



ORIGINAL PAPER

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## Healthcare services granted to patients with diagnosed acute initial or subsequent myocardial infarction in the Silesian voivodeship (Poland)

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### ABSTRACT

**Introduction and aim.** Cardiovascular diseases remains the leading cause of death in most of developed societies, including Poland. The study aimed to assess the changes in the number, duration, and costs of hospitalizations due to myocardial infarction in Silesian voivodeship (Poland) in 2009-2014.

**Material and methods.** Data were obtained from the Silesian Voivodeship Branch of the National Health Fund. The number, costs, and duration of healthcare services granted during an inpatient hospital stay to patients with acute initial or subsequent myocardial infarction in 2009-2014 were processed and analyzed quarterly for the whole Silesian voivodeship and its subregions.

**Results.** From 54826 patients aged  $66 \pm 12$ , the majority were males (62.3%) and 63.4% of 80866 hospitalizations were granted to them. We observed a decreasing trend for the total number of healthcare services granted in 2009-2014 that varied depending on the subregion. Simultaneously, we found that in most subregions the costs of services and the number of invasive services increased over time. We observed that treating patients above 80 years with acute initial or subsequent myocardial infarction generated lower costs of hospitalization but was extended in time.

**Conclusion.** Increased number and costs and accompanying reduced duration of hospitalizations granted in 2009-2014, especially in the range of invasive cardiology and cardiac surgery, results from implementing international guidelines and recommendations for acute myocardial infarction procedures. Lower cost and extended time of hospitalization for patients older than 80 years most likely result from using conservative (non-invasive) methods of treatment.

**Keywords.** acute myocardial infarction, cardiology, healthcare services, Silesian Voivodeship

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## Introduction

Cardiovascular disease (CVD) remains in the field of interest of western medicine since the second half of the 18<sup>th</sup> century when British physician William Heberden described unstable angina in 1768.<sup>1</sup> CVD also remains the leading health problem of the European societies despite the public health and health promotion programs focused on reducing the cardiovascular risk factors and despite the progress made in medicine.

The CVD costs incurred by the economies of the European Union members constantly increase. In 2015, the costs of inpatient treatment incurred by the European healthcare systems constituted 51% of the EUR 111 billion dedicated to CVD treatment. The largest proportion of the CVD expenditures was noted in Austria (66%) and Sweden (60%) while the lowest proportion (31%) was noted in Croatia and Slovenia.<sup>2</sup> In the OECD's European region member states, the average time of hospitalization due to myocardial infarction was 6.7 days and it varied strongly depending on the country. The longest hospitalization time, over 10 days, was noted in Germany, while the shortest hospitalization times were noted in Scandinavia: 4.7 days in Sweden, 4.0 days in Norway, and 3.9 days in Denmark.<sup>3</sup> Similarly, the ratio of inpatient treatment per 100,000 citizens for patients suffering from acute coronary syndromes (ACSs) highly varied between the countries. According to the European Statistical Office (Eurostat) data, in 2014 in Poland, bear 180 hospitalizations per 100,000 citizens were caused by the ACSs. At the same time, in other Central European countries, this coefficient was higher: 206 for the Czech Republic, 207 for Hungary, 220 for Slovakia, 276 for Lithuania, 288 for Sweden, and 290 for Germany. What is interesting, in the same year 17.7% of the Polish population complained of cardiovascular ailments, while for other countries this percentage was lower: 12.8% in Germany, 7.8% in Sweden, and 5.0% in the Czech Republic.<sup>3</sup> However, it is alarming that the number of hospitalizations caused by ACSs has been constantly increasing since 2006 in all countries of the region, besides Sweden.<sup>4</sup>

Silesian voivodeship is the most urbanized and the most densely populated (urbanization level: 76.7%; population density: 367.6 people per km<sup>2</sup>) area of Poland.<sup>5</sup> According to the Central Statistical Office data, the mortality due to ischemic heart disease in the Silesian voivodeship population noted in 2014 was one of the highest in Poland (79.6 per 100,000) and it was higher than Europe's average.<sup>4</sup> These facts make analyses of the healthcare services granted to the patients in the Silesian voivodeship necessary.

## Aim

The study aimed to analyze the number of healthcare services granted during an inpatient hospital stay to the patients with acute initial or subsequent myocardial in-

farction (diagnosis code I21-I22 according to the ICD-10 classification) in Silesian voivodeship in 2009-2014. It also aimed to assess the temporal and spatial variability of the hospitalization costs and hospitalization time over the same period.

## Material and methods

### *Ethical approval and consent to participate*

All experimental protocols were approved by Bioethical Commission of the Medical University of Silesia (permission N° KNW/0022/KB/68/17). All methods were carried out in accordance with relevant guidelines and regulations as well as respecting the confidentiality of biomedical data.

### *The range of the analyzed data*

Secondary epidemiological, depersonalized data was obtained from the Silesian Voivodeship Branch of the National Health Fund of Poland (NFZ) in Katowice.

We analyzed the healthcare services in the range of pulmonology, internal medicine, nephrology, geriatrics, cardiology/invasive cardiology, and cardiac surgery provided to patients with acute initial or subsequent myocardial infarction during their inpatients' hospital stay in the Silesian voivodeship in the 2009-2014 period. Patients with acute initial or subsequent myocardial infarction were identified based on the main cause of hospitalization reported by the healthcare providers and settled by the NFZ. We analyzed the data using the ecological study model.

The database contained 123,075 healthcare services granted to 64,472 patients in the Silesian voivodeship in the 2009-2014 period. The data were aggregated before the analyzes due to the way they had been processed by the NFZ during the billing process.

Because of a small number of services granted to patients with AMI in the 2009-2014 period in the pulmonology, geriatrics, and nephrology units, they were analyzed together with the internal medicine hospitalizations and created a group of *Internal Medicine*. Similarly, the services granted to patients in the range of cardiac surgery and invasive cardiology were pooled together and created a group of *Invasive Cardiology & Cardiac Surgery*.

The following services included Ordinance of the President of National Health Fund of Poland N°32/2008/DSOZ of the day June 11, 2008, were included: E10 – ACS-invasive diagnostics, E11 – ACS-two-step invasive treatment > 3 days, E12 – ACS-complex invasive treatment, E13 – Invasive treatment, E14 – ACS-invasive treatment < 4 days, E23 – Coronary angioplasty with single DES stent implantation, E24 – Angioplasty with implantation of not less than 2 stents or multi-vessel, E25 – Single-stent angioplasty and other procedures, E26 – Balloon coronary angioplasty.

The services with hospitalization exceeding 30 days, the services granted to patients below 25 years of age

or living outside the Silesian voivodeship's area were excluded from the data pool.

Finally, after initial data processing, 82,276 healthcare services granted to 55,143 patients were enrolled for analyses. Detailed information about the range of the enrolled services is presented in Table 1.

**Table 1.** The groups and the number of healthcare services in each range of services granted to patients with diagnosed acute or subsequent myocardial infarction in whole Silesian voivodeship and its subregions in 2009-2014 that were enrolled in the study

| Group of healthcare services          | Range of healthcare services   | N (%)                    |
|---------------------------------------|--|--------------------------|
| Internal Medicine                     | Pulmonology – hospitalization  | 15,201<br>(18.57%)       |
|                                       | Internal medicine – hospitalization                                  |                          |
|                                       | Geriatrics – hospitalization   |                          |
|                                       | Nephrology – hospitalization   |                          |
| Invasive Cardiology & Cardiac Surgery | Cardiac surgery – hospitalization                                    | 50,350<br>(61.5%)        |
|                                       | Cardiology <sup>a</sup> : – hospitalization, E11, E12, E13, E14      |                          |
|                                       | Cardiology <sup>b</sup> : – hospitalization, E10, E11, E12, E13, E14 |                          |
|                                       | Cardiology: – hospitalization, E23, E24, E25, E26                    |                          |
| Cardiology                            | Cardiology – hospitalization   | 16,315<br>(19.93%)       |
| <b>TOTAL:</b>                         |  | <b>81,866<br/>(100%)</b> |

<sup>a</sup> In the National Health Fund of Poland (NFZ) billings in the 2009-2012 period a homogeneous patients group included the services listed in the catalog as: E11, E12, E13, E14.

<sup>b</sup> In the National Health Fund of Poland (NFZ) billings in the 2013-2014 period a homogeneous patients group included the services listed in the catalog as: E11, E12, E13, E14, and additionally the invasive diagnostic services (E10).

Legend: Table contains the healthcare codes according to the Ordinance of the President of National Health Fund of Poland N°32/2008/DSOZ of the day June 11, 2008.

E10 – ACS-invasive diagnostics, E11 – ACS-two-step invasive treatment > 3 days, E12 – ACS-complex invasive treatment, E13 – Invasive treatment, E14 – ACS-invasive treatment < 4 days, E23 – Coronary angioplasty with single DES stent implantation, E24 – Angioplasty with implantation of not less than 2 stents or multi-vessel, E25 – Single-stent angioplasty and other procedures, E26 – Balloon coronary angioplasty

Legend abbreviations: ACS – Acute Coronary Syndrome, DES – Drug Eluting Stent

### Cost assessment

The cost of hospitalizations' was based on the valuation of healthcare services by NFZ provided to patients qualified for homogeneous therapeutic groups, according to

the Ordinance of the President of National Health Fund of Poland N°32/2008/DSOZ of the day June 11, 2008. The healthcare services were priced in Polish zloty (PLN) which is the official currency and legal tender of Poland. To enable comparison of the costs of therapy to other countries we present the costs of granted healthcare services in euro (€), according to the average PLN/euro exchange rate in 2009-2014, based on the archival data of the National Bank of Poland (1 € = 4.168 PLN).

### Statistical analysis

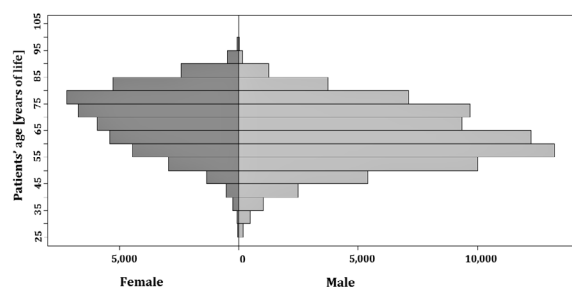
The statistical analyzes were performed with the R Cran x64 v. 3.3.1 software (Lucent Technologies FR, Vienna, Austria, www.R-project.org).

The number, costs, and duration of the healthcare services in the Silesian voivodeship in the 2009-2014 period were analyzed quarterly and assigned to Silesian's subregions (*Nomenclature of Territorial Units for Statistics-3*) according to the patients' domicile. The linear regression models for obtained results were performed, talking appropriate requirements. The standardized regression coefficient ( $\beta$ ) with the 95% confidence interval (95% CI) and the coefficient of determination ( $r^2$ ) were presented. To assess the relationship between the age group of patients' and the obtained therapeutic strategy the  $\chi^2$  test was used. Statistical significance was set at a *p-value* below 0.05.

## Results

### Study group demography

The demographic structure of the patients is presented in Figure 1. More than half of the healthcare services were granted to men (63.4%), who constituted 62.3% of patients in the database. Accordingly, 29,945 out of 81,866 healthcare services (36.6%) were granted to women. They constituted 37.7% of patients (20,658 out of 54,826) enrolled in the study. The average age of patients receiving healthcare services was  $66 \pm 12$  years. Women were about 6.5 years older than men ( $70 \pm 12$  years vs.  $64 \pm 12$  years, respectively).



**Fig. 1.** Demographic structure of patients with diagnosed acute initial or subsequent myocardial infarction that received healthcare services in Silesian voivodeship in 2009-2014

### Number, cost, and duration of healthcare services

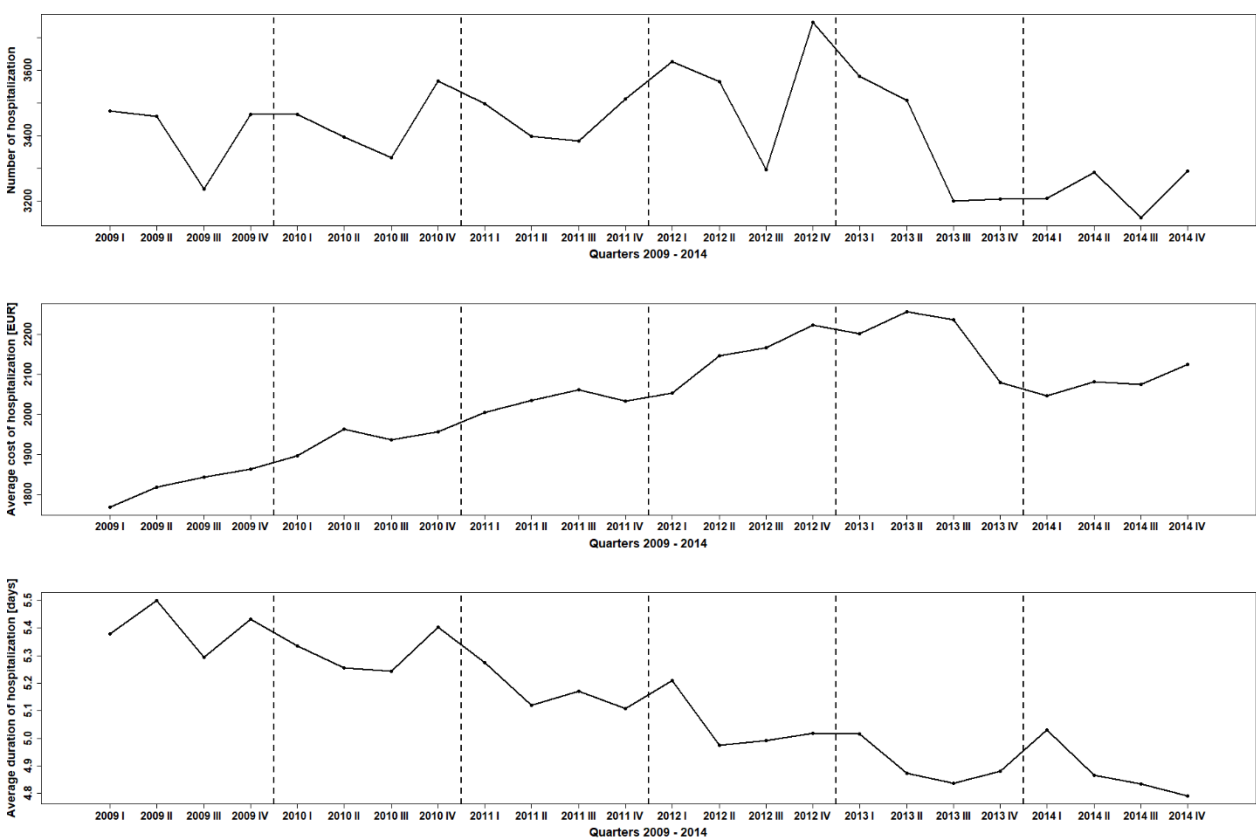
Our analyses showed that the cost of granted healthcare services constantly increased over the analysed 2009-2014 period. The sudden reduction of the average cost of healthcare services observed in the third quarter of 2013, accompanied by a reduction in their number, most likely indicates a change in the billing process by the NFZ. We also found that the average duration of services tended to decrease over the analysed 2009-2014 period. The number, the average cost, and the average duration of all analyzed healthcare services granted to patients with diagnosed acute initial or subsequent myocardial infarction (diagnosis I21, I22 according to the ICD-10) in the whole Silesian voivodeship in each quarter of 2009-2014 period are presented in Figure 2.

We noted a decreasing trend of the number of granted healthcare services granted over the 2009-2014 period in all analysed ranges in the whole Silesian voivodeship, but it slightly varied between subregions. Simultaneously, we found that the costs of healthcare services increased over time. The observed trends differed between the analysed groups of services. In the group of *Internal Medicine*, we noted decreasing trends in the number, average cost,

and duration of services for all analysed subregions. On the contrary, in the group of *Invasive Cardiology & Cardiac Surgery*, we found increasing trends for these variables for the whole Silesia voivodeship and analysed subregions, except for the Sosnowiec subregion. The values of the standardized regression coefficient  $b$  (with 95% CI) for each range of healthcare services granted to patients with acute initial or subsequent myocardial infarction in Silesian voivodeship and its subregions over 2009-2014 are presented in Table 2 and 3.

### Cost and duration of healthcare services concerning the patient's age

The data analysis showed that the average cost of healthcare services granted in the 2009-2014 period in the Silesian voivodeship for patients under 36 years of age increased by 80.6 € with each next one year of life (YOL). In the group of patients aged 37-79, the average cost of granted healthcare services remained constant ( $2,085.7 \pm 68.0$  €). In the group of patients over 80 years of age, the cost of services decreased by 50.2 € per one YOL. The relationship between the average costs of healthcare services concerning patients' age is presented in Figure 3.



**Fig. 2.** Characteristics of healthcare services granted quarterly to patients with diagnosed acute initial or subsequent myocardial infarction in Silesian voivodeship in 2009-2014: A) the number of hospitalizations; B) the average cost of hospitalizations; C) the average duration of hospitalizations

**Table 2.** Linear regression models  $\beta$  coefficients and 95% confidence interval (95% CI) for the number, the average cost, and the average duration of healthcare services granted in each range to patients with diagnosed acute or subsequent myocardial infarction in whole Silesian voivodeship and its subregions in 2009-2014

| Region                | Total healthcare services   |                             |                             | Hospitalizations in the group of <i>Internal Medicine</i> |                             |                             |
|-----------------------|-----------------------------|-----------------------------|-----------------------------|---|-----------------------------|-----------------------------|
|                       | Number                      | Average cost                | Average duration            | Number  | Average cost                | Average duration            |
| Silesian voivodeship  | -7.21<br>(-15.85 ÷ 1.43)    | 15.52***<br>(10.82 ÷ 20.22) | -0.03***<br>(-0.03 ÷ -0.02) | -21.31***<br>(-23.56 ÷ -19.06)                            | -2.51***<br>(-3.04 ÷ -1.98) | -0.09***<br>(-0.11 ÷ -0.07) |
|                       | 0.11                        | 0.66                        | 0.88                        | 0.94  | 0.80                        | 0.86                        |
| Bielsko subregion     | 1.94*<br>(0.18 ÷ 3.70)      | 10.89***<br>(7.07 ÷ 14.71)  | -0.09***<br>(-0.11 ÷ -0.07) | -3.31***<br>(-4.02 ÷ -2.60)                               | -2.12<br>(-4.84 ÷ 0.60)     | -0.15***<br>(-0.21 ÷ -0.09) |
|                       | 0.18                        | 0.59                        | 0.84                        | 0.79  | 0.10                        | 0.54                        |
| Bytom subregion       | 1.52<br>(-0.34 ÷ 3.38)      | 13.37***<br>(8.55 ÷ 18.19)  | 0.00<br>(-0.002 ÷ 0.002)    | -1.36***<br>(-1.87 ÷ -0.85)                               | -1.73*<br>(-3.04 ÷ -0.42)   | -0.06**<br>(-0.10 ÷ 0.02)   |
|                       | 0.10                        | 0.57                        | 0.00                        | 0.56  | 0.23                        | 0.33                        |
| Częstochowa subregion | -2.33<br>(-4.82 ÷ 0.16)     | 19.88***<br>(13.82 ÷ 25.94) | 0.01<br>(-0.01 ÷ 0.02)      | -3.25***<br>(-3.88 ÷ -2.62)                               | 0.00<br>(-1.51 ÷ 1.51)      | -0.03<br>(-0.07 ÷ 0.01)     |
|                       | 0.13                        | 0.65                        | 0.03                        | 0.83  | 0.00                        | 0.13                        |
| Gliwice subregion     | 1.02<br>(-0.20 ÷ 2.24)      | 12.14***<br>(7.50 ÷ 16.79)  | -0.03***<br>(-0.05 ÷ 0.01)  | -1.53***<br>(-2.02 ÷ -1.04)                               | -3.68***<br>(-5.50 ÷ -1.86) | -0.07**<br>(-0.11 ÷ -0.03)  |
|                       | 0.11                        | 0.54                        | 0.40                        | 0.62  | 0.41                        | 0.38                        |
| Katowice subregion    | -1.33<br>(-4.00 ÷ 1.34)     | 10.57**<br>(4.38 ÷ 16.76)   | -0.07***<br>(-0.08 ÷ -0.06) | -2.48***<br>(-3.50 ÷ -1.46)                               | -4.41***<br>(-5.76 ÷ -3.06) | -0.09***<br>(-0.13 ÷ -0.05) |
|                       | 0.04                        | 0.34                        | 0.86                        | 0.51  | 0.65                        | 0.52                        |
| Rybnik subregion      | 1.23<br>(-1.38 ÷ 3.84)      | 23.70***<br>(14.91 ÷ 32.48) | -0.02**<br>(-0.03 ÷ 0.00)   | -5.43***<br>(-6.39 ÷ -4.47)                               | -1.37*<br>(-2.33 ÷ -0.41)   | -0.04**<br>(-0.06 ÷ -0.02)  |
|                       | 0.04                        | 0.56                        | 0.25                        | 0.85  | 0.26                        | 0.28                        |
| Sosnowiec subregion   | -6.53***<br>(-8.74 ÷ -4.32) | 17.45***<br>(11,94 ÷ 22.96) | 0.02**<br>(0.01 ÷ 0.03)     | -1.94***<br>(-2.57 ÷ -1.31)                               | -1.57<br>(-3.24 ÷ 0.10)     | -0.09***<br>(-0.13 ÷ -0.05) |
|                       | 0.60                        | 0.64                        | 0.33                        | 0.62  | 0.14                        | 0.45                        |
| Tychy subregion       | -2.73***<br>(-4.12 ÷ -1.34) | 20.51***<br>(13.45 ÷ 27.57) | -0.05***<br>(-0.07 ÷ -0.03) | -1.94***<br>(-2.57 ÷ -1.31)                               | -5.36***<br>(-8.04 ÷ -2.67) | -0.18***<br>(-0.24 ÷ 0.12)  |
|                       | 0.40                        | 0.60                        | 0.56                        | 0.62  | 0.41                        | 0.60                        |

\*\*\*  $p < 0.001$  \*\*  $p < 0.01$  \*  $p < 0.05$

Moreover, our data analysis showed that the average duration of healthcare services increased with patients' age by the power function ( $r^2 = 0.83$ ). The average duration of hospitalizations in relation to patients' age is presented in Figure 4. We observed a longer duration of the healthcare services ( $> 6$  days) in a group of patients over 80 years of age and simultaneous reduction of costs of healthcare services that suggest using conservative (non-invasive) treatments or comorbidities in that group of patients compared to patients aged below 80.

The  $\chi^2$  test results confirm this supposition. We found that 63.4% of 70,949 healthcare services granted to patients below 80 years of life were invasive meanwhile in the group aged over 80 it was only 49.9% of 11,424 services,  $p < 0.001$ . Patients aged below 80 years of life had more than a 1.74 greater chance to get invasive treatment compared to the elderly group (95% CI: 1.67 – 1.81).

## Discussion

### Demographic structure

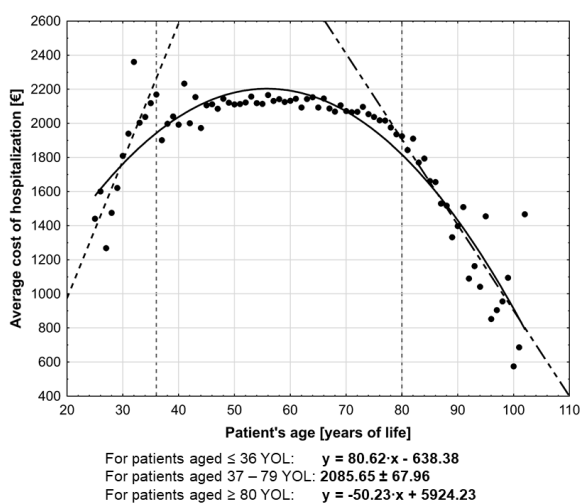
The available literature data emphasize that the risk of morbidity and mortality due to cardiovascular diseases increase with patients' age. The studies based on the *Ryzyko program* (eng. *Risk program*) algorithm show that the risk of cardiovascular diseases is over 20% higher in the group of patients aged over 70 years old, compared to a group of patients ten years younger.<sup>6</sup> There is also the relationship between the extension of the average length of life and an increase in society's healthcare needs and incurred medical costs.<sup>7, 8, 9</sup> According to the demographic prognosis for developed societies, by 2050 more than 50% of the population will be 65 years old and above.<sup>10, 11</sup>

In our study, women constituted 30.73% of patients enrolled in the study, and 36.64% of healthcare services were granted to them. They were also on average 6.5 years older than the men enrolled in this study ( $70 \pm 12$  years vs.  $64 \pm 12$  years). This can be explained by the car-

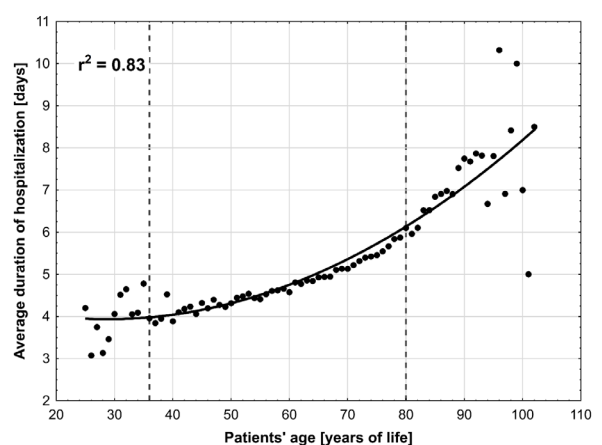
**Table 3.** Linear regression models  $\beta$  coefficients and 95% confidence interval (95% CI) for the number, the average cost, and the average duration of healthcare services granted in each range to patients with diagnosed acute or subsequent myocardial infarction in whole Silesian voivodeship and its subregions in 2009-2014

| Region                | Hospitalizations in the group of <i>Cardiology</i> |                |                  | Hospitalizations in the group of <i>Invasive Cardiology &amp; Cardiac Surgery</i> |                 |                  |
|-----------------------|--|----------------|------------------|---|-----------------|------------------|
|                       | Number   | Average cost   | Average duration | Number  | Average cost    | Average duration |
| Silesian voivodeship  | 2.20*  | 4.71***        | -0.08***         | 11.90*  | 2.88            | 0.01*            |
|                       | (0.26 ÷ 4.14)                                      | (4.02 ÷ 5.40)  | (-0.10 ÷ -0.06)  | (3.57 ÷ 20.23)  | (-1.00 ÷ 6.76)  | (0.00 ÷ 0.02)    |
| Bielsko subregion     | 0.18   | 0.89           | 0.81             | 0.26  | 0.09            | 0.21             |
|                       | 4.19***  | 6.23***        | -0.09***         | 1.07  | 13.64***        | -0.02***         |
| Bytom subregion       | (3.35 ÷ 5.03)                                      | (5.01 ÷ 7.45)  | (-0.11 ÷ -0.07)  | (0.01 ÷ 2.13)   | (10.92 ÷ 16.36) | (-0.03 ÷ -0.01)  |
|                       | 0.81   | 0.82           | 0.65             | 0.15  | 0.81            | 0.59             |
| Częstochowa subregion | 0.41*  | 4.69**         | -0.02            | 2.49**  | -1.50           | 0.02             |
|                       | (0.06 ÷ 0.76)                                      | (1.50 ÷ 7.88)  | (-0.06 ÷ 0.02)   | (1.20 ÷ 3.78)   | (-6.44 ÷ 3.44)  | (-0.00 ÷ 0.04)   |
| Gliwice subregion     | 0.19   | 0.27           | 0.07             | 0.39  | 0.02            | 0.11             |
|                       | -0.38  | 1.83*          | -0.15***         | 1.31  | 1.40            | 0.05***          |
| Katowice subregion    | (-0.91 ÷ 0.15)                                     | (0.22 ÷ 3.44)  | (-0.23 ÷ -0.07)  | (-0.51 ÷ 3.13)  | (-5.03 ÷ 7.83)  | (0.03 ÷ 0.07)    |
|                       | 0.08   | 0.18           | 0.45             | 0.08  | 0.01            | 0.70             |
| Rybnik subregion      | 0.66**   | -1.18          | -0.06**          | 1.88***   | 2.62            | -0.01            |
|                       | (0.21 ÷ 1.11)                                      | (-2.83 ÷ 0.47) | (-0.10 ÷ -0.02)  | (1.10 ÷ 2.66)   | (-2.10 ÷ 7.34)  | (-0.03 ÷ 0.01)   |
| Sosnowiec subregion   | 0.27   | 0.08           | 0.36             | 0.50  | 0.05            | 0.05             |
|                       | -1.05  | 1.09           | -0.17***         | 2.20*   | -1.78           | -0.04***         |
| Tychy subregion       | (-2.07 ÷ -0.03)                                    | (-0.69 ÷ 2.87) | (-0.21 ÷ -0.13)  | (0.44 ÷ 3.96)   | (-6.21 ÷ 2.65)  | (-0.06 ÷ -0.02)  |
|                       | 0.16   | 0.06           | 0.74             | 0.21  | 0.03            | 0.65             |
| Silesian voivodeship  | 2.21***  | 8.05***        | -0.03            | 4.45**  | -2.95           | -0.04***         |
|                       | (1.60 ÷ 2.82)                                      | (4.72 ÷ 11.38) | (-0.07 ÷ 0.01)   | (1.92 ÷ 6.98)   | (-7.52 ÷ 1.62)  | (-0.06 ÷ -0.02)  |
| Silesian voivodeship  | 0.69   | 0.51           | 0.14             | 0.35  | 0.07            | 0.50             |
|                       | -2.94***   | 6.77***        | -0.06***         | -1.66   | 9.68***         | 0.08***          |
| Silesian voivodeship  | (-3.90 ÷ -1.98)                                    | (4.99 ÷ 8.55)  | (-0.08 ÷ -0.04)  | (-3.56 ÷ 0.24)  | (5.49 ÷ 13.87)  | (0.06 ÷ 0.10)    |
|                       | 0.62   | 0.72           | 0.67             | 0.12  | 0.48            | 0.81             |
| Silesian voivodeship  | -0.91**  | 6.79***        | -0.06**          | 0.16  | 2.30            | -0.01            |
|                       | (-1.44 ÷ -0.38)                                    | (4.83 ÷ 8.75)  | (-0.10 ÷ -0.02)  | (-0.99 ÷ 1.32)  | (-2.76 ÷ 7.36)  | (-0.03 ÷ 0.01)   |
| Silesian voivodeship  | 0.33   | 0.68           | 0.38             | 0.03  | 0.03            | 0.05             |

\*\*\*  $p < 0.001$  \*\*  $p < 0.01$  \*  $p < 0.05$



**Fig. 3.** Cost of healthcare services granted to patients with diagnosed acute initial or subsequent myocardial infarction in Silesian voivodeship in 2009-2014 in relation to their age



**Fig. 4.** Time of hospitalization of patients with diagnosed acute or subsequent myocardial infarction in Silesian voivodeship in 2009-2014 in relation to their age

dioprotective effect of estrogens and increased burden cardiovascular risk factors in the group of men.<sup>12</sup> The data analysis showed no significant differences in the demographic structure of patients between individual subregions of the Silesian voivodeship. These results correspond with available literature data. According to the National Institute of Hygiene (PZH) report, the average age of patients, with myocardial infarction being the main cause of hospitalization or direct cause of death in 2009-2012, was 63 years for males and 74 years for female patients.<sup>13</sup> According to Loundon et al., the average age of patients with diagnosed myocardial infarction in the United Kingdom in the 2000-2013 period was  $67 \pm 14$  years and males constituted 64.2% of patients.<sup>14</sup> Some studies confirm our observation that females diagnosed with myocardial infarction are about 7 years older comparing to males.<sup>15,16</sup>

Levels of education and income are considered the factors influencing the risk of cardiovascular disease (CVD) development. According to the 2011 General Census, 18.5% of the Silesian voivodeship population over 25 years of age had tertiary education, 32.3% had secondary education and 43.6% had primary or vocational education. The education level of the Silesian voivodeship citizens did not differ significantly from the education level of populations of other regions of Poland and the national average (20.0%, 31.4%, and 43.1%, respectively). According to the Polish Central Statistical Office, the average monthly gross salary of the Silesian voivodeship inhabitants in the 2009-2014 period, slightly exceeded the national average.<sup>5</sup> Since both factors were at the comparable level as the national average we may conclude that the Silesian voivodeship population wasn't more prone to CVD development when taking into account these two factors.

#### *The number of granted healthcare services*

The demand for healthcare services depends on many factors like the aging of the population, increase of wealth, and an increase in the number of concluded commercial health insurance contracts. The last one mentioned is seen as the marker of increased health awareness, which is associated with more frequent use of healthcare resources.<sup>9</sup> The availability of services, comprehensiveness, continuity, effectiveness and high quality of services provided are measures of the effective healthcare system.<sup>10</sup> Moreover, control of the number of hospitalizations may be treated as the quality and effectiveness of primary care measures.<sup>17</sup>

In our study, we found that the number of services granted slightly decreased in all analysed groups of healthcare services in the Silesian voivodeship over the analysed period of 2009-2014. We also found that the number of healthcare services granted slightly varied between Silesian voivodeship's subregions. Un-

fortunately, the direct comparison with the literature data may be difficult for this indicator. Most studies analyse cases in which acute myocardial infarction was the leading diagnosis and was a direct cause of hospitalization meanwhile in our study we analysed healthcare services granted to patients with myocardial infarction apart from the primary diagnosis. An analysis based on assigning patients to homogeneous therapeutic groups, patients with many comorbidities may be omitted.<sup>18</sup> For example, in the United States, the number of healthcare services granted to patients with myocardial infarction increased from 28% to 40% in the 2002-2011 period. Simultaneously, the number of hospitalizations per 100,000 citizens due to acute myocardial infarction being the leading diagnosis, decreased from 1,067 to 677.<sup>18</sup>

In our study, we found that in the *Internal Medicine* group the number of hospitalizations significantly decreased in the Silesian voivodeship and all analysed subregions. Simultaneously, the number of services granted in the *Invasive Cardiology & Cardiac Surgery* group tended to increase in the Silesian voivodeship and all of the subregions, except for the Sosnowiec subregion. This may have been related to the fact, that the patients with AMI over time more often received healthcare services in specialized units of invasive cardiology centres. The network of invasive cardiology centres in Poland has been developing since 1981 and in 2016 the number of these centres corresponded to the recommendations of international scientific societies.<sup>19</sup> The increase of accessibility of the new therapeutic strategies in Poland, including cardiac surgery and invasive cardiology services contributed to the greatest reduction in the number of deaths due to cardiovascular diseases among Central European countries. It was estimated that the increase in the availability of new therapies caused a 37% reduction in deaths due to cardiovascular diseases.<sup>19</sup> This estimation was especially optimistic as according to Häkkinen et al. acute myocardial infarction was the reason for  $2.3 \pm 7.3\%$  of hospitalizations in Poland in 2009 and this percentage was higher than in other analysed Western Europe countries.<sup>20</sup>

Observed since the mid 2010 increase in the number of services granted in the *Invasive Cardiology & Cardiac Surgery* group in the Rybnik subregion most likely results from opening the Department of Cardiology, Electrocardiology, and Angiology in Racibórz Medical Centre on September 8, 2010. Similarly, the increasing number of the same services observed in the Bielsko subregion may result from launching the Department of Cardiac Surgery in the American Heart of Poland hospital in Bielsko-Biała in 2012. The trend of the increasing number of invasive services noted in Gliwice and Katowice subregions may result from the considerable availability of invasive cardiology units, including highly specialized academic centres.

The analysis showed the decreasing trend in the number of healthcare services granted in each analysed group of services for the Sosnowiec subregion what in comparison with the increased burden of deaths due to acute or subsequent myocardial infarction noted in our previous study is wondering.<sup>21</sup> The observed phenomenon may result from insufficient availability of highly specialized services in the field of cardiology, invasive cardiology, and cardiac surgery for the Sosnowiec subregion inhabitants. The above-mentioned increased burden of deaths due to AMI also noted for this subregion might support this hypothesis.<sup>21</sup> As of 2014, none of the medical entities operating in the Sosnowiec subregion have established a cardiac surgery department, and additionally, both Będzin and Zawiercie counties (that belong to this subregion) lack a cardiology department. Some authors interpret that a decrease in the number of hospitalizations due to acute myocardial infarction in conjunction with an increase in the costs of the granted healthcare services may be the marker of treatment improvement. But these conclusions may be unauthorized, and they usually overestimate the population health status.<sup>18</sup>

#### *Cost and the duration of the hospitalizations*

Acute myocardial infarction remains the leading cause of hospitalization in the majority of the developed countries.<sup>22</sup> The annual medical costs incurred by EU member states due to cardiovascular diseases amounted to EUR 106 billion in 2009. The largest part of this sum was inpatient treatment costs, which constituted between 34% to 76% of the expenditures.<sup>23</sup>

In our study, we noted the increase of the average cost of healthcare services granted in *Cardiology*, *Invasive Cardiology & Cardiac Surgery* groups in the whole Silesian voivodeship as well as in each of the analysed subregions. Our results correspond with available literature sources that also notice the general trend of increasing healthcare costs and explain it with the use of new therapeutic strategies recommended by the international scientific societies.<sup>7</sup> On the other hand, the problem of reporting the homogeneous group, which was the highest-rated by the National Health Fund, even if it was not related to the leading medical problem during hospitalization, is well known in Poland.

Some data show that the average cost of healthcare services granted to patients with myocardial infarction in the EU member states in the 2007-2012 period was USD 5,966 and it significantly varied between member states (USD 547-10,435). Moreover, the average cost of services granted in Eastern European countries was USD 992 and it was significantly lower than for "old EU member states".<sup>24</sup>

Zhao and Winget noted that the costs of healthcare services granted to patients with diagnosed myocardi-

al infarction increase with patients' age.<sup>7</sup> Also, there is a relationship between an optimal CVD risk profile and reduction of healthcare expenditures, and the inverse relationship between risk profile and the healthcare expenditures among the elderly.<sup>25</sup> Silesian voivodeship is one of the most urbanized and densely populated Polish regions (urbanization level: 76.7%, population density: 367.6 people per km<sup>2</sup>) which creates adverse environmental conditions that increase the risk of CVD.<sup>5</sup> Our results show that the average cost of healthcare services granted to patients aged 33-80 years of age is constant meanwhile among patients over 80 years of age it decreases. Our findings do not contradict the information cited above, but they indicate different treatment strategies in elderly patients. The advanced age of patients is also a factor influencing the average duration of hospitalization but the gender impact on the duration of hospitalization is not clearly defined. However, for sure, the comorbidities and an emergency admission may be the reason for the extension of an inpatient stay.<sup>15,25</sup> The duration of hospitalization frequently serves as the simplest indicator of the healthcare system's effectiveness.<sup>26</sup> The average duration of granted services increased in the 2008-2012 period in most European countries, besides Sweden and Finland.<sup>20</sup>

We noted a slight decrease in the average duration of healthcare services granted in the 2009-2014 period. This might be related to the reduction of the number of inpatient treatments within the *Internal Medicine* and *Cardiology* groups with slight variation between each of the subregions.

The average time of healthcare services granted in the *Invasive Cardiology & Cardiac Surgery* group remained constant for the whole Silesian voivodeship and most of the analysed subregions. The decreasing trends of average hospitalization time, observed in the Katowice and Rybnik subregions, may result from the effectiveness of healthcare services granted in highly specialized academic centres and new-formed commercial centre in Racibórz. Interestingly, the significant increase in the average hospitalization time and the accompanying decrease in the number of granted healthcare services were noted for the Sosnowiec subregion, including for the *Cardiology* and the *Invasive Cardiology & Cardiac Surgery* groups. That finding is alarming, especially in conjunction with a confirmed considerable burden of deaths due to acute initial or subsequent myocardial infarction among Sosnowiec subregion's citizens.<sup>21</sup> The Sosnowiec subregion is one of the most heterogeneous of Silesian voivodeship's subregions both in terms of environmental conditions and resources of the health care system. In our opinion, the connection between the observed death burden and the structure of the healthcare services granted to patients in the Sosnowiec subregion requires further analyses.



The average duration of hospitalization due to AMI noted in our study is insensibly lower, compared to the national average, as well as to most of the Central European countries (data for 2011).<sup>4</sup> It must be mentioned that the average duration of inpatients' stay in countries of the region varies from 4.8 days in Sweden to 8 days in Germany. The reduction in the average duration of inpatient stay in Poland occurs jointly with the increasing percentage of patients with diagnosed myocardial infarction. But at the same time, longer than the national average inpatient stays are frequent in many Polish hospitals.<sup>15,20</sup> This agrees with the observation that the duration of hospitalization is significantly longer when conservative treatment (non-invasive) is used.<sup>7, 25</sup> We observed a decrease in the average cost of services and an increase in the average duration of hospitalization for patients with diagnosed acute initial or subsequent myocardial infarction older than 80 years of age. These results may indicate that they were treated using conservative (non-invasive) methods of treatment. Some studies show that a longer time of hospitalization is observed in highly specialized academic centres when compared to hospitals with a lower level of reference but transferring patients from lower to high reference level centres may explain this phenomenon.<sup>15,25</sup> Also, a longer time of healthcare services granted is observed in cases ended with the patient's death.<sup>25</sup> Since the obtained data didn't include information such as the reference level of the healthcare services provider or the healthcare services' final outcome, we were not able to determine if that was true for the analysed data from Silesian voivodeship for the 2009-2014 period.

### Limitation

Although this study is based on the most reliable and complete data obtained from the National Health Fund of Poland it has some limitations.

First of all, our database includes secondary epidemiological data obtained after the billing medical services process completion, thus the authors did not have access to the original medical documentation of patients enrolled in the study.

The pattern of healthcare services and incurred costs may differ between STEMI and NSTEMI patients. Unfortunately, we do not know what type of MI was diagnosed in each case (MI with or without ST elevation), which makes data analysis difficult. Moreover, we do not know if the patients were admitted to the invasive cardiology unit within the "time window" entitled to perform the angioplasty which affects the selected therapeutic strategy and the treatment costs incurred.

### Conclusions

In the 2009-2014 period, we observed the increase in numbers and costs of healthcare services granted to patients and the reduction of hospitalization time of

patients with acute initial or subsequent myocardial infarction from the Silesian voivodeship in the range of invasive cardiology and cardiac surgery. We believe that this results from implanting the guidelines and recommendations of international scientific societies for acute myocardial infarction proceedings. We observed the decrease in the average cost of services and the increase in the average hospitalization time in the group of patients older than 80 years of age. We believe that they were treated using conservative (non-invasive) methods which are cheaper but require a longer recovery time when compared to a more modern approach.

The decreasing number of healthcare services granted to patients with acute initial or subsequent myocardial infarction from the Sosnowiec subregion requires further analyses.

### Declarations

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#### Author contributions

Conceptualization, P. Ch. and A.O.; Methodology, P.Ch. and A.O.; Software, P.Ch.; Validation, P.Ch., A.F. and A.O.; Formal Analysis, P.Ch.; Investigation, P.Ch., A.F. and A. O.; Data Curation, P. Ch.; Writing – Original Draft Preparation, P.Ch., M.K. and A.O.; Writing – Review & Editing, P.Ch. A.F, M.K. and A.O.; Visualization, P.Ch.; Supervision, A.F. and A.O.; Project Administration, P.Ch.; Funding Acquisition, A.O.

#### Conflicts of interest

The authors declare that they have no competing interests.

#### Data availability

Secondary epidemiological, depersonalized data was obtained from the Silesian Voivodeship Branch of the National Health Fund of Poland (NFZ) in Katowice after the healthcare services settlement process. Disclosure of data requires the consent of the National Health Fund of Poland, as data administrator.

The datasets analysed during the current study are not publicly available but there is possible to obtain them through access to public information. For this purpose, a written request addressed to the Director of Silesian Voivodeship Branch of the National Health Fund of Poland in Katowice should be made.

#### Ethics approval

All experimental protocols were approved by Bioethical Commission of the Medical University of Silesia (permission N° KNW/0022/KB/68/17).

## References

1. Kline KP, Conti CR, Winchester DE. Historical perspective and contemporary management of acute coronary syndromes: from MONA to THROMBINS2. *Postgrad Med.* 2015;127(8):855-862.
2. Wilkins E, Wilson L, Wickramasinghe K, et al. *European Cardiovascular Disease Statistics*. Brussels: European Heart Network. 2017.
3. Townsend N, Wilson L, Bhatnagar P, Wickramasinghe K, Rayner M, Nichols M. Cardiovascular disease in Europe: epidemiological update 2016. *Eur Heart J.* 2016;37(42):3232-3245.
4. European Statistical Office. URL: <http://ec.europa.eu/eurostat>; Accessed February 9, 2021.
5. Bank Danych Lokalnych Głównego Urzędu Statystycznego/ Local Data Bank of Statistics Poland. URL: <https://bdl.stat.gov.pl/BDL/start>; Accessed February 9, 2021.
6. Trzeciak BG, Siebert J, Gutknecht P, Molisz A, Filipiak KJ, Wożakowska-Kapłon B. Cardiovascular risk factors determined via internet in 2 periods of time: 2004-2009 and 2010-2015 in Poland. *Int J Occup Med Environ Health.* 2017;30(3):499-510.
7. Harding A, Pritchard C. UK and twenty comparable countries GDP-expenditure-on-health 1980-2013: the historic and continued low priority of UK health related expenditure. *Int J Health Policy Manag.* 2016;5(9):519-523.
8. Zelený T, Bencko V. Healthcare system financing and profits: all that glitters is not gold. *Cent Eur J Public Health.* 2015;23(1):3-7.
9. Kucharska E. System opieki zdrowotnej wobec wielopropoblemowości w pomocy społecznej. *Przegl Lek.* 2012;69(9):698-702.
10. Hulme C. The cost of health care resources in cardiovascular disease. *Resuscitation.* 2013;84(7):865-866.
11. Stanhewicz AE, Wenner MW, Stachenfeld NS. Sex differences in endothelial function important to vascular health and overall cardiovascular disease risk across the lifespan. *Am J Physiol Heart Circ Physiol.* 2018;315(6):H1569-1588.
12. Narodowy Instytut Zdrowia Publicznego – Państwowy Zakład Higieny, Śląski Uniwersytet Medyczny, Gdański Uniwersytet Medyczny, Warszawski Uniwersytet Medyczny. Raport: *Występowanie, leczenie i prewencja wtórna zawałów serca w Polsce*. Warszawa, Zabrze, Gdańsk; 2014.
13. Loudon BL, Gollop ND, Carter PR, Uppal H, Chandran S, Potluri R. Impact of cardiovascular risk factors and disease on length of stay and mortality in patients with acute coronary syndromes. *Int J Cardiol.* 2016;220:745-749.
14. Yin J, Lurås H, Hagen TP, Dahl FA. The effect of activity-based financing on hospital length of stay for elderly patients suffering from heart diseases in Norway. *BMC Health Serv Res.* 2013;13:172.
15. Lloyd-Jones D, Adams RJ, Brown TM et al. Heart disease and stroke statistics - 2010 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation.* 2010;121:e1-e170.
16. Lentsck MH, Latorre Mdo R, Mathias TA. Trends in hospitalization due to cardiovascular conditions sensitive to primary health care. *Rev Bras Epidemiol.* 2015;18(2):372-384.
17. Sacks NC, Ash AS, Ghosh K, Rosen AK, Wong JB, Rosen AB. Trends in acute myocardial infarction hospitalizations are we seeing the role picture? *Am Heart J.* 2015;170(6):1211-1219.
18. Kobza J, Geremek M. Explaining the Decrease in Deaths from Cardiovascular Disease in Poland. The Top-Down Risk Assessment Approach, from Policy to Health Impact. *Postepy Hig Med Dosw (Online).* 2016;70:295-304.
19. Häkkinen U, Chiarello P, Cots F, Peltola M, Rättö H. Patient classification and hospital costs of care for acute myocardial infarction in nine European countries. *Health Econ.* 2012;21(Suppl 2):19-29.
20. Choręza P, Filipecki A, Kowalska M, Owczarek A. Mortality due to acute myocardial infarction in the Silesian voivodeship (Poland) in 2009-2014. *Int J Occup Med Environ Health.* 2021;34(3):363-372.
21. Bacci MR, Fonseca FL, Nogueira LF, et al. Predominance of STEMI and severity of coronary artery disease in a cohort of patients hospitalized with acute coronary syndrome: a report from ABC Medical School. *Rev Assoc Med Bras.* 2015;61(3):240-243.
22. Tarride J, Lim M, DesMeules M, et al. A review of cardiovascular disease. *Can J Cardiol.* 2009;25:195-202.
23. Willis BL, DeFina LF, Bachmann JM, et al. Association of ideal cardiovascular health and long-term healthcare costs. *Am J Prev Med.* 2015;49(5):678-685.
24. Khosravizadeh O, Vatankhah S, Bastani P, Kalhor R, Alirezai S, Doosty F. Factors affecting length of stay in teaching hospitals of a middle-income country. *Electron Physician.* 2016;8(10):3042-3047.