

# MORTALITY DUE TO ACUTE MYOCARDIAL INFARCTION IN THE SILESIA VOIVODSHIP (POLAND) IN 2009–2014

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## Abstract

**Objectives:** According to the Organization for Economic Cooperation and Development (OECD) data, 13% of deaths recorded in the European Union in 2010 were related to coronary heart disease. The Polish Central Statistical Office data show that cardiovascular mortality in 2014 was at the level of 100.1/100 000 general population. The aim of the study was to assess the current burden of deaths due to acute myocardial infarction (AMI) with the assessment of temporal and spatial variability in the Silesian Voivodship, Poland. **Material and Methods:** Depersonalized data obtained from the Silesian Voivodship Branch of the National Health Fund of Poland, based in Katowice, were used as the study material. The death rate due to acute or subsequent myocardial infarction in each of the subregions of the Silesian Voivodship was standardized to the European Standard Population 2013. The analyses of the annual AMI death rate for 2009–2014 were performed and assigned to all the subregions of the Silesian Voivodship, according to the patients' domicile. **Results:** In this study, 37.7% of the patients (N = 20 806) were females, and 30 142 healthcare services were granted to them, accounting for 36.64% of all services provided to all patients. The average patient's age during the service provision was 66±12 years, with women being about 6.5 years older than men (70±12 years vs. 64±11 years, respectively). The standardized death rate (SDR) values in each of the 8 subregions of the Silesian Voivodship were analyzed. In 2009–2014, a substantial decrease in the SDR was noted in 7 of them, except for the Sosnowiec subregion in which an increase in the average annual SDR value was observed. Moreover, its values were the highest in the whole Silesian Voivodship. **Conclusions:** The obtained results confirmed the spatial variability of mortality due to AMI in the study region. The worst situation was observed in the Sosnowiec subregion in which the number of specific deaths continuously increased, probably due to the limited availability of cardiovascular and invasive cardiology treatments or adverse health conditions. *Int J Occup Med Environ Health.* 2021;34(3):363–72

## Key words:

cardiology, acute myocardial infarction, death rate, Silesian Voivodship, burden of deaths, standardized death rate

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## INTRODUCTION

Intensive urbanization which started at the beginning of the 18th century contributed to some initially unnoticeable social, economic, and ecological changes in European societies. In addition, huge advances in medical science and effective therapies have contributed to the continually extending life expectancy, especially in European populations. At the beginning of the 20th century, these changes caused a shift in the structure of deaths in Western Europe, making non-communicable diseases, especially cardiovascular diseases, the main reason for premature death [1]. In the 2010s, cardiovascular diseases caused over 4 million deaths in 53 countries of the European World Health Organization (WHO) region each year, with 1.9 million cases being observed in the European Union countries [2,3]. According to the Organization for Economic Cooperation and Development (OECD) data, 13% of deaths recorded in the European Union in 2010 were related to coronary heart disease. The Polish Central Statistical Office data show that cardiovascular mortality in 2014 was at the level of 100.1 per 100 000 general population, with a higher value in men than in women (113.0 vs. 88.1 per 100 000 general population, respectively). Simultane-

ously, current data indicate a significant spatial variability of this mortality [4].

The Silesian Voivodship is one of the 16 Polish regions established in 1999 and is located in the southern part of the country. In 2018, the Silesian population amounted to 4 533 565 people, accounting for 12% of the overall Polish population. Moreover, the studied region is highly urbanized (the level of urbanization is 76.7%) and densely populated (367.6 people/km<sup>2</sup>) [5]. According to the Central Statistical Office data, the mortality due to ischemic heart disease in the Silesian population recorded in 2014 was one of the highest in Poland (79.6 per 100 000 general population), and it was higher than Europe's average [6]. Table 1 presents the general characteristics of each of the 8 subregions of the Silesian Voivodship, including the general population, density, and available hospital beds (data regarding 2014 – the endpoint of the analysis). The currently recommended public health programs should be aimed at reducing health inequalities [7]. Many of these inequalities are related to socioeconomic conditions, demographics, and available medical infrastructure. Without the knowledge of the current regional differentiation of the health status of the population, it will not

**Table 1.** Baseline characteristics of the subregions of the Silesian Voivodship in 2014 (data according the Central Statistical Office [5])

Subregion	Population [n (%)]	Density [n/km <sup>2</sup> ]	Hospital beds		Registered unemployment*	Average monthly gross salary*
			n	n/10 000 residents		
Bielsko	665 269 (14.51)	276.3	4144	62.3	73.7	93.3
Bytom	444 543 (9.69)	244.0	3164	71.2	126.3	85.4
Częstochowa	523 256 (11.41)	137.9	2257	43.1	119.3	83.2
Gliwice	476 731 (10.40)	431.0	2886	60.5	77.2	103.0
Katowice	748 005 (16.31)	2066.5	5993	80.1	60.5	118.7
Rybnik	637 438 (13.90)	397.5	1432	22.5	78.9	112.6
Sosnowiec	697.730 (15.21)	471.3	2718	39.0	111.4	99.1
Tychy	392.952 (8.57)	350.2	3163	80.5	49.1	89.7
Silesian Voivodship	4 585 924 (100.00)	372.0	25 757	56.2	84.2	102.4

\* In relation to the national average (Poland = 100.0).

**Table 2.** Healthcare services (N = 82 276) granted to patients with acute or subsequent myocardial infarction in the Silesian Voivodship in 2009–2014, included in the analysis

Group	Range according to the diagnosis-related group defined by NFZ
Internal medicine (N = 15 282, 18.57%)	<ul style="list-style-type: none"> <li>– pulmonology – hospitalization</li> <li>– internal medicine – hospitalization</li> <li>– geriatrics – hospitalization</li> <li>– nephrology – hospitalization</li> </ul>
Invasive cardiology and cardiac surgery (N = 50 655, 61.57%)	<ul style="list-style-type: none"> <li>– cardiac surgery – hospitalization</li> <li>– invasive cardiology – hospitalization including ACS – invasive diagnostics; ACS – 2-stage invasive treatment &gt;3 days; ACS – combined invasive treatment; invasive treatment &gt;3 days; ACS – invasive treatment &lt;4 days</li> <li>– invasive cardiology – hospitalization including coronary angioplasty with the implantation of 1 DES; angioplasty with the implantation of <math>\geq 2</math> stents or multivessel angioplasty with the implantation of 1 stent and other treatments; balloon coronary angioplasty</li> </ul>
Cardiology (N = 16 339, 19.86%)	<ul style="list-style-type: none"> <li>– cardiology – hospitalization</li> </ul>

ACS – acute coronary syndrome; DES – drug eluting stent; NFZ – Narodowy Fundusz Zdrowia (the National Health Fund of Poland).

be possible to solve the problem of disparities in access to health improvement.

### Aim

The aim of the study was to assess the current burden of deaths due to acute myocardial infarction (AMI, diagnosis I21 or I22, according to the International Classification of Diseases, 10th Revision [ICD-10]) in the Silesian Voivodship with the assessment of temporal and spatial variability in 2009–2014.

## MATERIAL AND METHODS

### The range of the analyzed data

Secondary epidemiological and depersonalized data were obtained from the Silesian Voivodship Branch of the National Health Fund of Poland (Narodowy Fundusz Zdrowia – NFZ), based in Katowice, after the pre-processing in the billing process. The project has the permission of the Bioethics Commission of the Medical University of Silesia (No. KNW/0022/KB/68/17). In the model of an ecological study, the authors analyzed the healthcare services in the fields of pulmonology, internal medicine,

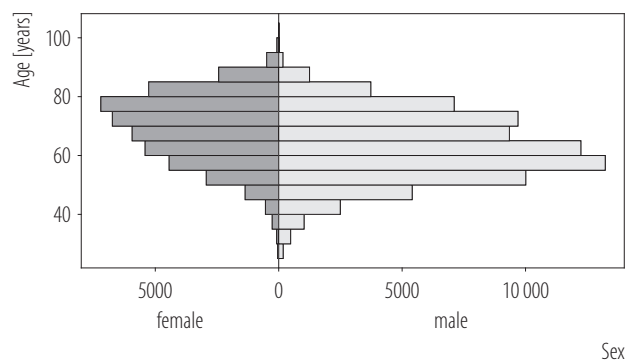
nephrology, geriatrics, cardiology/invasive cardiology, and cardiac surgery, carried out for patients with acute or subsequent myocardial infarction, in the Silesian Voivodship in 2009–2014 (Table 2). The patients with acute or subsequent myocardial infarction were defined based on the main cause of hospitalization, reported by the healthcare providers and settled by NFZ.

### Excluding criteria

The services with hospitalization lasting >30 days and the services granted to patients aged <25 years, or living outside the Silesian Voivodship's area, were excluded from the data pool. Finally, following data aggregation, 82 276 healthcare services granted to 55 143 patients were enrolled for the analyses.

### Statistical analysis

The statistical analyses were performed with the R Cran x64 v. 3.3.1 software (Lucent Technologies FR, Vienna, Austria, www.R-project.org). The raw specific death rates per 100 000 population in each of the subregions were determined. Subsequently, the death rate due to acute or



**Figure 1.** Patients' demographic structure in the study on assessing the current burden of deaths due to acute myocardial infarction (AMI) in the Silesian Voivodship, Poland

subsequent myocardial infarction was standardized to European Standard Population 2013 (ESP 2013) with the use of formula 1:

$$\text{SDR} = \frac{\sum_{i=1}^N \frac{k_i}{n_i} \times w_i}{\sum_{i=1}^N w_i} \quad (1)$$

where:

N – number of age groups,

$k_i$  – number of deaths in i-age group,

$n_i$  – population size in i-age group,

$w_i$  – weight assigned to i-age group based on ESP 2013.

The analyses of the annual AMI death rate for 2009–2014 were performed and assigned to the subregions of the Silesian Voivodship (based on Nomenclature of Territorial Units for Statistics-3), according to the patients' domicile.

## RESULTS

Data on 55 143 patients with diagnosed acute or subsequent myocardial infarction in 2009–2014 in the Silesian Voivodship were included in the study.

In this study, 37.7% of the patients (N = 20 806) were females and 30 142 healthcare services were granted to them, accounting for 36.64% of all services provided to all patients.

The average patient's age during the service provision was  $66 \pm 12$  years, with women being about 6.5 years older than men ( $70 \pm 12$  years vs.  $64 \pm 12$  years, respectively). The demographic structure of the patients is presented in Figure 1.

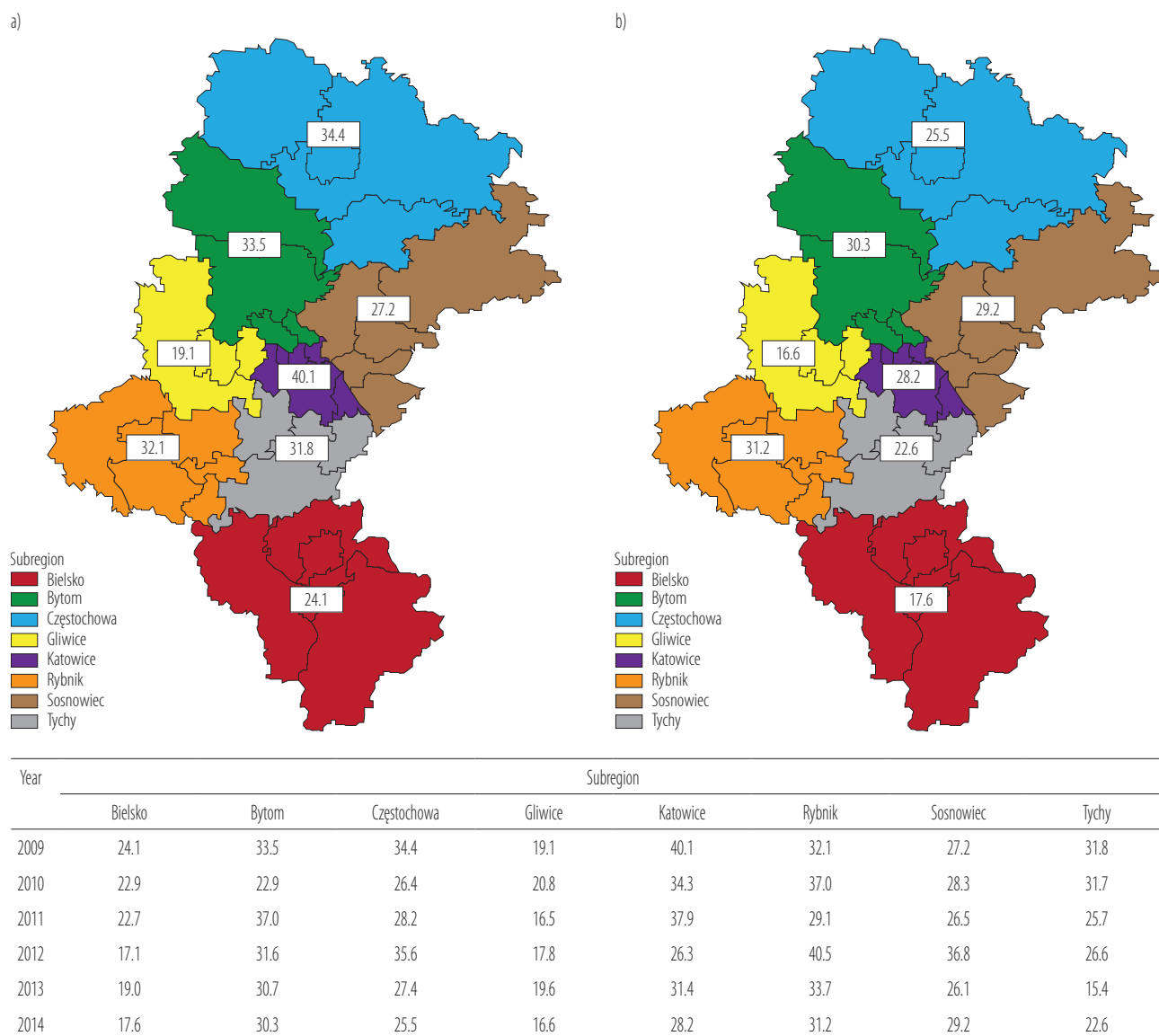
The number of healthcare services granted and the number of patients treated in each year of the study period are presented in Table 3. Some patients received healthcare services in more than 1 calendar year, so the sum of patients in this point is slightly different compared to the number of patients enrolled in the analyses.

The annual standardized death rate (SDR) for the patients with diagnosed acute or subsequent myocardial infarction in 2009–2014, in each of the subregions of the Silesian Voivodship, is presented in Figure 2.

## DISCUSSION

The differences in morbidity and mortality due to AMI between the developed and developing countries have been observed for over 30 years. According to the American Heart Association, cardiovascular diseases result in every third death in the USA, and the financial outlays related to therapy are estimated at 17% of the national healthcare expenditures [8,9]. A similar situation is observed in Western Europe, including Poland, where cardiovascular diseases are the main reason for death, constituting about 40% of all cases [10–12].

The literature data show an increase in the risk of morbidity or mortality due to cardiovascular diseases with the patient's age. A study based on the "Rzyko program" ("Risk program") algorithm emphasizes that in patients aged >70 years, the risk of occurrence of cardiovascular diseases is over 20% higher than in those aged 60 years [12]. Moreover, there is a relationship between the increase in life expectancy and the growth in both health-related needs and healthcare expenditures [13–15]. The demographic forecasts suggest that the percentage of people aged >65 years will increase by >50% until 2050 [16,17].



**Figure 2.** Standardized death rate (SDR) in the group of patients with diagnosed acute or subsequent myocardial infarction in each subregion of the Silesian Voivodship in a) 2009 and b) 2014

Therefore, it may be expected that the burden of cardiovascular diseases will increase as well.

In this study, 82 276 healthcare services granted to 55 143 patients with diagnosed acute or subsequent myocardial infarction in the Silesian Voivodship were analyzed. There were no differences in the patients' demographic structure between the subregions. The fact that the treated women were, on average, about 6.5 years

older than the treated men may be explained by the cardioprotective effect of estrogens and an increased burden of cardiovascular risk factors among men. These results correspond with other published data. A report by the Polish National Institute of Public Health – National Institute of Hygiene (NIH) revealed that, in 2009–2012 in Poland, the average age of men and women for whom AMI was the main reason for

**Table 3.** Healthcare services granted to patients with acute or subsequent myocardial infarction in the Silesian Voivodship in 2009–2014, included in the analysis

Variable	2009	2010	2011	2012	2013	2014	Total
Healthcare services [n]	13 712	13 830	13 864	14 302	13 562	13 006	82 276
Patients [n]	9688	9905	9978	10 342	99 792	9145	

hospitalization or death was 63 and 74 years, respectively [18].

According to Loudon et al. [19], the average age of the patients with the diagnosed AMI in 2003–2013 in the United Kingdom was  $67 \pm 14$  years, with the preponderance of men (64.2%). Yin et al. [20] noted that, in 2000–2007 in Norway, the average age of the patients with myocardial infarction was  $71 \pm 14$  years, and women were, on average, 7 years older than to men. Also, Lloyd-Jones's [21] results based on studies on the American population suffering from heart diseases and strokes indicated a higher average age of women compared to men (70 years vs. 64 years, respectively).

The unfavorable trend of morbidity due to cardiovascular diseases, which had been observed in Poland since the 1960s, stopped in 1992 [11,22]. Nevertheless, in 2013 in Poland, 433.3 cardiovascular-related deaths were recorded per 100 000 residents. According to the European Statistical Office, in 2014 in Poland, acute or subsequent myocardial infarction (diagnosis I21 or I22, according to ICD-10) was the reason for 48.3 deaths per 100 000 general population, and this rate was lower compared to the Central European countries and the European Union's average (49.7 per 100 000 general population). It is worth noting that the difference in the number of deaths in the Polish population was dependent on the region. The lowest value per 100 000 residents was recorded for the Opolskie Voivodship (33.3), and the highest for the Silesian Voivodship (61.9) [6]. It is worth mentioning that most of the data, including the Eurostat data, describe cases in which acute or subsequent myocardial infarction (diagnosis I21 or I22, according to ICD-10) was the direct

cause of death. Meanwhile, in this study, the values of SDR in the group of patients with acute or subsequent myocardial infarction were analyzed, irrespective of the direct cause of death. Information on the direct cause of death came from the death reports issued by the physicians declaring the death or performing an autopsy. This difference makes it impossible to directly compare these 2 sets of data.

The database used in this study contains 113 different direct causes of deaths identified by medical doctors. Many of them were single cases. A list of the most frequent ( $N > 100$ ) direct causes of death is presented in Table 4.

In this study, the SDR values in each of the 8 subregions of the Silesian Voivodship were analyzed. In 7 of them, a decrease in SDR was recorded in 2009–2014, and these results correspond with the NIH data [23]. A substantial decrease in the average SDR values was noticed in the Katowice subregion ( $\Delta = 11.9$  per 100 000 residents), the Tychy subregion ( $\Delta = 9.2$  per 100 000 residents), the Częstochowa subregion ( $\Delta = 8.9$  per 100 000 residents), and the Bielsko subregion ( $\Delta = 6.5$  per 100 000 residents). These areas, excluding the Katowice subregion, are mostly rural. A decrease in the number of deaths in the Katowice subregion, despite the unfavorable environmental conditions, may be explained by easier access to healthcare services, especially in the fields of invasive cardiology and cardiac surgery, provided by high-level referral academic centers. These results correspond to the conclusions formulated by André et al. [9] suggesting that patients living in urbanized areas can access specialist healthcare services in a shorter time, compared to those living in rural areas.

The Sosnowiec subregion was the only subregion showing an increase in the average annual SDR value in 2009–2014,



**Table 4.** The most frequent direct causes of death in the group of patients with acute or subsequent myocardial infarction in the Silesian Voivodship in 2009–2014

Direct cause of death*	n (%)
I46.9 Cardiac arrest, unspecified	1312 (29.68)
I21 Acute myocardial infarction	1009 (22.83)
I21.0 Acute transmural myocardial infarction of anterior wall	293 (6.63)
I21.4 Acute subendocardial myocardial infarction	277 (6.27)
I21.1 Acute transmural myocardial infarction of inferior wall	208 (4.71)
I21.9 Acute myocardial infarction, unspecified	140 (3.17)
I21.2 Acute transmural myocardial infarction of other sites	91 (2.06)
R57.0 Cardiogenic shock	592 (13.39)
R09.2 Respiratory arrest	466 (10.54)
I46.1 Sudden cardiac death, so described	188 (4.25)
I50.9 Heart failure, unspecified	145 (3.28)

\* According the International Classification of Diseases, 10th Revision (ICD-10).

and its values were the highest in the whole Silesian Voivodship. The NIH report shows similar results. According to these data, the counties of the Sosnowiec subregion are characterized by the highest values of cardiovascular SDR, and they are surrounded by other high SDR counties [24]. The demographic structure of the patients diagnosed with acute or subsequent myocardial infarction living in the Sosnowiec subregion is no different from the other subregions and the entire Silesian Voivodship. Limited availability of cardiological and invasive cardiology treatments or adverse health conditions, with an increase in cardiovascular risk factors in the Sosnowiec subregion population, may partially explain this phenomenon.

On the other hand, the heterogeneity of this subregion must be noted. The Sosnowiec subregion includes big urban centers such as Sosnowiec, Dąbrowa Górnicza and Jaworzno, with unfavorable environmental conditions. These cities provide relatively good healthcare services and have well-developed road infrastructure which enables quick access to specialist treatments. However, the rural counties (Będzin and Zawiercie) of the Sosnowiec subregion with lower environmental pollution have neither

easily accessible specialized healthcare services nor a well-developed transport system, which additionally extends the time to receive highly specialized health services.

According to Choi et al. [25], a low level of formal education, a limited household budget, and unemployment are the non-traditional cardiovascular risk factors. These components cause an increase in perceived stress. Pikala and Maniecka-Bryła [22] highlighted that gender, the level of education, and the place of residence affected the potential years of life lost and cardiovascular SDR. Moreover, Kucharska [16] noted that the patients' age, material status, and place of residence determined access to healthcare resources. These observations agree, to a limited extent, with the results of this study and the data presented by the Central Statistical Office describing the unemployment rate, the level of education, and the average monthly salary in individual subregions of the Silesian Voivodship.

In 2009–2014, both in the Silesian Voivodship and in each of the subregions, an increase in the unemployment rate, compared to the national average, was recorded (Poland = 100). In 2014, in the Silesian Voivod-

ship, the unemployment rate was 84.2. The lowest values were observed for the Tychy subregion (49.1), the Katowice subregion (60.5), and the Bielsko subregion (73.7), whereas the highest values were recorded for the Sosnowiec subregion (111.4), the Częstochowa subregion (119.3), and the Bytom subregion (126.3) [5]. These results, when compared to the Central Statistical Office data, suggest that the largest reduction in the number of deaths in the patients with acute or subsequent myocardial infarction was observed in the subregions with low unemployment rates. However, the statement that the a high unemployment rate causes an increase in the number of deaths is unproven. For example, in the Sosnowiec subregion, an increase in the SDR value was observed while the unemployment rate was higher compared to the regional and national average. At the same time, the SDR value recorded for the Bytom subregion decreased slightly despite the increase in the unemployment rate.

In 2009–2014, there were no significant changes in the average monthly salary in the Silesian Voivodship as a whole and in each of the subregions. In 2014, the average monthly salary recorded in the Silesian Voivodship was 2.4% higher compared to the national average, and it differed significantly depending on the subregion. The highest level of the average monthly salary was recorded in the Rybnik and Katowice subregions (12.6% and 18.7% higher than the national average, respectively). Adversely, in the Częstochowa, Bytom and Tychy subregions, the average monthly salary was lower than the national average (by 16.8%, 14.6%, 10.3%, respectively). The results obtained in this study, combined with these data, do not indicate the relationship between the average salary and household income with the burden of deaths due to acute and subsequent myocardial infarction.

According to the data obtained during the 2011 National Census, the level of education in the Silesian Voivodship was characterized by spatial diversity [5]. The results of this study, combined with the Central Statistical Office

data show that a higher percentage of people with a low level of formal education was related to the higher SDR values in the group of patients with acute or subsequent myocardial infarction. This conclusion corresponds with the results presented by Pikala and Maniecka-Bryla [22]. Unfortunately, the above-presented factors do not explain the observed increase in SDR values in the patients with the acute or myocardial infarction in the Sosnowiec subregion, involved in this study. The observed increase in the number of deaths in this group of patients may be caused by the worse health status of the Sosnowiec subregion's residents, or by the unsatisfactory quality or limited availability of specialist healthcare services. Without an explanation of the described differentiation, it will not be possible to eliminate the inequalities in health observed in the Silesian Voivodship.

### Limitations

The presented data do not fully describe the burden of cardiovascular risk factors for the residents of the Silesian Voivodship. However, the assessment of the burden of risk factors was not the objective of this study.

Lalonde [26] emphasized that health is determined by behavioral, environmental and genetic factors, and by the efficient functioning and use of the healthcare system resources. Changes in lifestyle, and especially a reduction in behavioral risk factors, have the greatest impact on the improvement of the health condition.

### CONCLUSIONS

The demographic structure of the patients with diagnosed acute or subsequent myocardial infarction in 2009–2014 in the Silesian Voivodship does not differ from national data. There were no differences in the demographic structure of these patients between the subregions.

The average value of SDR in the group of the patients living in the Sosnowiec subregion with diagnosed acute or subsequent myocardial infarction in 2009–2014 increased,



probably due to the unsatisfactory quality or limited availability of the specialist healthcare services.

The high average values of SDR in the patients with diagnosed acute or subsequent myocardial infarction, in 2009–2014 in the Bytom and Rybnik subregions, are an effect of the burden of risk factors, such as a low level of formal education and limited household income.

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