The economic burden of air pollution impact on health of Warsaw population

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Abstract: Aim of this study was to assess the annual social cost of air pollution impact on health of Warsaw population. The study consisted of three main parts, i.e. the determination of Warsaw citizens' exposure to air pollution, the quantification of the health effect as a result of this exposure and the economic evaluation of the assessed health impact. Value of Statistical Life (VSL) derived from Willingness To Pay (WTP) for mortality risk reduction was used to assess the costs of premature mortality, whereas the Cost of Illness (COI) Approach was applied for the estimation of the costs of excessive cardiovascular and respiratory hospitalizations as well as restricted activity days. Thorough search was performed to find the best assessment of VSL for the Warsaw population and finally the value of 1.9 Mio PLN was chosen. Annually, approximately 2 264 premature death cases, 351 839 restricted activity days, 684 and 1 551 excessive hospital admissions due to (respectively) respiratory and cardiovascular problems can be attributed to air pollution. The total costs of air pollution health effects in Warsaw amount to about 4,4 Bn PLN. The cost of air pollution impact on human health is significant. Therefore, more attention should be paid for the integrated environmental health policy, with a focus on cities as a priority.

Keywords: air pollution, social costs, particulate matter, value of statistical life, willingness to pay

1. Introduction

WHO (2011) defines air pollution as contamination of indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the

atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Air pollution is a cross border issue, entailing many negative effects, including: threat to human health, damage of ecosystems, damage to materials and buildings. These effects generate costs, which are borne by the whole society, and so it is important to know the height of them, in order to form the right environmental policy.

The most important air pollutants are: particulate matter (PM), nitrogen oxides, sulfur dioxide, ozone and volatile organic compounds (Maibach et al., 2008). Effects of these pollutants on health are correlated, i.e. epidemiological studies cannot strictly allocate observed effects to a single pollutant. A pollutant-by-pollutant assessment would grossly overestimate the impact. Therefore, usually one pollutant – typically PM_{10} or $PM_{2.5}$ – serves as an indicator of outdoor air pollution to derive the attributable cases (Künzli et al., 2000). PM is an air pollutant consisting of a mixture of particles that can be solid, liquid or both, suspended in the air and representing a complex mixture of organic and inorganic substances. Particles vary in size, composition and origin and their properties are usually determined by their aerodynamic diameter (particles with diameter less than 10 µm are called PM_{10} and less than 2.5 µm – $PM_{2.5}$). Primary particles are directly emitted into the atmosphere through natural and anthropogenic processes. The latter includes: combustion of fuel in car engines (both compression ignition and spark ignition), solid-fuel (coal, lignite and biomass) combustion in municipal sector, industrial activities (building, mining, smelting, manufacturing of cement, ceramic and bricks), abrasion of the road surface by vehicles and wear of the brakes and tires (WHO, 2006). Epidemiological studies attribute the most severe health effects of air pollution to PM. The evidence base for an association between PM and short-term (as well as long-term) health effects has become much stronger (EEA, 2013). It is estimated that $PM_{2.5}$ air pollution is responsible worldwide for approximately 0.8 million premature deaths and 6.4 million years of life lost per annum (Cohen et al., 2005).

According to an Europe-wide study performed by the European Environment Agency (EEA, 2013) in 2011 Poland was one of the most polluted countries in the European Union (Figure 1), in which the annual and daily limit values for PM_{10} were exceeded most often (alongside with Italy, Slovakia, the Balkan region, Turkey and also several urban regions, e.g. Paris, Marseille).

Figure 1. Annual mean concentrations of PM$_{10}$ in 2011.
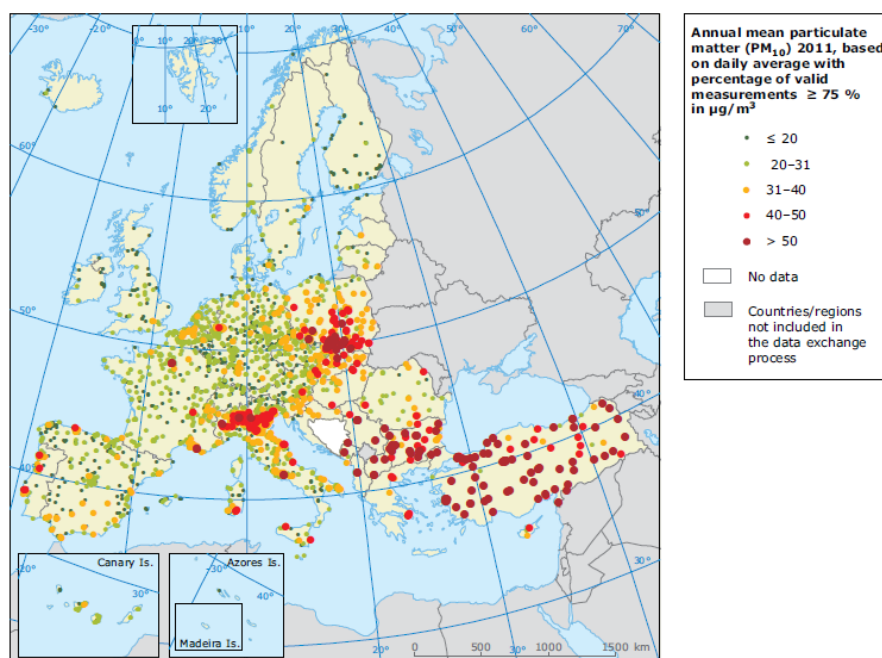

Source: (EEA, 2013: 29).

According to EEA (2013), the effects of poor air quality have been felt most strongly in two areas:

- in urban areas, where the majority of the European population lives, leading to adverse effects on public health;
- in ecosystems, where the pressure of air pollution impairs vegetation growth and harms biodiversity.

Warsaw is the capital of Poland and its biggest city with around 1.7 million inhabitants. The city has undergone rapid economic growth since the early 1990s. Monitoring and assessment of air quality in Warsaw is a part of the Monitoring System of Air Quality in the Masovian Voivodship. It is based on the measurements performed in eleven monitoring sites, ten of which are automatic and one manual. The location of the stations is shown in Figure 2. The results of measurements are obtained on-line as an one hour average concentration of (depending on the station) sulfur dioxide, nitrogen oxides, ozone, PM, carbon monoxide, benzene, toluene, ethylbenzene, xylene (ortho-, meta-, para-) as well as selected meteorological parameters. The

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PM_{10} is further analyzed for the concentration of metals (arsenic, cadmium, nickel, lead) and polycyclic aromatic hydrocarbons (including benzo(a)pyrene). Collected data is verified and test reports on the current state of air quality are prepared (Regional Inspectorate of Environmental Protection in Warsaw, 2012).

Figure 2. The location of air quality monitoring sites in Warsaw in 2011 (A-K).
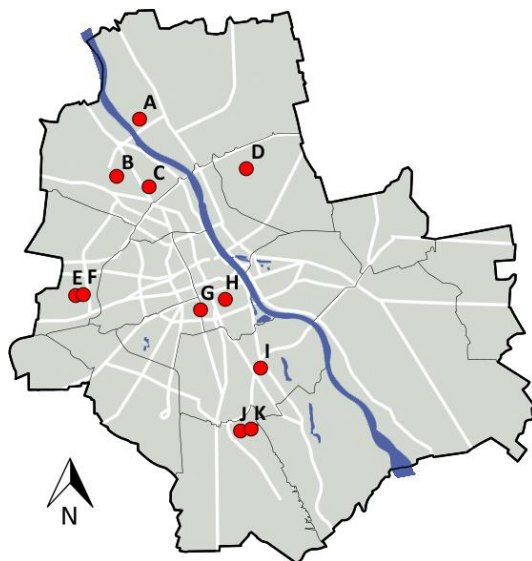
Source: authors' own elaboration based on Regional Inspectorate of Environmental Protection in Warsaw (2013) and Mfloryan (2013)

The results of air quality assessments carried out in 2011 have shown that the PM_{10} concentration exceeded the daily acceptable mean level (50.0 µg/m³) at all PM_{10} monitoring sites (Figure 2, sites: A, D, G, H, J, K) and the annual standard (40.0 µg/m³) was exceeded at one of them (located in the city center; Figure 2, site G). Comparing to the previous year, an increase in average annual concentration levels and in the number of days with exceeded daily acceptable mean level was observed for some of the monitoring sites (Regional Inspectorate of Environmental Protection in Warsaw, 2012).

The aim of this study was to evaluate the annual social costs of the negative impact of air pollution on health of the Warsaw population. Firstly, the assessment followed the basics of the Health Impact Assessment method and so consisted of four steps: hazard identification, exposure analysis, dose-effect relationships and finally the risk assessment. As a result the number of premature mortality cases, excessive hospitalizations due to respiratory and cardiovascular

diseases as well as the number of restricted activity days were obtained. At the end, an economic value was put on the these results and thus a social cost of air pollution in Warsaw was determined. Several similar studies have been conducted throughout Europe and worldwide, mostly (but not only) for whole countries (HAPINZ 2012; Orru et al., 2011; Xie et al., 2011).

2. Methods

The study consists of three main parts – the first one is concerned with air pollution, the second one with epidemiology and the third one with economic evaluation. Figure 3 presents the subsequent steps of the assessment performed in this study, which are further described in detail. Generally, the recognized methodology presented by Künzli (Künzli et al., 2000) was applied, with the adjustment to Warsaw conditions.

Figure 3. The study methodology scheme.
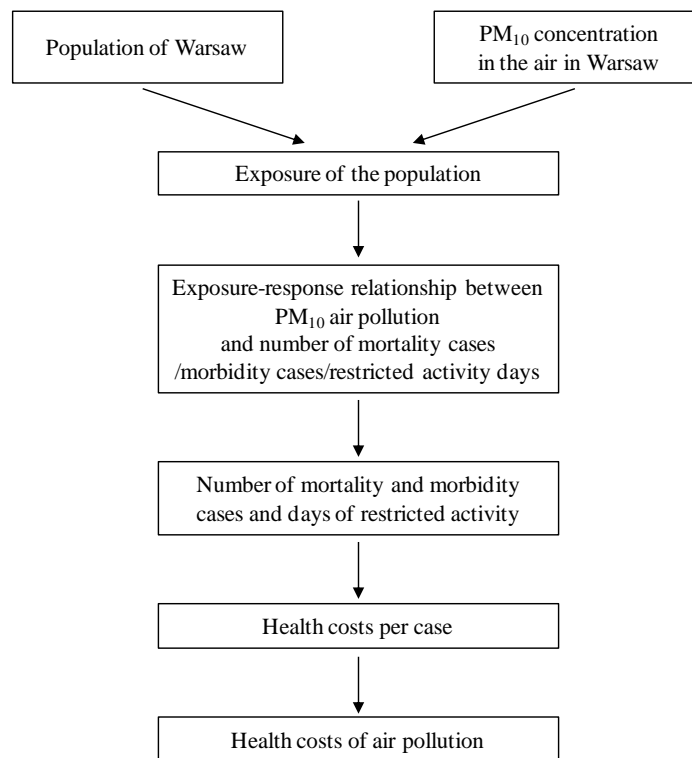
Source: authors' own elaboration.

All the data was obtained from the published and available on-line sources, primarily from: Central Statistical Office, Social Insurance Institution, Regional Inspectorate of Environmental Protection in Warsaw, Mazovian Province Office in Warsaw and National Health Fund (NFZ). In order to use as up-to-date data as possible, the latest editions of sources were always chosen, which means that "annual" data comes from years 2005-2012. Such approach should not lead to a serious distortion of the final results.

2.1. Assessment of the exposure of the Warsaw population to air pollution

In this study PM_{10} was assumed to be the best available indicator of air pollution. PM_{10} is considered to be generally a very good air pollution indicator and is widely used to assess the impact of air pollution on human health. The reason for that is the credibility and recognition of the epidemiological studies, which the dose-response functions are based on (*cf.* Pope and Dockery, 2006). What is more, PM_{10} is an air pollutant consisting of a mixture of particles that can be solid, liquid or both, suspended in the air and therefore represents a complex mixture of organic and inorganic substances (Harrison et al., 2004; Zereini and Wiseman, 2010). Lastly, PM_{10} has been widely used in other studies and projects, so this choice allows to make some comparisons between regions (e.g. Dhont et al., 2011; Künzli et al., 2000; Orru et al., 2011; HAPINZ, 2012).

In order to determine the annual exposure of the Warsaw population to PM_{10} several assumptions had to be made. Firstly, as the study concerns only one city (and not the whole country), the idea of modeling the concentration of PM_{10} in Warsaw was abandoned and instead the average annual concentration of PM_{10} [µg/m^3] from 6 monitoring stations in Warsaw was used for further calculations. All the results were similar (except for one site, located directly in the centre of Warsaw, with higher concentrations), which confirms that this simplifying assumption should not have a significant effect on the results. The last key assumption (adopted also in other studies) was that the whole population of Warsaw citizens is exposed equally to the average annual concentration (*cf.* Conclusions).

2.2.   Assessment of the impact of air-pollution on health

The evidence that particle exposures cause a range of adverse health effects primarily emerged from the findings of American epidemiological studies, which comprised both time-series and prospective cohort studies. They showed significant increase in respiratory and cardiovascular mortality associated with acute and chronic exposures to particulate air pollution (e.g. Schwartz and Dockery, 1992a, 1992b; Dockery et al., 1993; Pope et al., 1995). Also the impact of particulate air pollution on morbidity endpoints has been subject to intense study, resulting in strong evidence of detrimental effects on respiratory and cardiovascular conditions following both short-term and chronic exposures (e.g. Pope and Kanner, 1993; Pierse et al., 2006; Gehring et al., 2010; Peters et al., 2001; Pope et al., 2008).

There are several lines of studies indicating the relationship between concentration levels of PM_{10} and different endpoints. In this study only non-overlapping endpoints for which appropriate data for Warsaw population is available were considered (Table 1). Such an assumption follows the conservative "at-least approach", which means that the magnitude of the negative impact is more likely to be under- than overestimated. In order to assess the number of mortality and morbidity cases as well as restricted activity days[1], the exposure-response functions between air pollution and health impacts (which describe quantitatively how much a specified health effect changes when exposure to the specified agent changes by a given amount) were applied. As this relationship in case of PM_{10} seems to have a linear correlation with no threshold value below which there is no health effect (WHO, 2006), the gradient in form of relative risk (RR) derived from the meta-analysis presented by Künzli et al. (2000) was used. Table 1 shows this relationship in terms of relative risks per 10 μg/m³ of PM_{10}.

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[1] There is no one common definition in literature of restricted activity days. Usually they are defined as days when a person needs to change their normal activities because of illness, often regardless of age or employment status. This study bases on the research of Ostro (1990), which focused on currently working adults aged 18 to 65 years and their days off work as well as minor restrictions of daily life due to respiratory disease. In this study almost all of the restricted activity day burden related to days off. Therefore, as a source of restricted activity days the Polish data on annual work absenteeism for respiratory reasons (deducted by the number of respiratory hospitalizations in this group) among Warsaw citizens insured by the Social Insurance Institution was used, assuming that a major part of restricted activity days leads to absence from work. It must be however emphasized that there may be a pressure on workers not to take a sick-leave, which can significantly underestimate the total number of restricted activity days. This suspicion is based on the fact that for Mazovian Voivodship the number of days of absence due to disease per insured by Social Insurance Institution is among the lowest in Poland.

Table 1. Relative risks per 10 μg/m^3 of PM$_{10}$ for selected endpoints

Endpoints	Relative risk (RR) (95% CI)	Source of exposure-response function
Long-term mortality (age ≥30 years; from non-external causes)	1.043 (1.026-1.061)	(Pope et al., 1995; Dockery et al., 1993)
Respiratory hospital admissions (all ages)	1.0131 (1.001-1.025)	(Zmirou et al., 1998; Prescott et al. 1998; Wordley et al., 1997)
Cardiovascular hospital admissions (all ages)	1.0125 (1.007-1.019)	(Prescott et al., 1998; Wordley et al., 1997; Poloniecki et al., 1997; Medina et al., 1997)
Restricted activity days (age 18-65 years)*	1.094 (1.079-1.109)	(Ostro, 1990)

*total person-days per year

Source: authors' own elaboration based on (Künzli et al., 2000).

2.3. Assessment of social costs of air pollution impact on health

The idea of associating monetary value with human life and health always seems to be controversial. However, policy makers are regularly facing decisions that affect people risk of death and therefore require methods for comparing the costs of reducing risk with the expected benefits in terms of lives/live-years saved. In this study the costs of air pollution health effects (i.e. costs of loss of life, medical treatment and productivity loss) from the societal perspective in Warsaw were assessed.

2.3.1. Costs of mortality

Several approaches were taken into consideration while evaluating costs of mortality due to air pollution.

The first one was the gross output approach (known also as human capital approach), in which the major component of the cost of premature death of individual is defined as the discounted present value of the victim's future output. However, most people value safety, because of their aversion to the prospect of their own or others' death/injury rather than in terms of effects on output and income. What is more, this approach neglects the intangible costs such

as pain and suffering of the victims and their relatives (Rowlatt et al., 1998). Despite its simplicity, this method due to its many limitations is usually not used in the assessment of air-pollution attributable costs.

The second one was the WTP/VSL approach, which entails estimation of a value of statistical life (VSL) basing on individual willingness to pay (WTP) for safety improvement. This approach, firmly rooted in economic theory, requires measuring of people preferences for safety. VSL is also known as value of preventing a statistical fatality (VPF), which represents the value a given population places *ex ante* on avoiding the death of an unidentified individual. VSL is based on the sum of money each individual is prepared to pay for a given reduction in the risk of premature death, for example from diseases linked to air pollution. There are two main approaches to estimate WTP (Robinson, 2008):

– stated preference (SP) methods, which typically employ survey techniques to ask respondents what they would pay for a risk reduction of a particular type;

– revealed preference methods, which estimate the value of non-marketed goods based on observed behaviors or prices and preferences for related marketed goods.

Although this concept seems to reflect more aspects than the gross output, it is not without disadvantages. The major difficulty consists in conducting an empirical study for the target population for air pollution related mortality risk.

The third concept, which has recently been given increasingly more attention, is the VOLY approach, which usually entails the derivation of the value of a life-year (VOLY) from a predetermined VSL, where the latter is typically estimated on the basis of WTP. In recent years there have been several attempts to value VOLY directly (e.g. Chilton et al., 2004; Desaigues et al., 2011). The approach incorporates a change of life expectancy and uses VOLY to calculate the cost. Following Desaigues et.al. (2011) the advantage of this concept over the VSL approach includes, *inter alia*, the following arguments:

– air pollution cannot be identified as a primary cause of an individual death and is only a contributing cause;

– the number of deaths approach fails to take into account that the magnitude of the loss of life expectancy per death is very much smaller for premature deaths due to air pollution

(life expectancy loss in Europe and North America: less than a year) than for fatal accidents (life expectancy loss: typically 30-40 years), on which VSL estimates are usually based.

The above arguments seem to be reasonable and intuitive – it is undeniable that most avoided premature deaths due to environmental policies would concern elderly people. Treating elderly and nonelderly people as equivalent for valuation purposes seems inappropriate, because much fewer life-years are lost when the elderly dies. At the same time, the epidemiological literature is not as robust in life-years lost, and the VOLY literature is very thin, involving only a few studies that directly ask for WTP for additional life expectancy. Therefore, some authors (e.g. Krupnick, 2004) are critical to the suggestion to use VOLY in the main analysis, with VSL for a sensitivity analysis. The US Environmental Protection Agency has also recently cautioned against using VOLYs that are assumed to be constant with respect to age, due to the limited evidence underlying this assumption (OECD, 2012). What is more, the latest studies from 2012 (HAPINZ, 2012; OECD, 2012) also use the VSL approach, arguing that for example elder people have usually high WTP in comparison to others.

As there are still some controversies concerning the VOLY approach and significantly most international studies evaluated air pollution impact on health using the VSL method, in this study also the latter approach was chosen, so that the results are more comparable. As stated before, the problem with the VSL approach consists in performing a reliable study on population WTP for risk reduction in mortality due to air pollution. Obviously, VSL may vary between countries, because of differences in income or cultural norms, so it is essential to find the assessment of VSL for as close population to the target one as possible. The design of the study also plays a huge role in the obtained results. The profound search through many studies was carried out and finally three studies and one recommendation applicable to target population were found (Table 2). At last, despite several problems with WTP estimates stated by the author and the fact that the WTP was elicited not in environmental context, the latest study conducted in Warsaw (Giergiczny, 2006) was used (*cf*. Conclusions).

Table 2. Summary of estimated VSL for Poland.

Author, year of study	Method	VSL in 2012 PLN[2] (CPI)	Comments
Miller, 2000	Regression-based estimate	1 454 087* Range: 1 211 740-2 423 479	Value derived from estimated VSLs from 68 credible studies across 13 countries (no Polish studies)
Dziegielewska and Mendelsohn, 2005	CVM to elicit WTP to reduce death risk due to air pollution in Poland; the survey was conducted on a nation-wide random sample of 1 055 adults in 2000	VSL estimate not included in the publication; based on median WTP: 515 317-739 396	+ WTP estimate concerning air pollution + CVM + Respondents were informed that most people whose death is related to air pollution are usually 65 and older - survey conducted 13 years ago, nation-wide
Giergiczny, 2006	CVM** to elicit WTP for risk of death reduction; the survey was conducted on a sample of 408 Warsaw citizens between 50 and 80 years old in 2005	VSL estimate not included in the publication; based on mean WTP: 1 909 471 Range: 463 260-4 160 153 based on median WTP: 173 326-2 362 232	+ target population of Warsaw citizens + CVM - author mentions several problems with CVM results - WTP estimate in health (not environment) context ("product that will reduce respondents' risk of dying")
OECD, 2012	Meta-analysis of SP studies worldwide	5 554 554 *** Range 2 777 277-8 331 832	79 studies included (incl. Giergiczny, 2006; Dziegielewska, 2005 excluded as OECD included only sample mean VSL estimates to maintain a sufficient degree of homogeneity)

CBA – cost-benefit analysis; CPI – Consumer Price Index; CVM – Contingent Valuation Method; PPP – Purchasing Power Parity; SP – Stated Preference; VSL – Value Of Statistical Life; WTP – Willingness To Pay;

*Originally: USD 480 tsd. (1995-USD) with a range: USD 400-800 tsd. (1995-USD), these values were converted to PLN using PPP-adjusted exchange rates for 1995 and adjusted to current (2012) using CPI (Consumer Price Index);

**We considered only stated preference studies;

***OECD recommended for EU-27 countries VSL in range USD 1.8-5.4 Mio (2005-USD) with a base value of USD 3.6 Mio. These values were – following OECD recommendations – adjusted with income (in terms of PPP-adjusted Gross Domestic Product (GDP) per capita) and income elasticity factor, converted to PLN using PPP-adjusted exchange rates for 2005 and adjusted to current (2012) using CPI (Consumer Price Index) (cf. OECD 2012).

Source: authors' own elaboration based on (Miller, 2000; Dziegielewska and Mendelsohn, 2005; Giergiczny, 2006; OECD, 2012).

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[2]The average exchange rate for 2012: 1 EUR ~ 4,185 PLN, in PPP (Purchasing Power Parity) 1 EUR ~ 2,374 PLN.

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2.3.2. Costs of hospitalizations and restricted activity days

As in the case of mortality costs, the best − although not without drawbacks − approach seems to be the use of WTP also for avoiding hospitalization, which reflects the individuals utility of a risk reduction in air pollution related morbidity and reflects all costs the individual expects to bear in case of a disease, such as loss of earnings, costs of averting behavior or intangible costs, which cannot be measured by any other method. However, the literature on WTP based, air pollution-related morbidity costs is very rare in Europe. That is why in this study the Cost of Illness Approach (COI) was used, which incorporates direct and indirect costs, in the form of medical treatment costs (perceived as a waste of resources) and productivity loss due to illness, ignoring thereby intangible costs. The number of all excessive hospital admissions due to respiratory and cardiovascular diseases was multiplied by the average weighted medical cost per hospitalization due to these diseases (basing on National Health Fund data on diagnosis-related groups (DRG) in 2011) and the average loss of output per day in hospital (estimated as the average daily gross income in Warsaw). Following the methodology of HAPINZ (2012), the latter cost was estimated for the whole population, not just the employed. The cost of restricted activity days was assessed assuming that each restricted activity day equals the productivity loss, measured by the average daily gross income in Warsaw.

3.   Results

According to the calculations (Table 3), the average costs of hospitalization due to respiratory problems and cardiovascular diseases amounts to approximately 4 038 PLN and approximately 5 493 PLN per case, respectively, including direct costs of hospitalization and the productivity loss for the average number of days spent in hospital. For restricted activity days the cost per case amounted to 167 PLN. The VSL (for the estimation of air pollution attributable mortality) equals approximately 1.9 Mio PLN. The average concentration of PM_{10} in 2011, which Warsaw citizens were exposed to, amounted to 37.2 μg/m^3.

Table 3. The unit cost of the components of air pollution impact on health of the Warsaw population.

Cost category	Unit cost (per case or day) [PLN 2012]
Premature mortality (VSL)	1 909 471
Respiratory hospital admission	4 038
Cardiovascular hospital admission	5 493
Restricted activity day	167

Source: authors' own elaboration.

Annually approximately 2 264 Warsaw citizens die prematurely as a result of air pollution (Table 4). 351 839 restricted activity days, 684 and 1 551 excessive hospital admissions due to (respectively) respiratory and cardiovascular problems are caused annually by air pollution. The total costs of air pollution health effects in Warsaw amount to approximately 4 393.8 Mio PLN.

Table 4. Air pollution annual effect on the Warsaw population's health and its total costs from social perspective.

Health effect	Total air pollution (PM_{10}) health effects [number of cases/days]	Total costs [Mio PLN 2012]
Long-term mortality (age ≥30 years; from non-external causes)	2 264	4 323.8
Respiratory hospital admissions (all ages)	684	2.8
Cardiovascular hospital admissions (all ages)	1 551	8.5
Restricted activity days (age 20-65 years)	351 839	58.8
TOTAL		4 393.8

Source: authors' own elaboration.

4. Conclusions

The aim of this study was to assess the annual costs of air pollution impact on health of Warsaw population. Four components of this impact were taken into account: premature

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mortality, cardiovascular and respiratory hospital admissions as well as restricted activity days. According to the calculations, about 2 264 Warsaw citizens die in one year as a result of air pollution. Moreover, about 1 551 and 684 hospital admissions due to cardiovascular and respiratory diseases (respectively) and more than 351 839 restricted activity days can be attributed to air pollution. From the social perspective these losses generate costs, which add up to 4 394 Mio PLN annually. Premature mortality accounts for the majority of these costs (above 98%), which is not surprising taking into account the height of its cost per case.

In order to assess the unit cost of premature mortality three approaches were taken into consideration – human capital approach, VSL and VOLY. Finally, VSL approach, derived from the WTP for mortality risk reduction, was chosen. The thorough search was performed to find the best assessment of VSL for Warsaw population and as a result four studies were selected (*cf.* Table 2). The study of Miller (2000) was a regression-based estimate derived from credible studies across 13 countries and adjusted to other countries basing on their GDP. OECD recommendation (2012) concerned one value for all EU-27 countries, adjusted with income (in terms of PPP-adjusted GDP per capita). There were also two studies conducted among the Polish population (Dziegielewska and Mendelsohn, 2005) and the Warsaw population (Giergiczny, 2006). Despite some problems with an external scope test, the value of WTP elicited by CVM presented by Giergiczny (2006) was applied. The VSL derived from the assessed WTP amounted to 1,9 Mio PLN, which is fivefold less than OECD recommendation. The VSL based on the WTP presented by Dziegielewska and Mendelsohn (2005) was however much lower. There may be several reasons for this fact, *inter alia*, the study of Giergiczny (2006) was conducted among Warsaw citizens (and not nation-wide), who are on average wealthier than the rest of the Polish society. Another reason is that the study of Dziegielewska and Mendelsohn (2005) estimated WTP to reduce death risk due to air pollution and the understanding of air-pollution related threats may not be sufficient in Poland. Last but not least, in cities people are generally better educated and education plays an important role in the determination of the height of WTP.

To assess the costs of respiratory and cardiovascular hospitalizations as well as restricted activity days the Cost of Illness Approach was applied. Although it seems that the use of WTP for avoiding hospitalization would be a better approach, the literature on WTP for avoiding air pollution-related morbidity is very rare in Europe.

The study has also some other limitations, connected with the epidemiological and

environmental parts, that must be considered when analyzing the results. First of all, there is the assumption that the annual average concentration of PM_{10} is the exposure that the whole Warsaw population is facing. Many people spend the majority of their time indoors, where the PM_{10} concentration is much lower, whereas some spend a considerable amount of time outdoor, near major traffic routes. Nonetheless, the epidemiological studies were also conducted among citizens, whose "outdoor activity" differed. Another issue to consider is the transferability of the exposure-response functions, derived from epidemiological studies, in which population, its lifestyle and other factors differed from the Polish conditions. To this point there is also a problem with the site-specific chemical composition of particulate matter. However, it seems that thanks to the use of metaanalysis of different studies for deriving the relative risks, various compositions and their health effects on humans have been included.

Despite the above mentioned limitations, the estimated cost of air pollution impact on human health is significant and can be much higher in reality. Therefore, more attention should be paid for the integrated environmental health policy, with a focus on cities as a priority. Also the development of the VOLY methodology and its use as the sensitivity analysis should be considered.

Acknowledgements

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Koszt społeczny wpływu zanieczyszczenia powietrza na zdrowie mieszkańców Warszawy

Streszczenie

Celem pracy jest oszacowanie rocznego kosztu wpływu zanieczyszczenia powietrza na zdrowie mieszkańców Warszawy z perspektywy społecznej. Badanie składa się z trzech części: określenia ekspozycji mieszkańców Warszawy na zanieczyszczenie powietrza, kwantyfikacji wynikających z niej skutków zdrowotnych oraz oszacowania ich kosztu. Do wyznaczenia kosztu przedwczesnego zgonu wykorzystano metodę Wyceny Statystycznego Życia (ang. Value of Statistical Life, VSL) opartą na skłonności do płacenia (ang. Willingness To Pay, WTP) za obniżenie ryzyka zgonu. Do wyceny kosztu hospitalizacji z powodu chorób naczyniowo-sercowych i układu oddechowego, a także dni ograniczonej aktywności (ang. restricted activity days), zastosowano podejście Kosztu Choroby (ang. Cost of Illness Approach, COI). Na podstawie analizy wyników dotychczasowych badań przyjęto dla mieszkańców Warszawy wartość VSL na poziomie 1,9 mln PLN. Przeprowadzone obliczenia pozwoliły stwierdzić, że w ciągu roku w Warszawie zanieczyszczenie powietrza stanowi przyczynę około 2264 przedwczesnych zgonów, 351839 dni ograniczonej aktywności, a także 684 i 1551 dodatkowych hospitalizacji z powodu (odpowiednio) chorób układu oddechowego oraz chorób sercowo-naczyniowych. Całkowity koszt negatywnych skutków zanieczyszczenia powietrza w Warszawie oszacowano na około 4,4 mld PLN. Koszt ten jest wysoki, dlatego więcej uwagi powinno się poświęcić zintegrowanej polityce środowiskowej, ze szczególnym uwzględnieniem zdrowia mieszkańców miast.

Słowa kluczowe: zanieczyszczenie powietrza, koszty społeczne, cząstki stałe (PM), wycena życia statystycznego (VSL), skłonność do płacenia (WTP)