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INDIRECT COSTS OF BRONCHIAL ASTHMA AND ITS COMPLICATIONS

Authors: Kieliszek Ż., Szumiał S., Czerw A.

Medical University of Warsaw, Department of Health Economics and Medical Law

Abstract The study presents an analysis of indirect costs in Poland generated by bronchial asthma, which according to the ICD-10 classification was marked with number J45. The final indirect cost of absenteeism for asthma and asthmatic condition in 2016 amounted to PLN 236 513 435.66. The final cost of presenteeism is amounting to PLN 25 866 185,10. The final indirect cost of informal care in the amount of PLN 10 441 395.82 was obtained. The total amount of indirect costs of permanent or temporary inability to work due to asthma was obtained and it was PLN 588 322 336.36. The final indirect cost of deaths in the amount of PLN 48 609 887.82 was obtained.

Key words: indirect costs; bronchial asthma; absenteeism; presenteeism; informal care

Introduction

Diseases of the respiratory system, such as bronchial asthma, are one of the most severe and popular problems of modern medicine due to their high prevalence, covering about 3-5% of the population of people of different ages. The word asthma comes from Greek and means fast breathing due to breathlessness. It is a chronic inflammatory disease of the respiratory tract in which many inflammatory cells and substances released by them take part. This condition is caused by hyperresponsiveness of the respiratory tract, which leads to excessive response of smooth muscle of the tract to various stimuli. This disease is characterized by the occurrence of reversible bronchoconstriction and may lead to wheezing, shortness of breath, chest tightness and coughing, which are particularly observed in the morning or at night. These symptoms are accompanied by limited airflow in the lungs and occur spontaneously or under the influence of treatment [1,2,3].

Since the beginning of the 1970's, a significant increase in the number of bronchial asthma cases has been observed around the world. This increase is most visible in countries with a high level of economic development, for example, the United Kingdom, New Zealand, Australia, where the prevalence of asthma exceeds 15% of the general population. The smallest number of people with bronchial asthma is recorded in Asian countries such as China, India and Oceania, and the prevalence in these countries is 2-3% of the general population [4]. In Finland, Malta and some parts of France and Spain, the asthma incidence rate is over 9%, 6 to 9% in Germany, France, Italy, Sweden and Denmark, 3 to 6% in Australia, Spain, in Poland and Hungary, and below 3% in Portugal, Russia, Georgia and Greece [5]. Based on the ECRHS (European Community Respiratory Health Survey) survey conducted in 1991-1994 among people aged 20-44 in 22 countries, most of which were Western European countries, on average, 2-8% of the population are people with asthma. Based on the results of the GA^{2}LEN study (Global Allergy and Asthma Network of Excellence) carried out in 12 countries in 2008-2009, on a group of people aged 15-74, in three Polish cities asthma was detected in 5% of people living in Katowice, 6% in Łódź and 7.1% in Cracow [6]. The PMSEAD (Polish Multicenter Study of Epidemiology of Allergic Diseaes) study conducted on the Polish population in the 1990's indicated that the average occurrence of asthma in adults is 5.4% and in children it is 8.6%. Among children, asthma was found more often in boys (10.9%) than in girls (6.3%), in adults it was the opposite - more women (5.8%) and less men (4.9%).

According to the WHO, about 300 million people worldwide suffer from asthma, which gives us about 5% of the general population. The latest ECAP study (Epidemiology of Allergic Diseases in Poland) which covered over 22,700 people from 9 different regions of Poland, shows that the symptoms of asthma were more observed in more than 5.5% (16%) of Poles, of which the active form of asthma was experienced by about 4 million (12%). The problem of asthma especially affects people living in large cities where there is a 3-4 times greater number of new cases than among the inhabitants of rural areas. There is also a problem with the diagnosis of asthma, according to the ECAP study, 70-80% of the respondents who had clinical symptoms of the disease had their first diagnosis during this study [7].

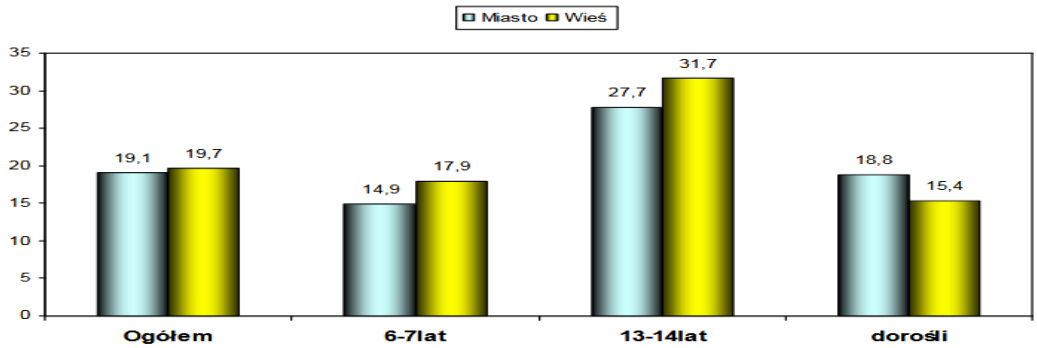

Figure 1. Percentage of people diagnosed with asthma before entering the ECAP program (V160) among respondents declaring the occurrence of wheezing and whistling in the chest (V136), representing 100% of the people analysed in the chart. (source: ECAP study)

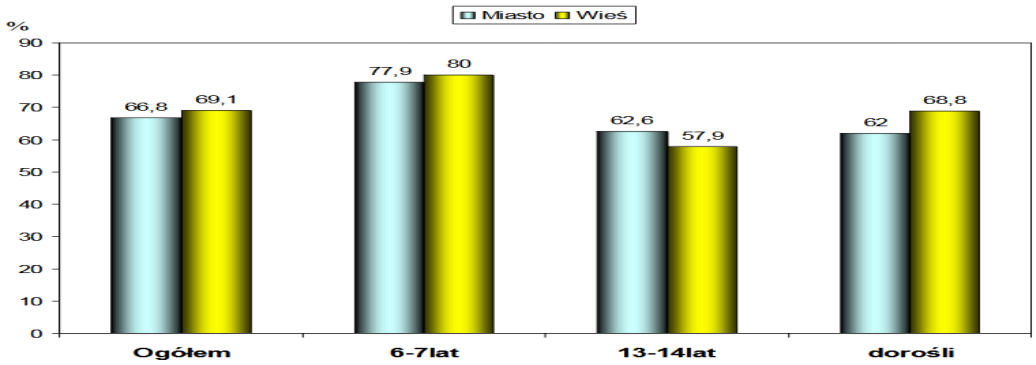

Figure 2. Undiagnosed asthma (v160) among people diagnosed with asthma in ECAP ambulatory tests (r622_1) (source: ECAP study)

Bronchial asthma is one of the most common chronic diseases in childhood age in almost all industrialized countries. It concerns children from families with atopic diseases. Progressive growth and maturation, and thus also changes in the structure of the respiratory system, affect both the course of the disease and the effectiveness of the administered treatment. In most cases, asthma begins in early childhood. About 30% of children with asthma had their first symptoms before the first year of life, in 50% of children the first symptoms appeared by the third year of life, while in 80% before the age of six. Wheezing is one of the most common symptoms of the disease in children under five years of age, it can appear even several months after birth, along with the cough accompanying it may give symptoms characteristic of respiratory infections. It is possible to early diagnose bronchial asthma in children based on the clinical risk factor for Asthma API (Asthma Predictive Index). The combination of bronchial obstruction in combination with a large criterion or two smaller ones may indicate the occurrence of asthma [4]. The phenotype of bronchial asthma may be the result of the coexistence of environmental and genetic factors. However, it is difficult to determine the factors that are responsible for the formation of attacks and those responsible for the disease [8].

Table 1. Clinical risk indicator of asthma

In a child over 3 years of age with episodes of recurring obturation (> 3 such events per year), the risk of asthma is increased when the following are met:	
One big criterion:	**or at least two small criteria:**
I - parents with asthma (medical diagnosis)	**1** - allergic rhinitis (medical diagnosis)
II - atopic eczema in a child (medical diagnosis)	**2** - obturation without infection
III - allergy to inhalation allergens in a child	**3** - eosinophilia ≥ 4%
	4 - allergy to food allergens

Source: Astma Oskrzelowa Grażyna Bochenek, Zbigniew Doniec, Elżbieta Kryj-Radziszewska; Wydawnictwo Lekarskie PZWL; Warszawa 2011

The increase in asthma incidence observed in recent years may have many causes, among others, a decrease in the number of cases for various types of bacterial, viral or parasitic infections in childhood, which may affect cytokinins during the development of the immune system. The reason for this phenomenon is also a significant increase in air pollution and active and passive smoking, which in a way explains the fact that both children and adults who live in large cities more often suffer from bronchial asthma than those who live in rural areas. Over the last years, a significant dependence has also been observed in the number of asthma cases among children who grow up in mechanized rural farms and children raised in natural conditions who suffer from asthma even 4 times less frequently [6]. Asthma mortality has changed significantly, which currently in Poland is at a level lower than 1/100 000. It is estimated that there are between 100.000.000 and 150.000.000 people around the world with asthma, and about 180.000 die every year [9]. The most frequent known causes that can be fatal include, among others, use of three or more drugs, abuse of inhaled beta-agonists, viral infection of the upper respiratory tract, emotional disturbances, significant variability of the morning and evening results of air flow [10].

Materials and methods

The study presents an analysis of indirect costs in Poland generated by bronchial asthma, which according to the ICD-10 classification was marked with number J45. The analysis uses data from the Statistical Office of the Social Insurance Institution (ZUS) and the Central Statistical Office on the size of GDP in 2016, and data on the percentage of working people in working age and the general population in 2016. The study was made using the analysis

method of indirect costs of bronchial asthma and asthmatic status using the human capital method. It is the most commonly used method and relatively easy to carry out in practice. The estimated indirect cost included data from the areas of absenteeism, presenteeism, informal care, permanent inability to work and deaths from asthma. Absenteeism is considered to be employee's absence at work related to asthma, where, as a result of absence, the volume of production that he would be able to do while being fully healthy is a resource lost from the point of view of the economy as a whole. However, presenteeism is the presence of an asthmatic patient at work, despite deteriorated well-being caused by the disease and resulting in lower work efficiency, compared to the work efficiency obtained by that employee in a situation where he is healthy. In turn, informal care included all forms of exercising informal care over an asthmatic patient and for providing help by people who do not provide professional care and rehabilitation of the sick. According to the adopted method, the estimation of indirect costs of asthma was the product of the number of hours worked in the examined population of patients with bronchial asthma as a result of disease and the value by which production decreases due to a one-hour loss in the economy.

Absenteeism

G. John, J.J. Martocchio and D.A. Harrison define absenteeism as absence from work when the employee has already planned to go to work. It may have many causes, among others, it may be caused by illness or inability to perform duties [11]. According to data from the statistical portal of the Social Insurance Institution on sickness absence in 2016, there were 69 412 medical certificates with a total duration of 741 095 days per the J45 unit. I considered the asthmatic condition as the only ICD-10 unit which may be a complication of bronchial asthma, the total time of which in 2016 was 6 355 days of sickness absence. The total time of absence due to bronchial asthma and asthmatic condition which can be considered as its complication amounted to 747,450 days.[1] In total, in terms of years of work, this gives the sum of 2 990 years of work assuming that one year has 250 working days. In 2016, GDP, or gross domestic product, as a measure of production produced in a given country [12] in Poland, amounted to PLN 1 861 112 million [2] . At that time, 15,293.30 employees were employed on the Polish labour market [3] which gives GDP per 1 employee equal to PLN 121 694.59. After multiplying the value of GDP per 1 working person with the number of years of absence, I got an indirect cost that would be incurred by the Polish State if the work was the only factor and amounted to PLN 363 866 824.10. Assuming that the correction factor is 0.65 [13], the final indirect cost of absenteeism for asthma and asthmatic condition in 2016 amounted to PLN 236 513 435.66. [4]

Presenteeism

Presenteeism is a phenomenon consisting in coming to work while being sick, and ailments affect the reduction of effectiveness of work, and may even be a threat to colleagues and expose the employer to financial losses through non-performance or poor performance of a given job. In Poland, statistics on bronchial asthma presenteeism are not made so to estimate the value of presenteeism for this disease entity I had to use approximate data from the WHO and the Central Statistical Office. According to the WHO, about 1.7 million people suffer from asthma in Poland, and nearly 2 million people have undiagnosed asthma despite the

1 https://psz.zus.pl/kategorie/absencja-chorobowa/absencja-chorobowa-z-tytulu-choroby-wlasnej-osob-ubezpieczonych-w-zus

2 https://bdm.stat.gov.pl/

3 https://bdm.stat.gov.pl/

4 Own calculations based on data from the Central Statistical Office and data from the Health Insurance Company

presence of symptoms, which gives about 4,000,000 people suffering from this disease [14]. There were 51.88% of these cases for people of working age 15-64. According to Eurostat data for this age group, the share of the number of employed in 2016 in the total population is 69%. The product of these 3 values is 4,000,000 * 51.88% = 2 075 200; 2 075 200 * 69% = 1 431 888 gives us about 1 431 888 cases of asthma among people working in a given age range. In view of the previously mentioned number of 61 612 of medical certificates this gives 1,362.476 cases in which the patient did not benefit from sick leave under social insurance. This number presents both cases of presenteeism and cases of absence from work or non-employment due to illness by people who do not have insurance in the Social Insurance Institution. Assuming that one case of presenteeism is responsible for a loss of 0.06 working day [15], 84,748,56 lost working days were obtained, which gives a total of about 327 years of lost work due to asthma in 2016 assuming that the year is about 250 working days. The value of this work after multiplication by the value of GDP per 1 working person is PLN 39 794 130.93 PLN, which is the value which estimates the cost of presenteeism if the work was the only factor of production. After multiplying this value by a correction factor adopted at the level of 0.65, the final cost of presenteeism due to bronchial asthma and its complication is an asthmatic condition amounting to PLN 25 866 185,10. [5]

Informal care

Another very important element in the calculation of indirect costs caused by asthma and asthmatic condition is informal care. These are the costs borne by the state for releasing a healthy person for the care of a close person suffering from a given disease. Due to the fact that statistics on the number of sickness leaves to take care over someone with asthma, the data I used is based on an estimate [16]. This data was obtained by assuming that the share of the total length of medical certificates issued due to bronchial asthma according to ICD-10 number J45 in the total length of certificates for own disease is the same as the share in medical certificates for caring for a child or other family members [16]. In 2016, 747 450 days of leaves due to asthma and asthmatic condition accounted for about 0.31% of the total duration of sick leaves caused by own illness (in total 238 659 822 days). Absenteeism due to caring for a child or other family member of insured persons is a total of 10,613.40 days of leaves.[6] After taking into account this value by the same percentage equal to 0.31%, we will get a total of 32 902 working days lost, which translates into 132 years of work lost, assuming that the year has 250 days. Taking into account the GDP per 1 employee during the year in the amount of PLN 121 694.59, it is PLN 16 063 685.88, which is the indirect cost resulting from informal care if the work was the only production factor. After taking into account the correction factor of 0.65, the final indirect cost of informal care in the amount of PLN 10 441 395.82 was obtained. [7]

Temporary and permanent inability to work

Inability to work is a total or partial loss of the ability to do paid work due to impairment of physical fitness. Total inability to work is when a person has lost the ability to do any paid work, temporary inability to work occurs when a person who has significantly lost the ability to work in accordance with the level of qualifications. The ruling on the inability to work is a basic condition for receiving a disability pension [17]. Due to the lack of SII data on the

5 Own calculations based on data from the Central Statistical Office, and data from the Health Insurance Company, as well as a report made by MEDICOVER

6 https://www.zus.pl/documents/10182/39590/Absencja+chorobowa+w+2016+roku.pdf/1475e6ca-1682-42fc-ac9e-d097d32e325c

7 Own calculations based on data from the Social Insurance Institution

number of pensioners and newly granted annuities by individual disease entities in ICD-10 classification, the consequences of permanent and temporary inability to work due to the occurrence of bronchial asthma were estimated on the basis of data on Social Insurance Fund expenses due to disability pensions paid out because of respiratory tract diseases. To calculate indirect costs resulting from permanent or temporary inability to work, the following assumptions regarding the structure of annuities as well as pensions granted in a timely manner and for an indefinite period were adopted. According to the adopted assumptions, the time in which a person with partial inability to work is able to work is 0.25 of the normal working time, which is adequate to the amount of benefit reaching, as a rule, 75% of the total disability pension. The total value of disability pensions due to respiratory diseases J00-J99 was in 2016 an amount of PLN 2 690,884.30. [8] This accounted for 7.7% of all pensions paid out by the Social Insurance Fund. I also assumed that the same share of cases caused by bronchial asthma can also be attributed to the number of newly granted pensions in each age group. Based on the Social Insurance Institution (ZUS) data, the average time of inability to work was determined in the case of a term pension granted for respiratory diseases which in 2016 was 15.9 months. By defining the path of future work efficiency, which was determined based on the GDP forecast for particular time intervals, an increase in labour productivity was observed to the level of 1.028% from 2016-2020. Then, a gradual decrease from 2021 to 2030 to the level of 1.022%, and to the level of 1.015% in the years 2031 to 2040 was observed. In the range from 2041 to 2050 to the level of 1,009% and a decrease to 1,008% in the period of 2051 to 2060. These are indicators by which the annual GDP per one working person was increased. The growth path obtained was discounted using a 5% growth rate per year according to the Regulation of the Minister of Health on minimum requirements [13]. This path has also been multiplied by the probability of a working person's survival. For this purpose, the CSO tables concerning life expectancy for various age groups were used. According to the division which the SII uses for newly granted pensions according to age groups 20-29, 30-39, 40-49, 50-59, 60-64, the unitary loss of GDP resulting from inability to work was calculated. After comparing the value obtained for the four categories of pensioners in 2016, and multiplying by the number of newly granted pensions in individual age groups, the total amount of indirect costs of permanent or temporary inability to work due to asthma was obtained. The cost amounted to PLN 588 322 336.36. Taking into account the correction factor of 0.65, an amount of PLN 376 241 038.10 was obtained.

Deaths

The data on deaths caused by asthma does not show full value because it is not available in many countries and rarely available to different populations [18]. According to the data of the Central Statistical Office on the number of deaths in 2016 with division into age, sex and cause of death, in 2016 there were 431 people who died due to diseases classified as J45.0 to J45.9 (including for particular age groups, respectively: 0-19 years 1, 20-24 years 1, 25-29 years 1; 30-34 years 2; 35-39 years 3, 40-44 years 6, 45-49 years 3, 50-54 years 13, 55-59 years 22, 60-64 years 46, 65-69 years 46, 70-74 years 42, 75- 79 years 62, 80-84 years 70, 85-89 years 67, 90-94 years 31, 95 years old and more 5) .[9] Based on the data on the probability of death according to shortened life tables, the probability of death for the 0-64 age group was determined, including both sexes in total equal to 0.026801. [10] After taking into account the GDP per 1 working person which in 2016 amounted to PLN 121 694.59, the result was equal

8https://www.zus.pl/documents/10182/39540/Wydatki+na+%C5%9Bwiadczenia+z+ubezpiecze%C5%84+spo%C5%82ecznych+zwi%C4%85zane+z+niezdolno%C5%9Bci%C4%85+do+pracy+w+2016+r.pdf/e806a70c-4096-4d59-8536-421868f094f9

9http://demografia.stat.gov.pl/bazademografia/Tables.aspx?fbclid=IwAR1C7Jk3BSFYhQmXcxsmqNZ2FyFt8Q5C0iWFRVPQWjtWDfQEURMqKGiP4xM

to PLN 1 405 722,32, and this value being the product of the three above-mentioned values. After multiplying the above-mentioned value by the employment rate of working-age population, according to a report prepared by the Ministry of Family, Labour and Social Policy of the Labour Market Department on the labour market in Poland in 2016, amounted to 53.2% [11], obtaining a result of PLN 74 784 427.42. After using the correction factor at the level of 0.65, the final indirect cost of deaths in the amount of PLN 48 609 887.82 was obtained. [12]

Total effect

In summary, indirect costs due to bronchial asthma and asthmatic status were calculated on the basis of the five categories considered: absenteeism, presenteeism, informal care, inability to work and deaths. The costs of these five categories were, respectively, PLN 236 513 435.66 absenteeism, PLN 25 866 845.10 presenteeism, PLN 10 411 395,82 informal care, PLN 376 241 098.10 inability to work and PLN 48 609 877.82 deaths. This together gives the indirect cost of bronchial asthma and asthmatic condition of PLN 697 671 932.50. In relation to the GDP of PLN 1 861 112, this resulted in a loss equal to 0.013% of GDP due to absenteeism, 0.0014% of GDP due to presenteeism, 0.0006% of GDP due to informal care, 0.02% of GDP due to temporary and permanent inability to work, and a loss of 0.003% of GDP due to premature deaths. The total loss of GDP resulting from indirect costs of asthma in 2016 amounted to 0.037% of GDP. However, it should be kept in mind that due to the lack of some data, some calculations were made based on certain assumptions.

Discussion

Asthma is a problem for many countries, with a great and growing epidemiological impact throughout the world, generating high economic costs, both direct and indirect. The exact cost of asthma in the world cannot be determined. The report presented by The Global Asthma Report 2011, presenting a systematic review from 2009 showed 8 national studies in which the total cost was recorded, illustrating its significant impact. Among those whose study duration was one year, all costs reported in US dollars were very high but also very diverse: in Canada, USD 654 million; Germany USD 2,740 million and USD 4,430 million; Singapore USD 49 million; Switzerland USD 1 413 million; USA USD 7 189 million, USD 8 256 million and USD 2 300 million. In 2004, new cases of occupational asthma alone in the UK cost GBP 70-100 million (about 91-130 million USD at the rate as of 12.05.2019). [19]. In 2009, GDP in these countries amounted to USD 3 425 billion in Germany, USD 1 357 billion in Canada, USD 173 billion in Singapore, USD 488 billion in Switzerland, USD 14 296 billion in the USA and USD 2 342 billion in the United Kingdom.[13] This means a loss of 0.08% and 0.12% of GDP in Germany, 0.05% of GDP in Canada, 0.03% of GDP in Singapore, 0.29% of GDP in Switzerland, 0.05%, and 0.06% and 0.02% of GDP in the USA and 0.004%-0.005% of GDP for new asthma cases in 2009 in the United Kingdom.
Another study showing the cost of asthma was carried out by Ludwig-Maximilians-University Munich in cooperation with the Munich School of Management - Institute for Health Economics and Management in Health Care and Munich Center for Health Sciences, Munich. The purpose of the review was to estimate the cost of disease for asthma and COPD in adults

10 https://stat.gov.pl/obszary-tematyczne/ludnosc/trwanie-zycia/trwanie-zycia-tablice,1,1.html?fbclid=IwAR05FRqUYDVCbNkJ9bI64FJPjYm_JGyySB0JGx6VttQEPltVgBBF66asaTM

11https://psz.praca.gov.pl/documents/10828/4536564/Rynek%20pracy%20w%20Polsce%20w%202016%20roku_.pdf/17c10d3b-3a9b-4cc0-8c75-243df1e0aca8?t=1492766515178

12 Own calculations based on data from the Central Statistical Office, shortened life tables and a report on the labour market in 2016.

13 https://inzynieria.com/wpis-branzy/rankingi/10/20045,lista-50-najwiekszych-gospodarek-swiata

in Germany in the years 1995-2012. Drugs were considered the most important component of direct costs and job loss as the most important component of indirect costs. The estimated costs of asthmatic disease over the years were 445-2 543 € [20].
The next report was made by Asthma Australia, in collaboration with National Asthma Council Australia, as part of wider ongoing consultations aimed at developing the National Asthma Strategy for 2016-2020. In the report, Deloitte Access Economics estimates the total cost of asthma in Australia, including health costs, productivity and other financial costs ("economic costs") and "burden of disease" (loss of a healthy life). The total cost of asthma in Australia in 2015 was $ 27.9 billion, including $ 3.3 billion in economic costs and $ 24.7 billion in disease costs. The total cost of asthma in Australia in 2015 is $ 11,740 per person. The sensitivity analysis of these estimates gives upper and lower limits of $ 27.95 billion and $ 27.89 billion, respectively. It is predicted that in 2016-2019, the costs of bronchial asthma for the Australian government will amount to approx. USD 4.0 billion [21]. GDP in Australia in 2015 amounted to USD 1 349 billion, which gives us approx. 0.000087% of GDP loss per person.

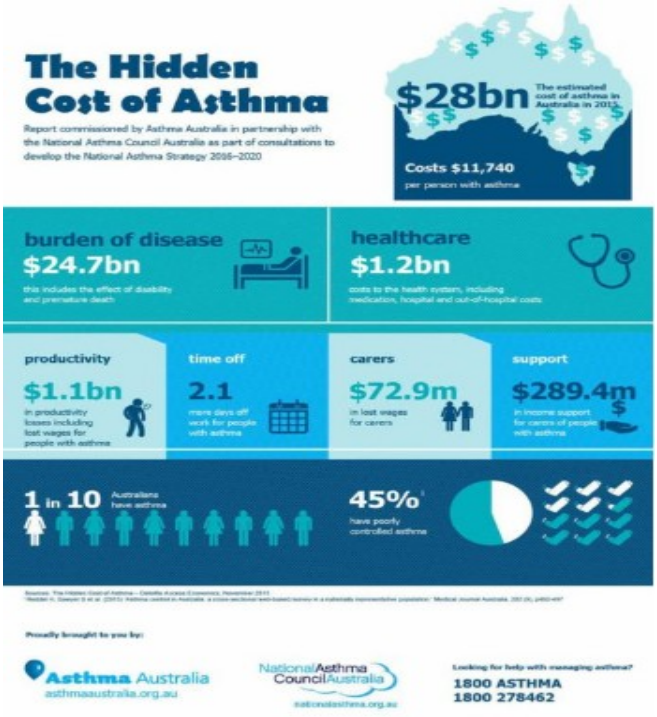

Figure 3. Costs of Asthma in 2015 in Australia, Source: The Hidden Cost of Asthma2015

According to studies conducted in the United States, the cost of asthma treatment per capita ranged from 1860 USD (Mississippi) to 2 514 USD (Michigan). The total cost of asthma treatment ranged from 60.7 million USD (Wyoming) to 3.4 billion USD (California). Medicaid costs ranged from 4.1 million USD (Wyoming) to 566,8 million USD (California), Medicare from 5.9 million USD (DC) to 446,6 million USD (California), and the costs paid by private insurers fluctuated from USD 27.2 million (DC) to 1.4 billion USD (California). The total annual time of lost school and work due to asthma ranged from 22.4 thousand (Wyoming) to 1.5 million days (California), and absenteeism costs ranged from 4.4 million USD (Wyoming) to 345 million USD (California). The expected increase in medical costs in 2015-2020 is estimated to range from 9% (DC) to 34% (Arizona) [22].

These studies show the scale of the problem, which is asthma, and what are the huge costs of both direct and indirect treatment of asthma not only in Poland but also in other countries. It also shows that this disease is a problem for many countries. It is difficult to state the reasons for this because asthma may be influenced by many factors. One of such factors may be environmental factors, e.g. an increase in environmental pollution associated with the development of a given country. They are responsible not only for the disease itself but also for changing its course, which can generate higher medical costs. Another reason may be drugs used. A relationship with the administration of antibiotics at an early stage of life with a subsequent occurrence of asthma was observed. Factors directly related to the patient, such as sex, age or diet, are also important. In countries such as the USA, where there is a large percentage of obese people, it can have a significant impact on the occurrence of this disease [23].

Conclusions

Calculating the economic burden of asthma is difficult because of its nature, it is a disease that is often undiagnosed and untreated, but is chronic and can affect patients throughout their lives. Management is often not optimal even in some of the best-equipped healthcare systems. Asthma is also fastest growing in low- and middle-income countries, many of which do not systematically collect data on asthma, outcome or cost indicators. However, treatment of asthma means much more than the cost of medication. It amounts to billions of dollars in both direct and indirect costs. The main indirect costs result from the loss of productivity due to lack of work and school. The costs incurred by healthcare systems also include a broad spectrum: from human resources, materials and equipment required to train asthma health professionals to the time and resources required to treat people suffering from asthma in both the acute version and in long-term. The costs increase when a person with asthma has other respiratory symptoms that can cause subsequent asthma emergency visits [19].

The second half of the 20th century is a period of significant increase in the incidence of allergic diseases, which are currently one of the biggest public health problems. Asthma is an important allergic disease, among others due to the generation of relatively high social costs. Therefore, epidemiological studies on the incidence of asthma are so important. However, their management is difficult due to problems with asthma diagnosis, variable course or various phenotypes of the disease [24].

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