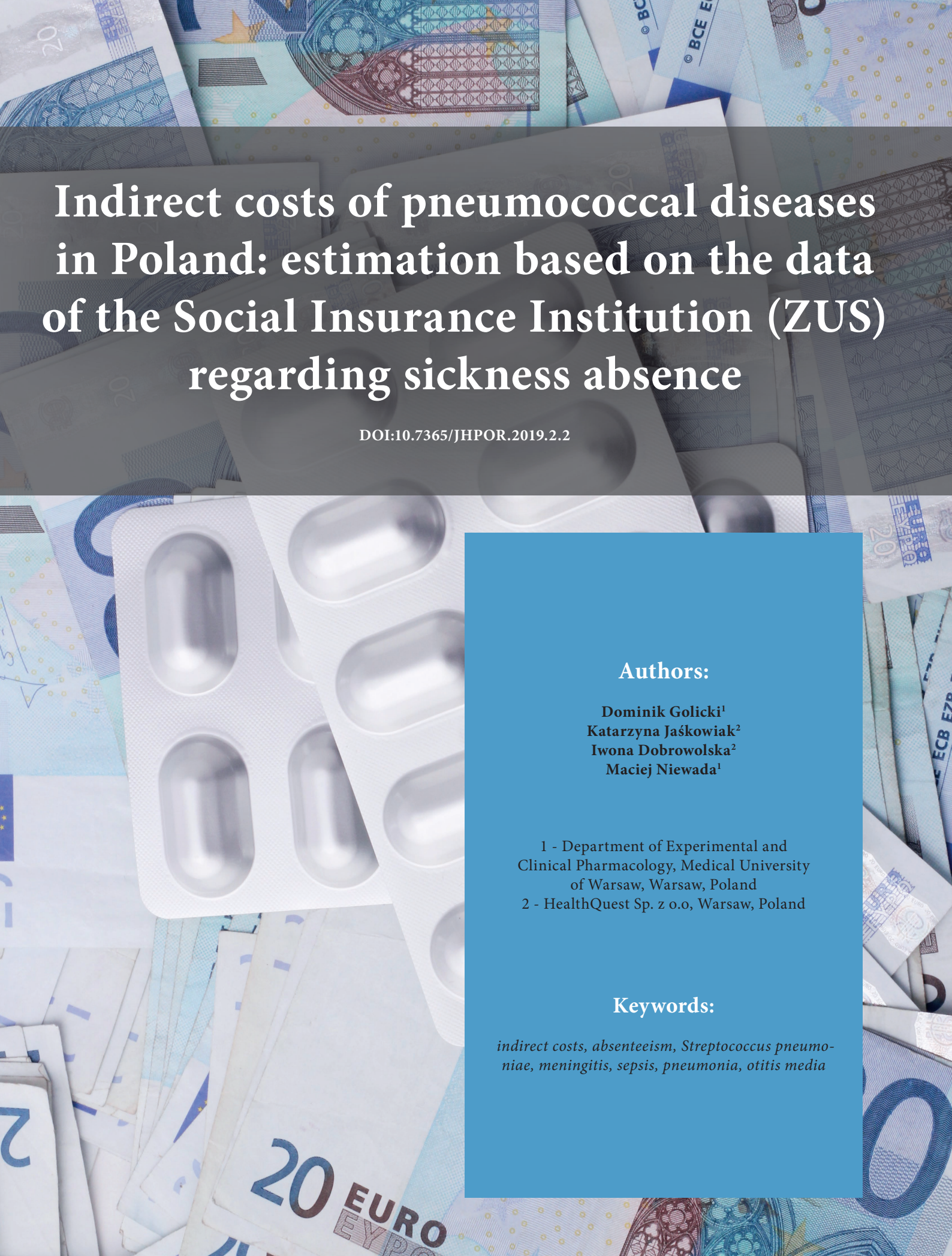

Indirect costs of pneumococcal diseases in Poland: estimation based on the data of the Social Insurance Institution (ZUS) regarding sickness absence

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Abstract

Background: The study aimed to estimate the indirect costs of pneumococcal diseases in Poland based on the data of the Social Insurance Institution (ZUS) regarding sickness absence.

Methods: The study included the following diseases, which may be caused by Streptococcus pneumoniae: meningitis, sepsis, pneumonia and otitis media (OM). Indirect costs resulting from adults' sick leave for their own sickness or for caring for a sick child were taken into account. The ZUS data concerning all diagnoses of the analysed diseases, regardless of the aetiology, was used. The data was corrected for the share of cases caused by S. pneumoniae, determined based on epidemiological data found in the literature. Epidemiological data were searched in the following databases: MEDLINE, Polska Bibliografia Lekarska and on the NIZP-PZH website. The unit cost of lost productivity was estimated based on the methodology recommended by AOTMiT HTA guidelines (2016), including methods suggested in the EY (2013) and INFARMA (2014) reports.

Results: Total absenteeism due to pneumococcal diseases amounted to approx. 302,000 days, of which 156,000 days were absences due to own illness and 146,000 days because of child care. The total indirect costs of absenteeism due to diseases caused by S. pneumoniae amounted to approx. PLN 95.5 million, of which PLN 49.4 million were the costs of diseases in the adult population (including 90% of pneumococcal pneumonia), and 46.1 PLN million costs resulting from children's diseases (in 57% and 42%, respectively, costs of OM and pneumonia).

Conclusions: Diseases with pneumococcal aetiology are the cause of a significant number of sickness absence and indirect costs arising from them are at a level similar to the costs of purchasing vaccines for the universal pneumococcal vaccination program.

Introduction

Pneumococcal infection is caused by Streptococcus pneumoniae, known colloquially as pneumococci. Pneumococci are the most common cause of community-acquired bacterial respiratory infections such as otitis media (OM), sinusitis, exacerbation of chronic bronchitis and pneumonia. The most severe form of pneumococcal infection is the so-called invasive pneumococcal disease (IPD). This concept includes meningitis, sepsis and pneumonia with bacteraemia.[1]

Pneumococcal infection is one of the leading causes of morbidity and mortality in the world.[2] According to WHO estimates based on data from 2000 (before the introduction of Prevenar® vaccine), S. pneumoniae was responsible for 14.5 million cases of severe infections and 735,000 deaths annually among children up to 5 years of age worldwide. According to more recent WHO estimates, in 2008, S. pneumoniae infections caused about 476,000 deaths among children up to 5 years of age not infected with HIV, which constitutes 5% of deaths among children in this age group.[3] In 2017 in Poland, the National Institute of Public Health (NIZP) and the Main Sanitary Inspectorate (GIS) recorded 1,877 IPD cases, including 171 cases of meningitis and 809 cases of sepsis.[4] According to the traditional division of costs in pharmacoeconomics, we distinguish the following cost categories: direct (medical and non-medical), indirect and intangible costs.[5] The category of indirect costs is associated with reduced productivity of patients in working age. In many diseases, the indirect costs are higher than the direct medical costs.[6]

Pneumococcal diseases are not only a significant clinical problem but also have significant social and financial consequences. In Poland, the economic consequences of pneumococcal diseases are relatively poorly studied. In particular, there are no publications on indirect costs. The analysis aimed to estimate the indirect costs of pneumococcal diseases in Poland based on the data of the Social Insurance Institution (ZUS) regarding absenteeism.

Material and methods

The study included the following diseases, which may be caused by S. pneumoniae: sepsis, meningitis, pneumonia and otitis media (OM).

The following categories of indirect costs were taken into account: sickness absenteeism due to own disease and absence resulting from taking care of sick children. The indirect costs of informal care, disease complications or premature death were not included. In the estimation of indirect costs due to an adult's disease, sickness absence due to otitis media was not considered due to the absence of an indication of Prevenar 13® vaccine for the prevention of OM in this population.[7]

Methods for estimating absenteeism

Indirect costs were estimated based on ZUS data on absenteeism. Publicly available data on adult sickness absence from their own diseases from 2012 - 2017 were analysed (Figure 1).[8] Data on sick leave for the care of a sick child was obtained from ZUS in the mode of access to public information.[9] Due to their time limit up to a single year, it was decided that in the case of both categories of absences, the data from the last available year (2017) will be used in the estimation of indirect costs.

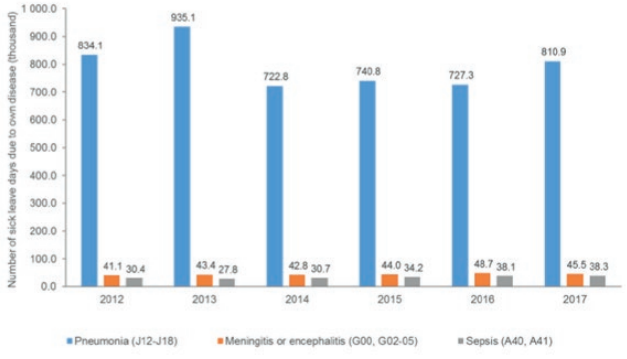

Figure 1. The number of days of sickness absence due to an adult's own disease in 2012-2017 due to pneumonia, meningitis, encephalitis or sepsis, regardless of the aetiology (Source: Social Insurance Institution data).

The information provided by the ZUS made it possible to analyse the causes of sick leave defined by the ICD-10 classification (three-character categories). Among the analysed diseases, bacterial meningitis and sepsis are a direct threat to the patient's life. Therefore, it is recommended to determine the etiological factor and its susceptibility to antibiotics and to notify the Poviat or Provincial Sanitary Inspector. Nevertheless, in some cases, it is difficult to obtain a positive and reliable result of the bacteriological examination.[10] In the case of community-acquired pneumonia and otitis media, the diagnosis is primarily based on symptoms. In an outpatient setting, a microbiological diagnosis of infection is rarely performed.[11] Given the above, ICD-10 diagnoses indicated by physicians issuing sick leave may not fully reflect the actual, detailed aetiology of the analysed diseases. It was decided that in the estimation of indirect costs of absenteeism, sick leaves with all diagnoses of the analysed diseases will be included, regardless of their aetiology (Table 1), while the total number of sick leave days for the analysed diseases will be adjusted by the percentage of cases caused by S. pneumoniae, determined based on epidemiological data found in the published literature.

According to the information provided by ZUS, in 80.8% of sick leaves for child care issued in 2017, there is no ICD-10 code of the disease entity.[9] It was assumed that the missing diagnoses are distributed in a manner proportional to the share of diagnoses reported and the number of absenteeism days due to care for a sick child in ZUS data was corrected by the index of 0.192.

Epidemiology of infections with the pneumococcal aetiology

In order to identify epidemiological data on the percentage of pneumonia, OM, meningitis and sepsis of pneumococcal aetiology in Poland, the following databases were searched: Polska Bibliografia Medyczna (PBL; since 1991), data from the National Institute of Public Health - National Institute of Hygiene (NIZP-PZH) regarding epidemiology of infections in Poland and hospital sickness as well as the MEDLINE base (PubMed). Because universal vaccination of children against pneumococcus was introduced in Poland from January 2017 and population effects have not yet fully developed, epidemiological data was sought regarding the period preceding the introduction of universal vaccination against pneumococci in a given region.

No specific Polish epidemiological data were found to estimate the proportion of pneumococcal aetiology in the total number of cases of pneumonia and OM infections in the pediatric population. The aforementioned involvement of the aetiology of S. pneumoniae was estimated based on published worldwide literature: 22.0% and 17.3% for pneumococcal pneumonia in children and adults, respectively - based on a study on the burden of pneumococcal disease in Canada[12] and a meta-analysis of observational studies;[13] 30.2% for pneumococcal OM in children - based on a systematic review.[14] The percentage of meningitis and sepsis cases with pneumococcal aetiology was estimated based on specific Polish data (NIZP-PZH, 2017) at 19.0% in both children and adults populations.[15]

Methods for estimating indirect costs

Indirect costs were estimated in accordance with the current HTA guidelines of the Agencja Oceny Technologii Medycznych i Taryfikacji (AOTMiT, 2016),[16] taking into account the methodology described in the reports "Methodology for measuring indirect costs in the Polish healthcare system" (EY, 2013)[17] and "Indirect costs in the health technology assessment. Methodology, pilot study and recommendations "(INFARMA, 2014).[6]

The estimation of unit costs of lost productivity (Table 2) is based on the latest, complete data of the Central Statistical Office of 2016, concerning the gross domestic product (GDP) and the number of employees.[18] In the first step, the value of GDP per employee was estimated. In the second, a correction factor was applied for marginal productivity - at the level of 0.65, adopted among others, by the European Commission.[17] It was assumed that the year consists of 250 working days. The adjusted cost of lost productivity for one day of work absence was estimated at PLN 315.99 (Table 2). Lost productivity due to absenteeism was estimated as the ratio of the number of days of sick leave and unit cost of lost productivity.

Results

The number of days of absenteeism

The analysis of the ZUS data on sickness absence due to own illness from 2012 - 2017 showed that among diseases with potentially pneumococcal aetiology, the highest sickness absence was due to pneumonia (ICD-10 J12-J18) - from approx. 723,000 up to 935,000 days of absence, in 2014 and 2013, respectively (Fig. 1). In the case of meningitis (ICD-10 G00, G02-G05), the number of absence days at work ranged from about 41,000 in 2012 to around 49,000 in 2016, and in the case of sepsis (A40, A41) at the level of about 28,000 days in 2013 to approx. 38,000 in 2017-2018. According to ZUS data, the average length of one sick leave for own illness was the highest in the case of sepsis (mean 25.1 days) and meningitis (21.5 days). In the case of pneumonia, it was at a lower level - an average of 9.4 days.[8]

Indirect costs were estimated based on ZUS data from 2017 (the only available data on absences because of childcare with ICD-10 codes; the last available ZUS data on absences from own sickness). In 2017, sickness absence among adults, caused by S. pneumoniae infections, was

Table 1. Included diseases with corresponding ICD-10 codes.

Disease	ICD-10 codes
Pneumonia	J12 Viral pneumonia, not elsewhere classified J13 Pneumonia due to Streptococcus pneumoniae J14 Pneumonia due to Haemophilus influenzae J15 Bacterial pneumonia, not elsewhere classified J16 Pneumonia due to other infectious organisms, not elsewhere classified J17 Pneumonia in diseases classified elsewhere J18 Pneumonia, organism unspecified
Otitis media	H65 Nonsuppurative otitis media H66 Suppurative and unspecified otitis media H67 Otitis media in diseases classified elsewhere
Meningitis or encephalitis	G00 Bacterial meningitis, not elsewhere classified G02 Meningitis in other infectious and parasitic diseases classified elsewhere G03 Meningitis due to other and unspecified causes G04 Encephalitis, myelitis and encephalomyelitis G05 Encephalitis, myelitis and encephalomyelitis in diseases classified elsewhere
Sepsis	A40 Streptococcal sepsis A41 Other sepsis

Table 2. Estimation of the unit cost of lost productivity.

Parameter	Value	Reference
Gross Domestic Product (GDP) [PLN million]	1,858,637	GUS 2018 [18]
Number of employee [thousand]	15,293.3	GUS 2018 [18]
GDP/employee [PLN]	121,532.76	Own estimation
Correction factor for decreasing, marginal work productivity	0.65	EY 2013 [17]
GDP/employee adjusted by decreasing, marginal productivity of work [PLN]	78,996.30	Own estimation
The number of working days in a year	250	Assumption
The unit cost of lost productivity [PLN/day of absence]	315.99	Own estimation

estimated at 156,200 of which the majority (89.8%) were caused by absence due to pneumococcal pneumonia, with pneumococcal meningitis and sepsis accounting for 5.5% and 4.7% of the number of days of absence, respectively (Table 3). In the same year, the number of days of sick leave due to child care, resulting from pneumococcal aetiology diseases, amounted to about 146,000. The pneumococcal OM and pneumonia were responsible for the most significant number of days of absence - 56.6% and 41.9%, respectively. Absenteeism of caregivers due to pneumococcal diseases of children with the severe course - meningitis and sepsis accounted for 0.8% and 0.6% of the number of absence days, respectively (Table 3, Table 4).

Indirect costs

The indirect costs of absenteeism due to diseases caused by S. pneumoniae in the adult population in 2017 were estimated at approximately PLN 49.4 million (Table 3). These included indirect costs due to: pneumococcal pneumonia - approx. PLN 44.3 million, meningitis - approx. PLN 2.7 million and sepsis - approx. 2.3 million.

The indirect costs of absenteeism due to child care caused by S. pneumoniae infections were at a similar level as indirect costs due to own illness and amounted to approx. PLN 46.1 million. These included mainly the indirect costs of pneumococcal OM and pneumonia - 26.1 and 19.3 million, respectively, and, to a much lesser extent, the costs of pneumococcal meningitis and sepsis – PLN 0.4 and 0.3 million, respectively.

In total, in 2017, as a result of S. pneumoniae infections, about 302,200 sick leave days, of which approx. 48.3% related to absence due to the care of a sick child. The indirect costs of absence from work caused by S. pneumoniae infections can be estimated at a total of approx. PLN 95.5 million (Figure 2).

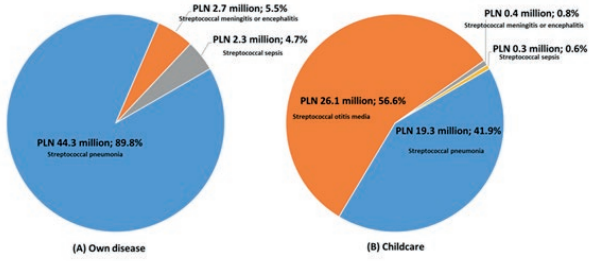

Figure 2. List of indirect costs of sick leave due to S. pneumoniae infection (A) for own illness* and (B) for childcare in 2017 (Source: own estimations based on ZUS data and published literature review).**

** the number of days of sick absence was estimated based on the percentages of pneumococcal etiology: pneumonia - 22.0%, meningitis or encephalitis, sepsis - 19.0%; ** estimated using the following percentages of pneumococcal etiology: pneumonia 22.0%, otitis media - 30.2%, meningitis or encephalitis, sepsis - 19.0%.*

Table 3. Number of sick leave days due to S. pneumoniae infection for own sickness in 2017 and estimated indirect costs.

The reason for the sick leave (ICD-10 code)	The number of sick days without regard to etiology[8, 9]	Percentage of cases of pneumococcal etiology	The number of days of sick leave due to S. pneumoniae	The indirect cost of sick leave due to S. pneumoniae infections* [PLN]
Pneumonia (J12-J18)	810,888	17.3%[13]	140,284	44,327,547
Meningitis or encephalitis (G00, G02-G05)	45,499	19%[15]	8,636	2,728,756
Sepsis (A40, A41)	38,325	19%[15]	7,274	2,298,503
Total	894,712	n.a.	156,193	49,354,806

** Assuming the unit cost of lost productivity at the level of PLN 315.99; n.a. – not adequate.*

Table 4. Number of sick leave days due to S. pneumoniae infection for sick child care in 2017 and estimated indirect costs.

The reason for the sick leave (ICD-10 code)	The number of sick days without regard to etiology[8, 9] Raw data	The number of sick days without regard to etiology[8, 9] Adjusted data*	Percentage of cases of pneumococcal etiology	The number of days of sick leave due to S. pneumoniae	The indirect cost of sick leave due to S. pneumoniae infections** [PLN]
Pneumonia (J12-J18)	53,410	278,177	22%[12]	61,199	19,337,964
Otitis media (H65-H67)	52,586	273,885	30.2%[14]	82,713	26,136,208
Meningitis or encephalitis (G00, G02-G05)	1,214	6,323	19%[15]	1,200	379,211
Sepsis (A40, A41)	916	4,771	19%[15]	906	286,126
Total	108,126	563,156	n.a.	146,018	46,139,508

** The percentage of sick leaves without the given diagnosis was taken into account (80.8%; correction factor 0.192); ** Assuming the unit cost of lost productivity at the level of PLN 315.99; n.a. – not adequate.*

Discussion

In the present study, we estimated the indirect costs of absenteeism caused by pneumococcal pneumonia, meningitis and sepsis in 2017 in Poland. We based our calculations on the ZUS data on the number of days of sickness absence due to own disease or care for a sick child, epidemiological data on the participation of S. pneumoniae in the aetiology of the diseases mentioned above and estimation of the unit cost of lost productivity in accordance with the AOTMiT guidelines.

In our analysis, we focused on indirect costs of sickness absence in professionally active people, omitting several other categories of indirect costs, such as costs of informal care, premature death or presenteeism.[5] Due to the difficulties with the clear identification of primary data, we did not take into account the indirect costs of long-term complications resulting from severe pneumococcal diseases (e.g. deafness or disability after pneumococcal meningitis). In connection with the above, the total, real indirect costs of pneumococcal diseases will be higher than estimated in this analysis.

Even though ZUS data on sick leave have three-character ICD-10 codes, they are not a reliable source of information on the detailed aetiology of infection (S. pneumoniae or other pathogenic microbe). Certain diseases - e.g. community-acquired pneumonia or otitis media - are usually treated without a microbiological examination. Even in the case of serious diseases - meningitis - where cultures are performed routinely, the proportion of cases with undetermined bacterial or other aetiology can reach 74% (data from NIPP-PZH, 2015).[15] For this reason, it was decided that ZUS data will be a source of general information about the disease (pneumonia, OM, meningitis, sepsis), while the participation of S. pneumoniae aetiology will be estimated based on available data from the review of epidemiological studies. Regarding non-hospital pneumonia in adults and children and the OM in children, we did not find Polish epidemiological data, and the percentage of infections caused by S. pneumoniae was based on observational data from other countries. In turn, in relation to meningitis and sepsis, due to the lack of data divided into children and adults, it was assumed that in both populations, the percentage of pneumococcal aetiology would be the same.

An essential limitation of the ZUS data on sick leave due to childcare is the lack of information on the diagnosis of the disease (ICD-10 code) at the level of 80.8% of all records.[9] It can be assumed that in the case of severe diseases associated with hospitalisation (sepsis or meningitis) the percentage of diagnosis reporting is greater, but due to the lack of data, it is impossible to estimate. An assumption was made about the proportionality of missing data to available data (equal participation of a given disease in all diagnoses), and adjustment of raw ZUS data was carried out.

To our knowledge, the current study is the first published estimate of indirect costs of pneumococcal diseases in Poland. In general, the literature on this topic is not numerous, although research has been found from Denmark, Switzerland, Turkey or the United States.[19,20,21,22] The US authors indicate that vaccinations against pneumococcus allow savings in indirect costs exceeding 70% savings in direct costs.[22] According to the Turkish researchers, indirect costs account for 21%, 26% and 84% of of pneumococcal meningitis, pneumonia and OM total costs, respectively.[21] The Danish authors indicate that the failure to take indirect costs into account in the economic analysis of pneumococcal vaccination leads to undervaluation of pneumococcal vaccination.[19]

Considering the practical implications of our analysis, it should be noted that the estimated total value of indirect costs of absenteeism due to pneumococcal diseases of professionally active people is at a level similar to the expenditure of the Ministry of Health for pneumococcal vaccines under the universal vaccination program (PSO). Considering that we omitted several indirect costs categories in the estimation and we did not refer to direct medical costs at all, the introduction of universal vaccinations against pneumococcus seems to involve a high budget saving potential, balancing the direct expenditure on the purchase of vaccines.

Future studies on indirect costs of pneumococcal diseases in Poland should focus on determining the costs associated with premature deaths, informal care and presentism. It is also crucial to determine the indirect costs of long-term complications of severe pneumococcal diseases - e.g. deafness or disability after meningitis, which will require good quality data from real clinical practice (real world data, RWD). Finally, studies using quality of life questionnaires can broaden our knowledge about the intangible costs of pneumococcal diseases.

Conclusions

Diseases with pneumococcal aetiology are the cause of a significant number of sickness absence and indirect costs arising from them at a level similar to the costs of vaccines for the universal pneumococcal vaccination program. In adults, the primary source of indirect costs is pneumonia, in children - otitis media together with pneumonia.

Conflict of interests

The study was supported by Pfizer Polska Sp. z o.o.

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