerous legal acts and to strict control, contrary to the uncontrolled practice of burning fuels and waste in household furnaces, which, however, is gradually normalizing [Juda-Rezler 2016]. For this reason, the emission of pollutants from low sources (so-called low emission) has a greater influence on air quality at the ground level of the atmosphere where fuels of low quality are often burnt, rather than from high sources (steel plants, cogeneration plants, etc.) where the quality of fuels used is incomparably higher, and in addition they are obligatorily equipped with high efficiency dust collectors [Juda-Rezler 2016]. In Poland, the most commonly used device for heating detached houses “is a boiler or coal furnace, less often a fireplace or a boiler fu-
Among the effects of short-term exposure to toxicants is increasing. The sources of low emission show multiple variations, depending on the chemical composition of pollutants and their emission intensity as well as the technical conditions of the emitter (height, diameter, etc.) [Degór ska 2016]. The sources of anthropogenic origin is emitted from municipal and household sources, and above all from energy and industrial sources associated with the chemical composition of pollutants and their emission intensity as well as the technical conditions of the emitter (height, diameter, etc.) [Degórska 2016].

**SOURCES AND IMPACT OF AIR POLLUTANTS ON HUMAN HEALTH**

The analysis of the related literature does not cast any doubt that the occurrence of some diseases is directly or at least indirectly associated with the pathogenic exposure to air pollution, especially in urban agglomerations. The relationship between the air pollutants and their impact on the health of inhabitants of urban agglomerations, especially metropolitan cities, concerns not only the morbidity of respiratory and immune system diseases or neurological symptoms, but also the prevalence of prematurity, spontaneous abortion, low birth weight and birth defects of newborns that lower their intellectual and immunological potential in subsequent developmental stages [Report on the state of health 2011].

Low emission of suspended particulate matter from the sources of municipal and household sector as well as from the so-called secondary emission related to the negligence of city cleanliness and the growing intensity of car transport is a real problem in Polish cities [Wnuka 2010]. Suspended particulate matter has its toxic impact on significant areas due to its cross-border nature caused by meteorological factors that may stimulate the spread of pollutants by air or restrict air ventilation in rural and urbanized areas [Kozłowska et al. 2011; Wnuka 2010]. Primary particulate matter emission comes from natural and anthropogenic sources, while the particulate matter generated as a result of chemical reactions becomes a secondary toxicant in the atmospheric air [Degór ska 2016].

The number of research projects in which confirmation or exclusion of dependence between high concentrations of suspended particulate matter and the higher number diagnoses of specific diseases in people susceptible to short or long-term exposure to these toxicants is increasing. Among the effects of short-term exposure to the absorption of higher concentrations of suspended particulate matter by the body, acute responses of the respiratory system were found in individual age categories. Long-term exposure, even to relatively low concentrations of particulate matter, over many years leads to the development of chronic diseases, including cancer, especially lung cancer, as confirmed by the International Agency for Research on Cancer (IARC) [Skotak 2016].

The prenatal and perinatal exposure to toxic effects of suspended particulate matter may lead to fetal development disorders and cause perinatal complications; it also poses a higher risk of developing allergies, diabetes, asthma, nervous system diseases, etc. in a child’s adult life [Skotak 2016]. The risk of recurrent pneumonia is even three times higher in the children whose mothers were exposed to high levels of PM2.5 during pregnancy [Warczyński 2016]. In etiopathogenesis of diseases, both the finest particulate matter fractions and the concentration of its individual constituent substances can be critical. It is believed that it is the content of hydrocarbons or transition metals exert more influence on the development of asthma than the total concentration of particulate matter [Jędrak, Badyda and Konduracka 2016]. Physical activity, which intensifies lung ventilation, exposes the people doing sport under the conditions of higher particulate matter concentration to the inhalation of higher content of the toxicant [Malec and Borowski 2016]. There is no safe level of concentration below which there are no adverse health effects of exposure to this toxicant [Skotak 2016].

The number of medical consultations as well as absenteeism in schools and workplaces rises when the concentration of suspended particulate matter is relatively low. Higher concentrations may determine the increase in the number of people being hospitalized as well as in the number of deaths [Skotak 2016]. Every year in Poland, more than fifteen times more people die from the diseases related to air pollution than from road accidents. This is estimated at forty-five thousand people a year [Warczyński 2016].

Black smog occurring in industrial areas in the winter is particularly dangerous for human health [Juda-Rezler 2000] due to the high concentrations of sulphur dioxide. Sulphur dioxide (SO2) of anthropogenic origin is emitted from municipal and household sources, and above all from the energy and industrial sources associated with
the extraction, processing and combustion of fossil fuels, in particular, hard coal in Poland [Kordylewski 2008]. Exposure to high concentrations of the colourless gas characterized by a choking odour is fraught with a high risk of airway damage [Kostrz and Satora 2017].

In the case of nitrogen dioxide ($\text{NO}_2$), there is an upward trend in its anthropogenic emission from urban transport sources, with a noticeable reduction in the production of nitrogen oxides in the energy industry [Juda-Rezler 2000]. On the one hand, this is due to the increasing share of cars in urban transport, on the other, it results from the use of modern technologies in the power industry [Juda-Rezler 2000]. Exhaust fumes constitute the main source of carbon monoxide (CO) emission although combustion of fuels in the municipal and household sector, accounting for nearly 50% of its national emissions plays also a significant role [Zakrzewski 1995; Juda-Rezler 2000; Hławiczka 2008].

AIR POLLUTION IN CRACOW

Road transport is a critical source of particulate matter emission. Not only is the dust caused by the combustion of fuels in car engines, but also by the wear of brake pads and the abrasion of tires and road surfaces, including re-suspension, i.e. re-lifting of road dust during road traffic [Degórska 2016]. According to the data of the Department of Municipal Economy and Environmental Protection of the Municipal Office of Cracow, collected on the basis of vehicular traffic measurements, approximately 40,000 vehicles pass through Cracow through transit traffic every day, and the total number of people entering the city daily amounts to 246 thousand. The most traffic-laden are: Kościuszko barrage, the Dębnicki Bridge, as well as ul. Wielicka and Zakopiańska [“Gazeta Krakowska” 2017].

It was estimated that several hundred people die due to air pollution in Cracow per year. “The average number of avoidable deaths per year was estimated for 2001 in relation to the level of pollution reduction (average annual PM2.5). The reduction to the level of 25 $\mu\text{g/m}^3$ would decrease the number of deaths on average by 232, to the level of 20 $\mu\text{g/m}^3$ by 362, to the level of 15 $\mu\text{g/m}^3$ by 492, and to the level of 10 $\mu\text{g/m}^3$ (WHO recommendation) by 612. In addition, it was estimated that a statistical resident of Cracow would live one year longer, on average, if the mean annual concentration of particulate matter PM2.5 could be reduced to 15 $\mu\text{g/m}^3$” [bip.malopolska.pl 2017].

The data from the Krakow Smog Alert indicated that the daily dose of benzo[a]pyrene absorbed by residents of Krakow during the year 2011 corresponded to the smoking an average of seven cigarettes [Pankowska, Gorczyca 2015].

The measurements carried out in the air quality control stations at the main communication routes in Cracow showed that the permissible level of PM10 particulate matter concentration had been exceeded in the years 2010–2015 (Table 1). Despite the exceedance of standards, a decrease in the concentration of average annual PM10 in the analyzed five-year period was observed at all measuring points.

In the same period, the values of average annual PM 2.5 concentration also exceeded the permissible standards (Table 2). As in the case of PM 10, a downward trend of PM 2.5 concentrations was noticeable in the years 2011–2015. In 2016, in the Cracow agglomeration, more than 35 exceedances of the permissible standard of PM10 concentrations were observed at all monitoring stations within 24-hour period (Table 3).

<table>
<thead>
<tr>
<th>Location of the measuring station</th>
<th>Concentration of average annual PM 10 $[\mu\text{g/m}^3]$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permissible level (since 2005) 40 $[\mu\text{g/m}^3]$</td>
</tr>
<tr>
<td>Ul. Bujakowa</td>
<td>54</td>
</tr>
<tr>
<td>Ul. Bułwarowa</td>
<td>77</td>
</tr>
<tr>
<td>Al. Krasiańskiego</td>
<td>63</td>
</tr>
</tbody>
</table>

AIR POLLUTION AND INCIDENCES OF THE RESPIRATORY SYSTEM CANCERS, BRONCHI AND LUNGS CANCERS AS WELL AS CARDIAC DYSRHYTHMIA IN CRACOW

Malignancies caused by environmental pollution, mainly air pollution, constitute nearly 2% of the diagnosed malignancies, although this index is even higher in the populations of the Małopolskie and Silesia region [Kapka et al. 2009]. In the urban population, lung cancer is diagnosed more often than in the rural population [Gładka and Zatoński 2016]. In the population of Cracow, this risk increases by 4.5% in the male group and 10.5% in the female group [Kapka et al. 2009]. Air pollution is a critical factor in the development of lung cancer, which is second only to smoking [Gładka and Zatoński 2016, Gladysz et al. 2010]. It is believed that the abnormal concentration of nitrogen dioxide has the largest pathogenic impact on the occurrence of lung cancer [Gładka and Zatoński 2016]. People exposed to prolonged exposure of suspended particulate matter in the air are also highly susceptible due to the fact that the period of lung cancer development under the conditions of intense particulate matter exposure is by four years shorter than in the case of other carcinogenic substances that pollute the air [Cembrzyńska and in 2012]. Household stoves, in which plastic wastes are burnt, are one of the main emitters of toxicants with a mutagenic and cytotoxic effect [Jędrak et al. 2016].

In the years 2010–2016, men comprised the largest group of the patients treated for malignancy in Cracow; in hospital wards, inpatient emergency departments and admission rooms, the share of men accounted for 62% of the total number of patients treated, while in outpatient clinics it amounted to 60% of the total number of consulted patients (Table 4). Analyzing the diversity of the age structure, it should be stated that men dominated in all age categories. In the years 2011, 2012, 2015 and 2016, no female in the age range of 0–34 applied for treatment in hospital wards, inpatient emergency departments and admission rooms, whereas in outpatient clinics such a situation occurred in 2016. In the male group, the patients in the age range of 0–34 were not treated in hospital wards and in admission rooms in the years 2014 and 2016. There was a noticeable disproportion, both in the female and male group between the number of people in the age range of 0–34 and the total number of people ben-
Table 4. List of patients by sex and age living Cracow treated in the years 2010–2016 for the respiratory system cancers, bronchial and lung malignancy

<table>
<thead>
<tr>
<th>Name of the disease entity</th>
<th>Year</th>
<th>Total number of medical services</th>
<th>Hospital departments with the inpatient emergency departments and the admission room</th>
<th>Outpatient specialist care clinics contracted by Krakow’s hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>age 0–34</td>
<td>age 35–64</td>
</tr>
<tr>
<td>C-34 (Bronchial and lung malignancy)</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>4684</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>4704</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>5495</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>5232</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>5443</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>5246</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>5697</td>
<td>0</td>
<td>0</td>
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Source: Own study based on data from the Malopolska Provincial Branch of the National Health Fund in Krakow obtained applying the public information act (correspondence of 6 July 2017).

The research confirmed that even a short-term exposure to suspended particulate matter may cause electrophysiological changes in the heart that result in cardiac dysrhythmia and intensify susceptibility to this type of heart anomalies [Kowalska and Krzych 2007; Malec and Borowski 2016]. Obese and older people (over 65 years of age), patients treated for obstructive pulmonary disease or diabetes, and those with chronic respiratory and cardiovascular diseases are listed in the high-risk group [Jędrak et al. 2016 Kowalska and Kocot 2016]. A long-term exposure to low-emission toxicants is also a pathogenic factor of the inflammatory system in young healthy people [Annex No. 1 to Resolution No. XXXII/451/17 of the Regional Assembly of the Malopolska Region 23 January 2017]. Excessive concentrations of smog toxicants may be responsible for a larger number of urgent hospitalizations caused by the onset or exacerbation of cardiovascular disease symptoms [Kowalska and Krzych 2007]. “It was also proven that the increase in the concentration of PM2.5 by only 10μg/m³ in a short time (<24 hours) r the relative risk of cardiovascular deaths from 0.4% to 1.0%” [Jędrak, Badyda and Konduracka 2016].

In the period from 2010 to 2016 (Table 5), women constituted the largest group of patients treated in Cracow due to dysrhythmias in both hospital wards, inpatient emergency departments and admission rooms (65% of total patients), as well as in outpatient clinics (69%). In the distribution of the age structure, there was a strong dominance of women in all age ranges. In the group of men treated in hospital wards, inpatient emergency departments and in admission rooms, patients over 65 comprised the largest group (37%). In turn, in the group of men treated in outpatient clinics, the majority of patients were in the age range of 0–34 (48%). A small number of men aged 65+ who had medical consultations due to heart rhythm disorders in outpatient clinics (15%) was evident.
Table 5. List of patients by sex and age living Cracow treated in the years 2010–2016 for cardiac dysrhythmia

<table>
<thead>
<tr>
<th>Name of the disease entity</th>
<th>Year</th>
<th>Total number of medical services</th>
<th>Hospital departments with the inpatient emergency departments and the admission room</th>
<th>Outpatient specialist care clinics contracted by Krakow’s hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>age 0-34</td>
<td>age 35-64</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>M  F</td>
<td>M  F</td>
</tr>
<tr>
<td>R00 (cardiac arrhythmia)</td>
<td>2010</td>
<td>414</td>
<td>18 19 14 35 13 32 45 86 25 54 21 60 2 17 48</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>388</td>
<td>20 32 18 42 16 37 54 111 25 33 10 56 7 14 42</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>457</td>
<td>17 33 23 42 30 54 70 129 32 39 16 52 5 15 53</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>567</td>
<td>37 48 34 84 37 58 108 190 27 38 14 61 9 22 50</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>590</td>
<td>35 50 42 70 45 69 122 189 32 47 26 65 11 15 69</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>683</td>
<td>35 53 43 116 44 87 122 256 22 43 28 76 9 22 59</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>611</td>
<td>37 67 30 70 53 76 120 213 24 31 28 71 17 17 32</td>
<td>69 134</td>
</tr>
</tbody>
</table>

Source: Own study based on data from the Malopolska Provincial Branch of the National Health Fund in Krakow obtained applying the public information act (correspondence of 6 July 2017).

Among the women subject to treatment in hospital wards and admission rooms, female patients in the age range of 35–64 comprised the largest group (39%); a similar trend was in outpatient clinics (51%). In the analyzed six-year period, a relatively constant upward tendency in the number of medical services provided to the patients with arrhythmias was noticed. In 2016, the number increased by 197 services compared to 2010.

CONCLUSIONS

1. In the years 2010–2016, men constituted the largest group of patients treated for malignancy in Cracow. The morbidity of lung and bronchial malignancy mainly concerned the people over 35 years of age, with a significant majority of male patients. The highest morbidity was found in people over 65 years of age.
2. In the period from 2010 to 2016, women constituted the largest group of patients treated for dysrhythmias. In the distribution of the age structure, strong dominance of women in all age ranges was visible at that time.
3. The latest literature data show that the human exposure to suspended particulate matter (PM10 and PM2.5), sulfur dioxide (SO₂), nitrogen dioxide (NO₂) and carbon monoxide (CO) is associated with an increased risk of cardiac arrhythmia, lung and bronchial malignancy as well as asthma.
4. The analysis of the state of air pollution: PM10 and PM2.5, SO₂, NO₂, CO showed that there were unfavorable weather conditions in the city of Cracow, resulting in long-term excessive concentrations of low-emission toxicants.

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