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ORIGINAL ARTICLE

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Observational, retrospective study evaluating the temporal variability of out-of-hospital cardiac arrests (OHCA) in the district of Bydgoszcz in a 24-month period

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ABSTRACT

Introduction: The incidence of out-of-hospital cardiac arrests (OHCA) varies periodically. The aim of our study was to assess the temporal variability of OHCA occurrence in adult population of Bydgoszcz district.

Material and methods: A retrospective analysis of 782 cases of OHCA, which occurred between January 1st, 2018, and December 31st, 2019, was performed. The temporal variability of OHCA occurrence was assessed during the day (within twenty-four 1-hour periods and four 6-hour time intervals), weeks, months, and seasons of the year.

Results: The incidence of OHCA in the analyzed population was 84 per 100,000 inhabitants/year. The highest incidence of OHCA was observed between 08:00 and 08:59 and between 15:00 and 15:59. The lowest number of OHCA occurred at night ($n = 84$; 10.7%; $p < 0.001$). During the week, the lowest number of OHCA was noted on Saturday (12.4%) and the highest on Monday (16.5%), with no significant differences between days. The highest incidence of OHCA was observed in winter and the lowest in summer [225 (28.8%) *vs.* 171 (21.9%), $p = 0.006$]. December was the month with the highest number of OHCA cases, and July the lowest.

Conclusions: The present analysis confirms that the occurrence of OHCA demonstrates circadian, monthly, and seasonal rhythm. The highest incidence of OHCA was in the morning and afternoon, and in winter, especially in December. The lowest occurrence of OHCA was at night and in the summer, particularly in July. There was a weekly pattern with the highest occurrence of OHCA on Mondays; however' no significant differences between weekdays were achieved.

Key words: acute coronary syndrome, chronobiology, circadian rhythm, out-of-hospital cardiac arrest, resuscitation

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Introduction

Out-of-hospital cardiac arrest (OHCA) remains a significant issue worldwide. It is defined as the loss of functional cardiac mechanical activity in association with an absence of systemic circulation, occurring outside of hospital [1]. OHCA is the leading cause of death in developed countries [1, 2]. The average occurrence of OHCA in adults worldwide is 95.9/100,000 per year, while European incidence varies according to sources from 16 to 119/100,000 per year [2]. In Poland, the estimated total number of OHCA is 15200 per year [3]. The predominant cause of OHCA is coronary artery disease [1]. According to the analysis by Berdowski at al., the global average incidence of OHCA of presumed cardiac cause was 55 adult per 100,000 person-years [4]. Large

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differences in reported rates may result from the use of different OHCA definitions, investigated populations, differences in Emergency Medical Services (EMS) in various regions, as well as research methodology. Regardless of the reported number, the survival rate after OHCA is frighteningly low with the average at 7% in the adult population [4].

Circadian rhythms — well established in humans — affect not only hormone, cytokine, and fibrinogen changes, but also influence endothelial function, vascular tone, and blood pressure [5]. That, in turn, translates into occurrence of acute coronary syndromes throughout the day [6]. Furthermore, it was demonstrated that the incidence of OHCA of cardiac etiology shows not only daily, but also weekly, monthly, and seasonal variation [7]. OHCA due to its unexpected nature and life-threatening features remains at the center of interest of researchers and healthcare professionals. A better understanding this complex phenomenon will enable more effective assistance to our patients and improve long-term outcomes. Hence, the need for further research in this area.

The aim of our study was to assess the temporal variability of OHCA occurrence in the adult population of Bydgoszcz district.

Material and methods

A retrospective analysis of dispatched cards from EMS in Bydgoszcz district between January 1st, 2018, and December 31st, 2019, was performed. Dispatch cards were compatible with the Utstein template. Bydgoszcz district includes the city of Bydgoszcz and surrounding towns and occupies 1395 km^2 [8]. During the study period, it was inhibited by approximately 470000 citizens [8, 9]. The district includes 176 km^2 of urban areas inhibited by 75.5% of the population and 1219 km^2 of suburban areas.

An OHCA was defined as a sudden and unexpected event leading to a cardiac arrest. The mechanism of cardiac arrest was determined based on the first recorded heart rhythm: shockable (ventricular fibrillation [VF] or ventricular tachycardia [VT]) or non-shockable (asystole or pulseless electrical activity [PEA]). Patients with OHCA due to trauma, younger than 18 years of age and with late signs of death (i.e., rigor mortis, decomposition) were excluded from the analysis.

To maintain comparability with other studies a similar pattern of division was used to analyze the OHCA occurrence. Circadian rhythm was investigated within twenty-four 1-hour periods and four 6-hour time intervals: night (0:00– 5:59), morning (6:00–11:59), afternoon (12:00–17:59), and evening (18:00–23:59). The weekly variation was analyzed for days of the week and monthly variation was analyzed for individual months. The seasons were defined as: spring (March, April, May), summer (June, July, August), autumn (September, October, November), and winter (December, January, February).

The present study was approved by the Ethics Committee of the Nicolaus Copernicus University in Torun, Collegium Medicum in Bydgoszcz and was conducted in accordance with Declaration of Helsinki and Good Clinical Practice guidelines.

Statistical analysis

IBM SPSS Statistic software version 27 was used to perform the statistical analysis. The data distribution was checked using the Shapiro-Wilk test. Categorical variables were presented as counts and percentages. Continuous variables were reported as means with standard deviation (SD) or medians with interquartile range (IQR). The distribution of OHCA cases was generally non-normal and the differences between medians were small even when statistically significant. Therefore, it was decided to present the data as percentages to better visualize observed differences. The differences between variables were tested using the Mann-Whitney test or the Kruskal-Wallis test, as appropriate. Two-sided p-value < 0.05 was applied for statistical significance.

Results

General characteristic

There were 782 cases of OHCA included in the present analysis. The incidence of OHCA in the present population was 84 per 100,000 inhabitants per year. Among the enrolled patients, the majority were men (63.6%, $p < 0.001$). The mean age of patients was 69.2 ± 14.2 years. Non-shockable rhythm as the first recorded rhythm was present in 79% cases. The majority of OHCA events occurred in the urban area (84.5%, $p < 0.001$). Baseline characteristics of the study population is presented in Table 1. The higher incidence of OHCA was observed in the population > 60 years of age ($p < 0.001$) (Fig.1).

Circadian variation of OHCA

The highest incidence of OHCA was observed between 08:00–08:59 and then between 15:00–15:59 (Fig. 2). The fewest events of OHCA were observed during the night between 01:00–04:59 (Fig. 2). When analyzing 6-hours intervals (Fig. 3), the lowest number of OHCA occurred at night (n = 84; 10.7%; $p < 0.001$). Numerically, the highest incidence of OHCA was registered in the afternoon (n = 254; 32.5%). However, there were no significant differences between the number of OHCA in the morning (n = 239; 30.6%), afternoon (n = 254; 32.5%), and evening intervals (n = 205, 26.2%) (Fig. 3).

Table 1. Baseline characteristics of the study population

Variable	Study population
Number of cases	782
Mean age [years]	69.2 ± 14.8
Female	36.4%
Initial rhythm	
VF/VT	21%
Asystole/PEA	79%
Location	
Urban	84.5%
Suburban	15.5%

Weekly variation of OHCA

The lowest number of OHCA was noted on Saturday (n = 97, 12.4%) and the highest on Monday (n = 129, 16.5%) (Fig. 4). However, no significant differences between particular days regarding the number of OHCA events were observed.

Monthly and seasonal variation of OHCA

Figure 5 demonstrates monthly distribution of the number of OHCA. A gradual decrease in the number of OHCA was observed from May to July, with the fewest events in the latter (July: n = 50), while the highest num-

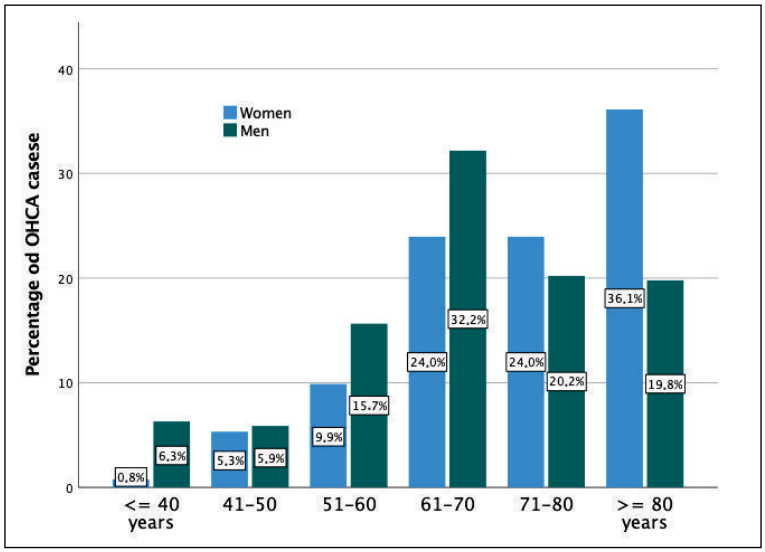

Figure 1. Distribution of out-of-hospital cardiac arrest (OHCA) in different age groups depending on gender

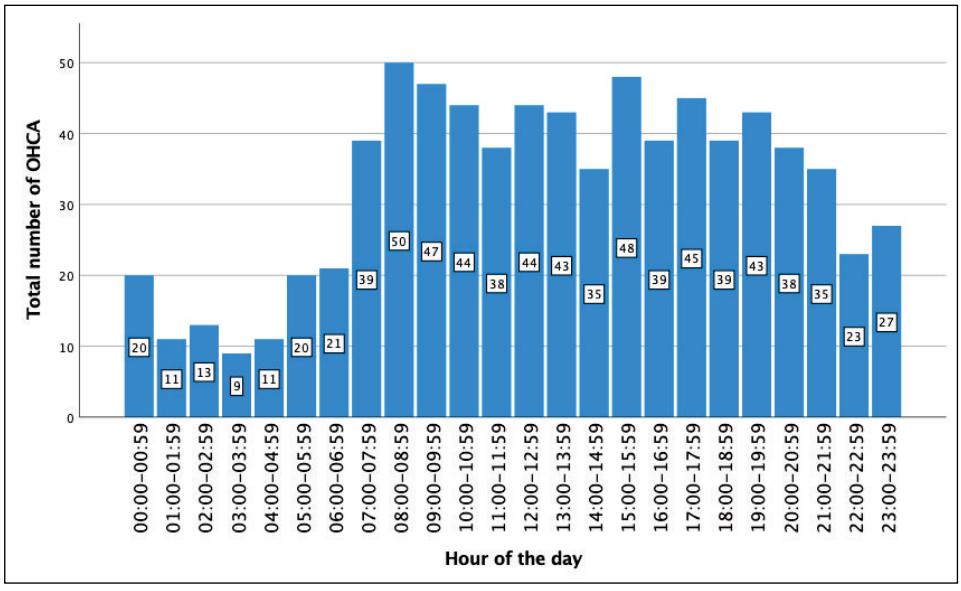

Figure 2. Circadian distribution of out-of-hospital cardiac arrest (OHCA) occurrence divided into 1-hour periods

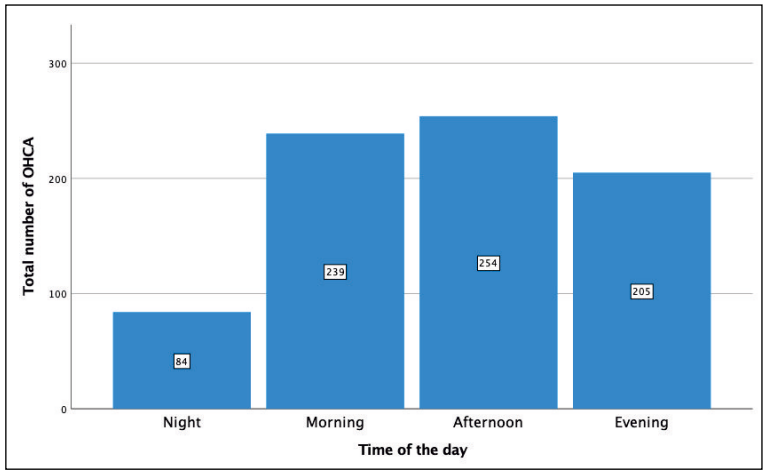

Figure 3. Number of out-of-hospital cardiac arrest (OHCA) in 6-hour intervals. Night *vs.* Morning: $p < 0.001$; Night *vs.* Afternoon: $p < 0.001$; Night *vs.* Evening: $p < 0.001$; Morning *vs.* Afternoon: $p = 0.242$; Evening *vs.* Afternoon: $p = 0.038$; Evening *vs.* Morning: $p = 0.365$

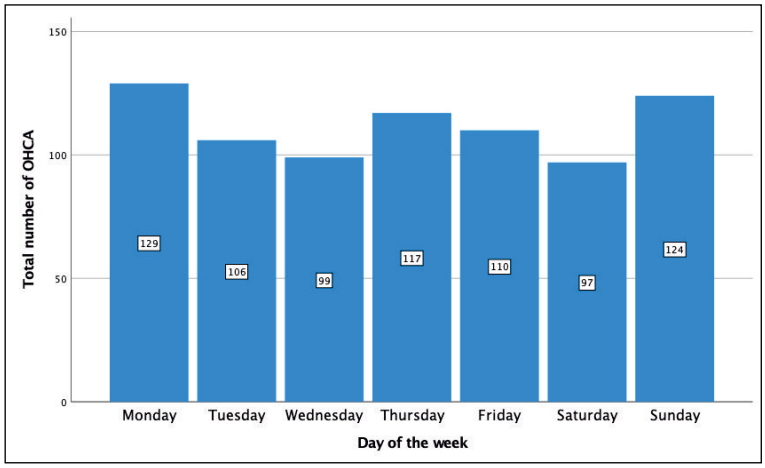

Figure 4. Distribution of out-of-hospital cardiac arrest (OHCA) events in subsequent days of week ($p = 0.095$)

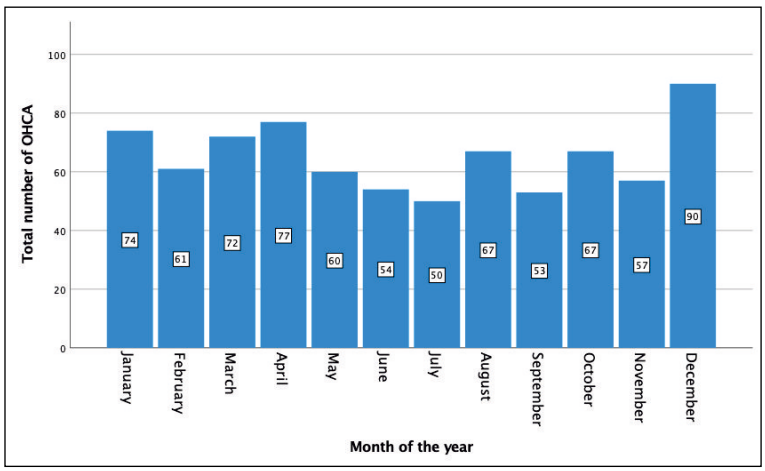

Figure 5. Distribution of out-of-hospital cardiac arrest (OHCA) events in subsequent months of the year ($p = 0.52$)

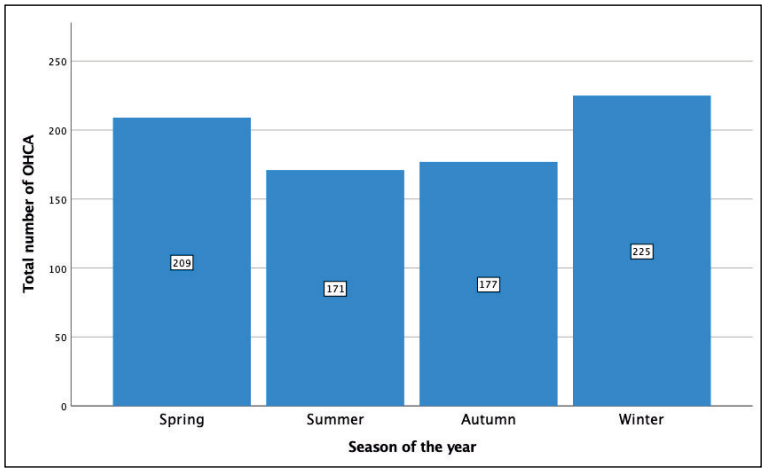

Figure 6. Seasonal distribution of out-of-hospital cardiac arrest (OHCA) events

ber of OHCA cases was registered in December [July *vs.* December: 50 (6.4%) *vs.* 90 (11.5%), p = 0.002]. The variability in subsequent months, according to number of OHCA, was statistically insignificant (p = 0.52).

Considering the seasons of the year, we observed different results. There were significant seasonal differences between number of OHCA in the spring vs. summer [209 (26.7%) *vs.* 171 (21.9%), p = 0.021), autumn *vs.* winter [177 (22.6%) *vs.* 225 (28.8%), p = 0.047], and summer *vs.* winter [171 (21.9%) *vs.* 225 (28.8%), p = 0.006) (Fig. 6). No significant difference in the number of OHCA events was observed between spring and winter [209 (26.7%) *vs.* 225 (28.8%), p = 0.645].

Discussion

Our study evaluating temporal variability of OHCA confirmed circadian rhythm of OHCA incidence, as well as monthly and seasonal patterns. To the best of our knowledge, it is the first study investigating temporal variation of OHCA conducted in the Bydgoszcz district.

The incidence of OHCA in our study was 84/100,000 inhabitants per year, which corresponds to the European indicators within the range 16–119/100,000 inhabitants [2]. The rate in our study is lower than demonstrated by Szczerbinski 156/100,000 [10, 11] and Gach 170/100,000 [3]. However, the population analyzed by Gach [3] was older, and it has been demonstrated that the number of OHCA increases with age.

The circadian rhythm of OHCA was associated with the lowest number of events at night. Our results are consistent with other studies in this regard [3, 7, 10, 12–14]. The highest incidence of OHCA in our study was noted in the morning (08:00–08:59) and in the afternoon (15:00–15:59). Similar results were demonstrated in numerous studies [15–20], where two-peak occurrence curve was shown. However, the afternoon peak in the mentioned studies was later (16:00–20:00) in comparison to our result [15–20]. Other reports presented three peaks of OHCA occurrence: morning (08:00–10:59), afternoon (14:00–15:59), and evening peak (18:00–21:59) [10, 21]. Morning increase in the incidence of OHCA is associated with an increased incidence of acute coronary syndromes during this time. These, in turn, are the most common causes of cardiac arrest and occur as a result of diurnal changes in blood pressure, vascular tone, heart rate, endothelial function, platelet aggregability, and catecholamines [5, 10, 14, 22–24]. The authors agree that the early morning peak of OHCA may be related to the fact that these arrests occurred without witnesses and patients were found by family members in the morning or after returning home from work in the afternoon [10, 14]. Although, in our study the analysis of witnessed and non-witnessed OHCA was not performed.

When analyzing individual days of the week, the highest number of OHCA was recorded on Monday, and the lowest on Saturday. Although, the weekly variability did not reach statistical significance in our study. A similar distribution with the Monday peak in OHCA incidence was demonstrated by Herlitz et al. [7] in the Swedish population, Naknishi et al. [15] among the Japanese, and Ong et al. [16] in the population of Singapore. Contrary to our analysis, Brooks et al. [17] found the highest incidence of OHCA on Saturdays, while Allegra et al. [25] found both Monday and Saturday with the highest occurrence of OHCAs. Another analysis concerning the Polish subpopulation from the Opole district showed an increased frequency of OHCA on Saturdays, Sundays, and Mondays [10]. However, in a long-term follow-up of 13 years, Szczerbinski et al. [12] demonstrated the highest frequency of sudden cardiac arrest on Mondays. A possible explanation for the Monday peak in the OHCA occurrence is related to human behavior, work patterns, and the stress level

[16]. A similar pattern has previously been shown for the incidence of myocardial infarctions [26, 27].

The incidence of OHCA also shows seasonal variability, with a significantly greater number of events in winter and the lowest in summer. According to monthly variability, the highest occurrence of OHCA was noted in December, and the lowest in July. Our observations are in line with the results of other researchers' [3, 7, 12, 15, 17, 25]. Meanwhile, observations from Singapore [16] did not confirm the seasonal variability in the incidence of OHCA. However, the equatorial climate of Singapore has a constant temperature and weather throughout the year [16]. Meanwhile, studies conducted in a moderate climate, where we observe seasonal changes in temperature, air pressure, and precipitation, clearly indicate the influence of atmospheric conditions on the occurrence of OHCA. A possible explanation is the effect of low temperature on arterial blood pressure [16, 28], arterial spasm, platelet and red blood cells count, blood viscosity [16, 29], and serum cholesterol levels [16, 30]. Low temperature affects hemodynamic processes, including an increase in systemic vascular resistance and oxygen consumption by myocardium [16, 31].

The last two years have unexpectedly brought another threat – related to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic. As reported by the latest registers from around the world, the incidence of OHCA increased significantly during the pandemic [32, 34–39]. Moreover, performed meta-analyzes demonstrated that not only the incidence but also mortality following OHCA were higher during the COVID-19 pandemic [32, 33, 40]. Borkowska et al. [40] explained that reduced survival rate after OHCA in suspected or diagnosed COVID-19 patients was probably due to the lower rate of shockable rhythms in COVID-19 patients [32, 40]. Further studies on the impact of COVID-19 on the OHCA occurrence, taking into account previously demonstrated risk factors and treatments, are necessary [41–45].

Cardiac arrest is a complex process that requires a prompt and professional action to restore a haemodynamically efficient heart rhythm, followed by continued treatment for the causes of the condition [46, 47]. Hence, further intensive research on this phenomenon is necessary to improve outcomes after OHCA. The COVID-19 pandemic has revealed how much remains to be done.

Conclusions

The present analysis confirms that the occurrence of OHCA demonstrates circadian, monthly, and seasonal rhythm. The highest incidence of OHCA was in the early morning and afternoon and in winter, especially in December. The lowest occurrence of OHCA was at night and in summer, particularly in July. There was a weekly pattern with the highest occurrence of OHCA on Mondays; however, no significant differences between days of the week were achieved.

Limitations: *The present study has several limitations. Firstly, our study is a retrospective analysis which makes it difficult or even sometimes impossible to recover some data. Secondly, the analyzed period covered only two years and a longer follow-up would certainly be more reliable. Third, the collected data concerned only the district of Bydgoszcz and larger scale studies are necessary.*

Conflict of interest: *None.*

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