Out-of-hospital cardiac arrest in the Pilsen Region in 2018

Robin Sin[a,b], Ivana Vodehnalova[a], Denisa Charlotte Ralbovska[a,c], Denisa Struncova[a], Lenka Cechurova[a]

Aims. To acquire epidemiological data on pre-hospital cardiac arrest incidents occurring in the Pilsen Region of the Czech Republic in 2018, and the results of subsequent cardiopulmonary resuscitation
Methods. A prospective observational study of the survival rate of out-of-hospital cardiac arrest (OHCA) in patients undergoing CPR carried out by emergency medical service personnel. The observed time period was from January 1st, 2018 until December 31st, 2018. The data were acquired from patients' records in paper and electronic forms.
Results. In the monitored period 707 patients with signs of cardiac arrest were recorded in the Pilsen Region with an incidence rate of 128.9 per 100,000 inhabitants. Emergency medical units performed CPR in 484 cases. The incidence rate of pre-hospital CPR was 88.2 cases per 100,000 inhabitants. Spontaneous blood circulation was temporarily or permanently restored in 276 patients (57.0%), 203 (41.9%) patients were transferred to a hospital, and there were 61 (12.6%) cases of survival with Cerebral Performance Category (CPC) score of 1 or 2. The first monitored rhythm was a shockable in 134 (27.7%) cases. In this sub-group ROSC was achieved in 94 (70.1%) cases and 58 (43.3%) of those were subsequently transferred to a hospital. A good CPC result was achieved in 41 (30.6%) patients of this sub group.
Conclusion. The study has provided valuable epidemiological data on OHCA and prehospital CPR in the area of the Pilsen Region in 2018. The collected data, compared to international results, show a higher survival rate with good neurological score in 12.6% of cases.

Key words: out-of-hospital cardiac arrest, cardiopulmonary resuscitation, cerebral performance category, emergency medical service

Received: October 3, 2019; Revised: December 18, 2019; Accepted: December 18, 2019; Available online: January 20, 2020
https://doi.org/10.5507/bp.2019.064

[a]Emergency Medical Service of the Pilsen Region, Pilsen, Czech Republic
[b]Department of Infectious Diseases and Travel Medicine, Faculty of Medicine in Pilsen, Charles University and University Hospital Pilsen, Czech Republic
[c]Faculty of Biomedical Engineering, Czech Technical University in Prague, Kladno, Czech Republic
Corresponding author: Robin Sin, e-mail: robin.sin@zzspk.cz

INTRODUCTION

Out-of-hospital cardiac arrest causes approximately half the deaths associated with a heart disease, and in developed countries it accounts for up to 20% of all deaths with no obvious cause[1,2]. The goal of this study was to acquire epidemiological data on out-of-hospital cardiac arrests and the outcomes of cardiopulmonary resuscitation (CPR) in patients with out-of-hospital cardiac arrest (OHCA) within the territory of the Pilsen Region in 2018. The data may serve as a basis for new organizational, operational and educational measure, and thus may improve the level of provided prehospital emergency care of patients in life-threatening conditions.

The Pilsen Region is a territorial administrative district in the western part of the Czech Republic, which is located in Central Europe. The region covers an area of 7,649 km^2 with a population of 584,672 inhabitants. The population density is 75 citizens per km^2. The city of Pilsen, with the population of 172,441 people, serves as an administrative unit of the region. The city of Pilsen has the largest hospital of the region, the University Hospital Pilsen comprising of 1,739 beds, where majority of patients with return of spontaneous circulation (ROSC) are transferred to.

The only provider of pre-hospital emergency care in covering the entire Pilsen Region is the Emergency Medical Service of the Pilsen Region. There are 44 emergency medical units strategically distributed in 26 ambulance stations throughout the Pilsen Region. The rapid-response vehicles (RRV) are staffed by an emergency medical service (EMS) physician and a paramedic-driver. The ambulances are always staffed by non-physician emergency medical personnel (paramedics and rescue drivers). The dispatchers of the centralized emergency medical dispatch center, located in Pilsen, respond to the calls to the emergency medical phone number 155.

MATERIALS AND METHODS

Physicians working at the EMS of the Czech Republic are namely specialized in emergency medicine, anesthesiology, intensive care medicine, internal medicine, surgery and pediatrics. The benefit of a physician's presence at pre-hospital CPRs has been a subject to numerous studies, the outcomes of which do not confirm that a physician in the team increases the chance of OHCA survival[3-6]. The non-physician emergency medical personnel in emergency

crews comprise paramedics, with a bachelor's degree or a professional diploma, and trained paramedic-driver. The emergency dispatch center is staffed by paramedics, general nurses specialized in intensive care medicine, and general nurses with a specialized course certificate. A chief physician, specialized in emergency medicine, is continuously available for consultation.

The dispatchers of the dispatch center classify the severity of the emergency calls, in accordance with valid state legislature, into four levels. The highest level of emergency includes cases of vital signs failure or cases of a significant risk of vital signs failure. A sudden cardiac arrest belongs to this category as well. The dispatchers' task is to locate the site of the emergency as quickly as possible, to detect cardiac arrest, to dispatch the closest emergency crew, and to provide dispatcher-assisted CPR. If the closest emergency medical unit (ambulance) is not staffed by a physician, the dispatch center has to dispatch also the closest RRV, or a medical helicopter as well. If available, an emergency medical service supervisor is dispatched to the site as support to the emergency medical units.

The dispatcher-assisted CPR is a routine and integral part of emergency dispatchers' work. Dispatchers play an important role in the chain of survival, as they are able to recognize sudden cardiac arrest, to provide dispatcher-assisted CPR, and to ensure localization and delivery of the nearest automated external defibrillator (AED) to the patient[7]. The guidelines for dispatcher-assisted CPR got simplified. Since the method of pulse-check on one of the carotids has proven to be inaccurate for recognizing sudden cardiac arrest[8,9], it is now recommended to solely assess the patient's state of consciousness and breathing. Due to the fact that gasping may be mistaken for regular breathing[10,11], the guidelines solely require checking whether the breathing is regular. If the breathing is irregular, or is not detected at all, BLS is performed.

The emergency dispatch center has a list of 72 AEDs in its database, and if locally available, a first responder may be activated as well. Public access to an AED is an effective way of providing quick and timely defibrillation[12]. Stationary AEDs are located in places with higher population densities and traffic, and in sport facilities. Firefighters units and police units are equipped with the majority of mobile AEDs. In the Czech Republic, an AED owner is not obliged to report possession of the AED to the EMS, nor is he or she obliged to assist. Therefore, based on experience, it is assumed that there are dozens of AEDs throughout the Pilsen Region with no possibility of their activation by the emergency medical dispatch center.

In accordance with the valid laws and internal regulations of the EMS, a medical record is completed when providing pre-hospital emergency care. The medical record is completed electronically using a tablet and an Electronic Patient's Record software, provided by the company EMD (Bratislava, Slovakia).

The study includes data on all out-of-hospital CPRs provided by the emergency medical units in the Pilsen Region from January 1st, 2018 until December 31st, 2018. No exclusive criteria were applied. The data were obtained from the Electronic Patient's Record software, CPR protocols and dispatcher software SOS (Per4mance, Brno, Czech Republic). The data from all emergences were complete.

One of the most important criteria observed is the response time of EMS in case of out-of-hospital cardiac arrest. Fast response may shorten the defibrillation time and thus increase the chance of survival. As "time zero" was determined the time when an emergency call was received by an emergency medical dispatcher. When the first emergency medical unit reached the site of emergency, the time count was stopped.

Secondary survival of patients was assessed within a 30-day period of sudden cardiac arrest. Neurological condition was assessed using the Cerebral Performance Category. The data were collected through the phone and email enquiries to hospitals in the Pilsen Region and these methods contributed to successful collection of data on all patients transferred to hospitals with ROSC.

The computer program Microsoft Excel 2007 (Microsoft, Redmond, USA) was employed.

RESULTS

Within the observed time period, from January 1st, 2018 until December 31st, 2018, the emergency units solved 61,858 emergency medical cases based on received emergency calls. Ambulance crews alone solved 79.1% of those cases (n = 48,672). A RRV with a physician onboard was dispatched to cooperate with an ambulance in 20.8% of cases (n = 12,842). RRVs alone solved 0.1% of cases (n = 45). RRVs with a physician were dispatched to all cases of OHCA. There is a long-term year-on-year increase of emergency interventions to which only paramedic units are dispatched to, since the majority of other dispatched emergencies is classified as a lower degree of emergency.

In 2018, emergency units performed 484 CPRs within the Pilsen Region. In total there were 707 patients with signs of cardiac arrest. Based on emergency physician's decision, CPR was not performed in 223 patients. In all the cases the decision not to perform CPR was made on the basis of methodical instructions. None of the patients was a holder of a written document in which they would express their decision not to be resuscitated, which is based on the Czech law system, known as a Previously Expressed Wish. An overview of the collected data in accordance with the Utstein-style protocol is shown in Fig. 1.

In 313 cases (64.7%) the cardiac arrest occurred at home. There were 132 cases (27.3%) of cardiac arrest occurring in public places, and 39 cases (8%) in other locations. Out of the total number of 484 cases of sudden cardiac arrest, 325 (67.1%) were witnessed by a bystander and 159 (32.9%) were unwitnessed.

95 (19.6%) patients were conscious at the time of calling the emergency line. In 389 (80.4%) cases, the patient was already unconscious. In 52 cases (13.4%) dispatcher-assisted CPR was not performed (Table 1), 26 cases of not performing the CPR were due to a third-party call,

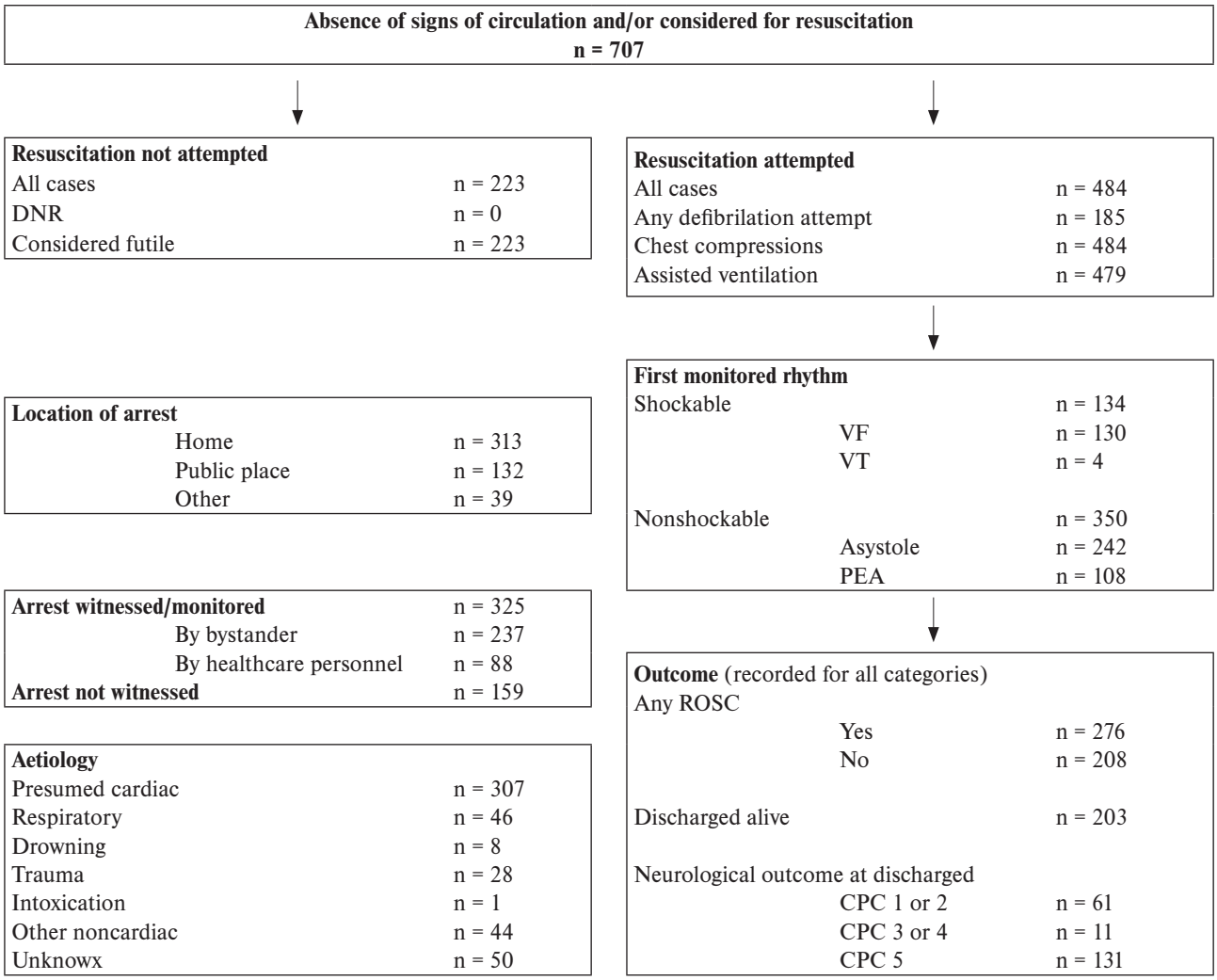

Fig. 1. Utstein flowchart of 2018 OHCA events where CPR is commenced or continued by EMS in Pilsen Region.
DNR = do not resuscitate, VF = ventricular fibrillation, VT = ventricular tachycardia, PEA = pulseless electrical activity, CPC = cerebral performance category
* Discharge from hospital acute care unit
** At hospital discharge or the best result during 1 month follow-up

Table 1. Dispatcher-assisted CPR.

	No. of such patients [n (%)]	CPC 1 - 2 [n (%)]
Resuscitated	484 (100.0)	61 (12.6)
conscious at the time of calling	95 (19.6)	11 (11.6)
unconscious at the time of calling	389 (80.4)	47 (12.1)
dispatcher-assisted CPR - yes	337 (86.6)	42 (12.5)
dispatcher-assisted CPR - no	52 (13.4)	5 (9.6)

Dispatcher-assisted CPR = CPR instructions provided over the telephone by the dispatcher on the emergency medical phone number 155

high age in 8 cases, caller's refusal to perform CPR in 4 cases, and phone call connection failure in 3 cases. A disorder of consciousness was not recognized by an emergency medical dispatcher in 11 cases.

BLS was performed in 337 patients. In 98.5% of cases (n = 322) only chest compressions were performed, and in 1.5% (n = 5) of cases, the rescuer performed chest compressions along with mouth-to-mouth breathing. In 249 cases BLS was performed by a layperson, in 88 cases by medical personnel. If the patient was unconscious at the time of calling the emergency line (n = 389), a trained first responder was activated by the emergency medical dispatch center in 42 cases (10.8%). The activation was always performed through a telephone conversation. An AED was used in 10 cases. An electric shock was delivered by the AED in 4 cases.

Table 2. Comparison of all rhythms and shockable rhythm groups.

Basic data	All	Shockable
Resuscitated [n]	484	134
Incidence (rel. to 100,000)	82.8	22.9
Averrage age [years]	65.1 ± 16.8	64.3 ± 15.5
Averrage response time [min:s]*	9:10 ± 5:05	9:15 ± 5:14
Patients with shockable rhythm [n(%)]	134 (27.7)	134 (100.0)
ROSC [n(%)]	276 (57.0)	94 (70.1)
Discharged alive [n(%)]**	203 (41.9)	58 (43.3)
CPC1 - 2 [n(%)]	61 (12.6)	41 (30.6)

* Time from the start of the emergency call to the stopping of the first ambulance vehicle at the scene
** Discharge from hospital acute care unit

Table 3. Comparison of survival rates in first rhythm/place of arrest/witnessing the cardiac arrest/presumed origin subgroups.

	No. of such patients [n (%)]	CPC 1 - 2 [n (%)]
First monitored rhythm		
Shockable	134 (27.7)	41 (30.6)
Non-shockable	350 (72.3)	20 (5.7)
Place of the cardiac arrest		
Home	313 (64.7)	29 (9.3)
Public place	132 (27.3)	26 (19.7)
Other	39 (8.0)	6 (15.4)
Witnessing the cardiac arrest		
Witnessed	325 (67.1)	48 (14.8)
Not witnessed	159 (32.9)	13 (8.2)
Presumed origin of the cardiac arrest		
Cardiac	307 (63.4)	46 (15.0)
Respiratory	46 (9.5)	5 (10.9)
Drowning	8 (1.7)	1 (12.5)
Trauma	28 (5.8)	2 (7.1)
Intoxication	1 (0.2)	0 (0)
Other non-cardiac	44 (9.1)	3 (6.8)
Unknown	50 (10.3)	4 (8.0)

An average response time was 10:10 minutes with a standard deviation of 5:05 minutes. The first observed heart rhythm was shockable, i.e. ventricular fibrillation or pulseless ventricular tachycardia, in 134 cases (27.7%). The remaining 350 cases (72.3%) contained other non-shockable rhythm. ROSC was achieved in 276 patients (57.0%) out of which 203 (41.9%) were transferred to a hospital with spontaneous blood circulation, and 61 patients (12.6%) reached CPC of 1 or 2. In cases of a shockable initial rhythm, ROSC was achieved in 94 cases (70.1%) and 58 patients (43.4%) were subsequently handed over to a hospital. CPC 1 or 2 was reached by 41 patients (30.6%) of this observed subgroup. The comparison of results of OHCA group of all patients with the subgroup of patients with a shockable rhythm is depicted by Table 2.

The cardiac cause of OHCA was diagnosed in the majority of cases (n = 307, 63.4%). In 46 cases (9.5%), the emergency physician diagnosed a respiratory cause, in 8 cases (1.7%) the cause was drowning. A trauma was the cause of OHCA with subsequent CPR in 28 cases (5.8%). There was only 1 recorded case (0.2%) of intoxication. In another 44 cases (9.1%) there were other causes and in 50 cases (10.3%) the cause could not be determined by the emergency physician.

The interdependence of OHCA survival with a good neurological score of CPC 1 or 2 on the site of cardiac arrest, its witnessing, its cause and the initial monitored rhythm are shown in Table 3.

The incidence of all OHCA cases was 128.9 per 100,000 inhabitants, and of OHCA cases followed by CPR was 88.2 cases per 100,000 inhabitants. In 482 cases

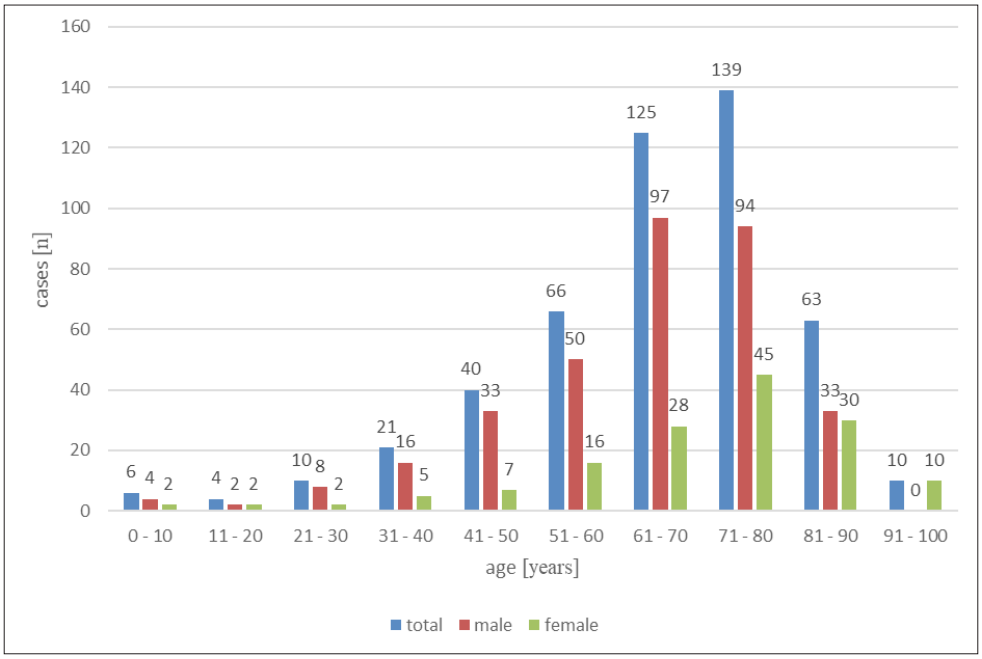

Fig. 2. Number of cardiac arrests according to age group and gender.

(99.6%) the patient was an adult, in remaining 6 cases (0.4%) it was a child i.e. a person younger than 18 years. 69.9% of cases (n = 337) were represented by men and 30.4% of cases (n = 147) by women. The most frequent age group of patients suffering from cardiac arrest, were patients between 71 and 80 years, of which there were 139 cases (28.7%). The numbers of patients, their age, and gender are shown in Fig. 2.

A review of the medical records revealed that, during the reported period, the pharmacotherapy as it is recommended by the European Resuscitation Council Guidelines 2015, was predominantly complied with. As a standard, 1 mg of adrenalin was administered intravenously in adults. With non-shockable rhythms, the adrenalin was administered immediately upon initiation of CPR, with shockable rhythms, adrenalin was administered after the third failed defibrillation shock. Within the CPR, adrenalin was then administered each 3-5 min. Amiodarone was administered solely in patients with shockable rhythm, namely the first dose of 300 mg intravenously after the third failed shock and the second dose of 150 mg intravenously after the eventual fifth failed shock. No record on lidocaine administration was found as amiodarone was each time available and administered. In children, no antiarrhythmics were administered within CPR as all patients of this age group suffered from OHCA with non-shockable rhythm. Atropine was, in the case of non-shockable rhythm, administered to 8 patients (2.3%) even though it is no longer usually recommended.

DISCUSSION

The incidence of pre-hospital CPR in Europe is on average 49 cases per 100,000 inhabitants[13]. In the Czech Republic, only the data from the capital Prague resemble those of the European average rate with 41.1 recorded cases per 100,000 inhabitants[14]. Our study recorded an incidence of 88.2 cases per 100,000 citizens. We anticipate that the incidence will be higher in other regions of the Czech Republic as well, as the comparison to the capital Prague is less accurate due to greater accessibility of medical services in a smaller territorial area and younger average age of the citizens. Another study performed in a larger territory of East Bohemia also found a lower incidence of 46.4 cases per 100,000 inhabitants[15]. There are significant differences worldwide as well. In the United States, the recorded incidence is 54.6 cases per 100,000 citizens, in Australia it is 44.0 and in Asia it is 28.3 cases[16]. Patients have a greater chance of OHCA survival if the initial monitored rhythm is shockable[17,18] and therefore this subgroup is the subject of numerous studies. Many report that ventricular fibrillation occurs as the first monitored rhythm, in 11% to 50% of patients[16,19-22]. In our study, the initial shockable rhythm, i.e. ventricular fibrillation or pulseless ventricular tachycardia, occurred in 27.7% cases. The data acquired from other Czech studies do not significantly differ from our results or other international studies[14,15].

ROSC at the site of emergency was achieved, regardless of the initial rhythm, in 57.0% of patients of the observed group. 41.9% of patients were transferred to a hospital with spontaneous circulation, and a CPC score of 1 or 2 was achieved in 12.6% of cases. If the initial rhythm was shockable, ROSC was achieved in 70.1% of cases and 43.3% of patients were handed over to a hospital. This observed subgroup included 30.6% of patients with CPC 1 or 2. Our study confirmed observations and data of other authors from Europe and other continents[18,21,23-25].

This study confirms that an early phone call to an emergency number, identification of cardiac arrest by an emergency medical dispatcher, dispatcher-assisted CPR,

first responder activation, and employment of AED increase the chance of survival[26-28]. Immediate start of CPR may increase the chance of survival from twice up to four times[29,30]. Our data indicate that if the patient was unconscious at the time of calling the emergency line, BLS was performed in 86.6% of cases. In 2016, Plodr et al. from the Hradec Králové Region came to the same conclusion[31]. According to Lewis et al. the dispatchers should be able to identify 95% of all cardiac arrests, provided that they have all the necessary information from the caller[32]. In 2018, the dispatchers of the emergency medical dispatch center could not recognize cardiac arrest in 11 of 384 patients, and thus the success rate was 97.2%.

An AED became new phenomenon in providing BLS in the 21st century. The employment of an AED demonstrably increases the chance of OHCA survival[23,33,34]. Defibrillation within the first 3-5 minutes after the collapse may lead to survival in 50-70% of cases[21,35,36]. Unfortunately its use by bystanders on public places is not yet so frequent and an AED is estimated to be used in 2-4% of cases[37-39]. In the study, we have also observed that an AED was used in 10 out of 484 cases, which represents 2.1% of cases.

Trained first responders are gradually integrated in the system of pre-hospital CPR. These are dispatched to the site of emergency after a phone activation, if the emergency medical dispatcher presumes that the first responder will be able to reach the site of the emergency sooner than the first emergency medical unit, and thus it will possible to provide a quality CPR sooner, potentially using an AED. In 2018, a first responder was activated by the emergency medical dispatch center in 10.8% of cases (n = 42), if the patient was unconscious at the time of the emergency phone call. The system of first responders is composed namely of the integrated rescues system bodies and number of voluntary organizations. Further planned step is to engage the public through a mobile application. These volunteers will be repeatedly, and free of charge, trained in CPR and first aid.

Majority of OHCAs in the observed time period occurred at home (64,7%). This result correlates with the data of other studies from the Czech Republic and abroad[13-15,24,31]. In 27.3% of cases the cardiac arrest happened in a public place. Cardiac cause was the most frequent cause of a cardiac arrest, i.e. 63.4% of cases agrees with other authors[13-16]. The highest survival rate of 15.0% (46 out of 307 cases) was in OHCAs with a cardiac cause. The other prevailing causes of OHCA are a respiratory cause and trauma.

Study limitations

The limits of our study are mainly in the change of population count of the Pilsen Region in the observed time period. The number of citizens with a permanent residence in the Pilsen Region during the time was 584,672. In the statutory city of Pilsen itself, there are several administrative authorities, two universities with many out-of-region students, and in the entire region there are dozens of factories employing predominantly foreign workers. These aspects increase the number of people in the Pilsen Region. It is very likely that this increases the population count by dozens of thousands of people, and therefore the study results, which are related to a rate per 100,000 inhabitants, may be distorted.

CONCLUSION

The study introduced the epidemiological data of OHCA and pre-hospital CPR from the Pilsen Region in 2018. When compared to the results of international studies, the collected data present a higher survival rate with a good neurological result in 12.6% of cases. Furthermore, the data confirm the benefits of routinely provided dispatcher-assisted CPR and a high rate of BLS. An opportunity for further improvement lies in increasing of the number of AEDs, their public accessibility and their early activation. It is necessary to continue in the established training of emergency medical dispatchers and the staff of emergency medical units. Henceforward, it is advisable to assess the data in accordance with the Utstein recommendations.

Acknowledgement: We express cordial thanks to all dispatchers and EMS professionals in the field for careful data collection.

Author contributions: RS: principal investigator, study design, manuscript writing, literature search; IV: data collection, data analysis, manuscript writing; DCHR: data analysis, literature search, manuscript writing; DS: data analysis, data interpretation; LC: data collection, data interpretation.

Conflict of interest statement: The authors state that there are no conflicts of interest regarding the publication of this article.

REFERENCES

1. Gillum RF. Geographic variation in sudden coronary death. Am Heart J 1990;119:380-9. doi:10.1016/s0002-8703(05)80031-6
2. Myerburg RJ, Interian Jr. A, Mitrani RM, Kessler KM, Castellanos A. Frequency of sudden cardiac death and profiles of risk. Am J Cardiol 1997;80:10f-19f. doi:10.1016/s0002-9149(97)00477-3
3. Silfvast T, Ekstrand A. The effect of experience of on-site physicians on survival from prehospital cardiac arrest. Resuscitation 1996;31:101-5. doi:10.1016/0300-9572(95)00915-9
4. Mitchell RG, Brady W, Guly UM, Pirrallo RG, Robertson CE. Comparison of two emergency response systems and their effect on survival from out of hospital cardiac arrest. Resuscitation 1997;35:225-9. doi:10.1016/s0300-9572(97)00072-5
5. Arntz HR, Wenzel V, Dissmann R, Marschalk A, Breckwoldt J, Muller D. Out-of-hospital thrombolysis during cardiopulmonary resuscitation in patients with high likelihood of ST-elevation myocardial infarction. Resuscitation 2008;76:180-4. doi:10.1016/j.resuscitation.2007.07.012
6. Olasveengen TM, Lund-Kordahl I, Steen PA, Sunde K. Out-of hospital advanced life support with or without a physician: effects on quality of CPR and outcome. Resuscitation 2009;80:1248-52. doi:10.1016/j.resuscitation.2009.07.018
7. Perkins GD, Handley AJ, Koster RW, Castrén M, Smyth MA, Olasveegen T, Monsieurs KG, Raffay V, Gräsner JT, Wenzel V, Ristagno G, Soar J. European Resuscitation Council Guidelines for Resuscitation 2015 Section 2. Adult basic life support and automat-

ed external defibrillation. Resuscitation 2019;95:81-99. doi:10.1016/j.resuscitation.2015.07.015
8. Tibballs J, Russell P. Reliability of pulse palpation by healthcare personnel to diagnose paediatric cardiac arrest. Resuscitation 2009;80:61-4. doi:10.1016/j.resuscitation.2008.10.002
9. Tibballs J, Weeranatna C. The influence of time on the accuracy of healthcare personnel to diagnose paediatric cardiac arrest by pulse palpation. Resuscitation 2010;81:671-5. doi:10.1016/j.resuscitation.2010.01.030
10. Tanaka Y, Taniguchi J, Wato Y, Yoshida Y, Inaba H. The continuous quality improvement project for telephone-assisted instruction of cardiopulmonary resuscitation increased the incidence of bystander CPR and improved the outcomes of out-of-hospital cardiac arrests. Resuscitation 2012;83:1235-41. doi:10.1016/j.resuscitation.2012.02.013
11. Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted cardiopulmonary resuscitation: time to identify cardiac arrest and deliver chest compression instructions. Circulation 2013;128:1522-30. doi:10.1161/CIRCULATIONAHA.113.002627
12. Bækgaard Josefine S, Viereck S, Møller Thea P, Ersbøll Annette K, Lippert F, Folke F. The effects of public access defibrillation on survival after out-of-hospital cardiac arrest. Circulation 2017;136:954-65. doi:10.1161/CIRCULATIONAHA.117.029067
13. Gräsner JT, Lefering R, Koster RW, Masterson S, Böttiger BW, Herlitz J, Wnent J, Tjelmeland IB, Ortiz FR, Maurer H, Baubin M, Mols P, Hadžibegović I, Ioannides M, Škulec R, Wissenberg M, Salo A, Hubert H, Nikolaou NI, Lóczi G, Svavarsdóttir H, Semeraro F, Wright PJ, Clarens C, Pijls R, Cebula G, Correia VG, Cimpoesu D, Raffay V, Trenkler S, Markota A, Strömsöe A, Burkart R, Perkins GD, Bossaert LL. EuReCa ONE–27 Nations, ONE Europe, ONE Registry. A prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. Resuscitation 2016;105:188-95. doi:10.1016/j.resuscitation.2016.06.004
14. Franek O, Pokorna M, Sukupova P. Pre-hospital cardiac arrest in Prague, Czech Republic – The Utstein-style report. Resuscitation 2010;81:831-35. doi:10.1016/j.resuscitation.2010.03.005
15. Pleskot M, Babu A, Kajzr J, Kvasnicka J, Stritecky J, Cermakova E, Mestan M, Parizek P, Tauchmam M, Tusl Z, Perna P. Characteristics and short-term survival of individuals with out-of-hospital cardiac arrests in the East Bohemian region. Resuscitation 2006;68:209-20. doi:10.1016/j.resuscitation.2005.06.017
16. Berdowski J, Berg RA, Tijssen JG, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation 2010;81:1479-87. doi:10.1016/j.resuscitation.2010.08.006
17. Nadkarni VM, Larkin GL, Peberdy MA, Carey SM, Kaye W, Mancini ME, Nichol G, Lane-Truitt T, Potts J, Ornato JP, Berg RA. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. Jama 2006;295:50-7. doi:10.1001/jama.295.1.50
18. Daya MR, Schmicker RH, Zive DM, Rea TD, Nichol G, Buick JE, Brooks S, Christenson J, MacPhee R, Craig A, Rittenberger JC, Davis DP, May S, Wigginton J, Wang H. Out-of-hospital cardiac arrest survival improving over time: Results from the Resuscitation Outcomes Consortium (ROC). Resuscitation 2015;91:108-15. doi:10.1016/j.resuscitation.2015.02.003
19. Ringh M, Herlitz J, Hollenberg J, Rosenqvist M, Svensson L. Out of hospital cardiac arrest outside home in Sweden, change in characteristics, outcome and availability for public access defibrillation. Scand J Trauma Resusc Emerg Med 2009;17:18. doi:10.1186/1757-7241-17-18
20. Hulleman M, Berdowski J, de Groot JR, van Dessel PF, Borleffs CJ, Blom MT, Bardai A, de Cock CC, Tan HL, Tijssen JG, Koster RW. Implantable cardioverter-defibrillators have reduced the incidence of resuscitation for out-of-hospital cardiac arrest caused by lethal arrhythmias. Circulation 2012;126:815-21. doi:10.1161/circulationaha.111.089425
21. Blom MT, Beesems SG, Homma PC, Zijlstra JA, Hulleman M, van Hoeijen DA, Bardai A, Tijssen Tan HL, Koster RW. Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. Circulation 2014;130:1868-75. doi:10.1161/circulationaha.114.010905
22. Chan PS, McNally B, Tang F, Kellermann A. Recent trends in survival from out-of-hospital cardiac arrest in the United States. Circulation 2014;130:1876-82. doi:10.1161/circulationaha.114.009711
23. Lai H, Choong CV, Fook-Chong S, Ng YY, Finkelstein EA, Haaland B, Goh ES, Leong BS, Gan HN, Foo D, Tham LP, Charles R, Ong ME. Interventional strategies associated with improvements in survival for out-of-hospital cardiac arrests in Singapore over 10 years. Resuscitation 2015;89:155-61. doi:10.1016/j.resuscitation.2015.01.034
24. Adnet F, Triba MN, Borron SW, Lapostolle F, Hubert H, Gueugniaud PY, Escutnaire J, Guenin A, Hoogvorst A, Marbeuf-Gueye C, Reuter PG, Javaud N, Vicaut E, Chevret S. Cardiopulmonary resuscitation duration and survival in out-of-hospital cardiac arrest patients. Resuscitation 2017;111:74-81. doi:10.1016/j.resuscitation.2016.11.024
25. Okubo M, Kiyohara K, Iwami T, Callaway CW, Kitamura T. Nationwide and regional trends in survival from out-of-hospital cardiac arrest in Japan: A 10-year cohort study from 2005 to 2014. Resuscitation 2017;115:120-8. doi:10.1016/j.resuscitation.2017.03.036.
26. Takei Y, Inaba H, Yachida T, Enami M, Goto Y, Ohta K. Analysis of reasons for emergency call delays in Japan in relation to location: high incidence of correctable causes and the impact of delays on patient outcomes. Resuscitation 2010;81:1492-8. doi:10.1016/j.resuscitation.2010.05.022
27. Nehme Z, Andrew E, Cameron P, Bray JE, Meredith IT, Bernard S, Smith K. Direction of first bystander call for help is associated with outcome from out-of-hospital cardiac arrest. Resuscitation 2014;85:42-8. doi:10.1016/j.resuscitation.2013.08.258
28. Stromsoe A, Svensson L, Axelsson AB, Claesson A, Göransson KE, Nordberg P, Herlitz J. Improved outcome in Sweden after out-of-hospital cardiac arrest and possible association with improvements in every link in the chain of survival. Eur Heart J 2015;36:863-71. doi:10.1093/eurheartj/ehu240
29. Wissenberg M, Lippert FK, Folke F, Weeke P, Hansen CM, Christensen EF, Jans H, Hansen PA, Lang-Jensen T, Olesen JB, Lindhardsen J, Fosbol EL, Nielsen SL, Gislason GH, Kober L, Torp-Pedersen C. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310:1377-84. doi:10.1001/jama.2013.278483
30. Hasselqvist-Ax I, Riva G, Herlitz J, Rosenqvist M, Hollenberg JE, Nordberg P, Ringh M, Jonsson M, Axelsson C, Lindqvist J, Karlsson T, Svensson L. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2307-15. doi:10.1056/NEJMoa1405796
31. Plodr M, Truhlar A, Krencikova J, Praunova M, Svaba V, Masek J, Bejrova D, Paral J. Effect of introduction of a standardized protocol in dispatcher-assisted cardiopulmonary resuscitation. Resuscitation 2016;106:18-23. doi:10.1016/j.resuscitation.2016.05.031
32. Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted cardiopulmonary resuscitation: time to identify cardiac arrest and delivery chest compression instructions. Circulation 2013;128:1522-30. doi:10.1161/CIRCULATIONAHA.113.002627
33. Hallstrom AP, Ornato JP. Public-access defibrillation and survival after out-of-hospital cardiac arrest. N Engl J Med 2004;351:637-46. doi:10.1056/NEJMoa040566
34. Weisfeldt ML, Sitlani CM, Ornato JP, Rea T, Aufderheide TP, Davis D, Dreyer J, Hess EP, Jui J, Maloney J, Sopko G, Powell L, Nichol G, Morrison LJ. Survival after application of automatic external defibrillators before arrival of the emergency medical system: evaluation in the resuscitation outcomes consortium population of 21 million. J Am Coll Cardiol 2010;55:1713-20. doi:10.1016/j.jacc.2009.11.077
35. Berdowski J, Blom MT, Bardai A, Tan HL, Tijssen JG, Koster RW. Impact of onsite or dispatched automated external defibrillator use on survival after out-ofhospital cardiac arrest. Circulation 2011;124:2225-32. doi:10.1161/circulationaha.110.015545
36. Ringh M, Rosenqvist M, Hollenberg J, Jonsson M, Fredman D, Nordberg P, Järnbert-Pettersson H, Hasselqvist-Ax I, Riva G, Svensson L. Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2316-25. doi:10.1056/NEJMoa1406038.
37. Ong ME, Shin SD, De Souza NN, Tanaka H, Nishiuchi T, Song KJ, Ko PC, Leong BS, Khunkhlai N, Naroo GY, Sarah AK, Ng YY, Li WY, Ma MH. Outcomes for out-of-hospital cardiacarrests across 7 countries in Asia: The Pan Asian Resuscitation Outcomes Study (PAROS). Resuscitation 2015;96:100-8. doi:10.1016/j.resuscitation.2015.07.026.

38. Moon S, Vadeboncoeur TF, Kortuem W, Kisakye M, Karamooz M, White B, Brazil P, Spaite DW, Bobrow BJ. Analysis of out-of-hospital cardiac arrest location and public access defibrillator placement in metropolitan Phoenix, Arizona. Resuscitation 2015;89:43-9. doi:10.1016/j.resuscitation.2014.10.029

39. Kitamura T, Kiyohara K, Sakai T, Matsuyama T, Hatakeyama T, Shimamoto T, Izawa J, Fujii T, Nishiyama C, Kawamura T, Iwami T. Public-access defibrillation and out-of-hospital cardiac arrest in Japan. N Engl J Med 2016;375:1649-59. doi:10.1056/NEJMsa1600011