

## OHCA survey in Lombardy: comparison between years 2014 and 2019 (pre COVID-19)

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**Abstract.** *Background and aim:* The incidence of Out of Hospital Cardiac Arrest (OHCA) is estimated at 1/1000 persons/year. In the pre-Covid-19 era world, OHCA survival rate in Europe was 7-6%. The main objective is to analyze OHCA survival in the Lombardy region by highlighting the factors related to both the victims' characteristics and the chain of survival. *Methods:* All OHCA were grouped into four pre-established periods in 2019 (14-23 January; 15-24 April; 15-24 July; 14-23 October). Following the Utstein method, we selected witnessed OHCA with presumed cardiac etiology. The outcome of each case was collected in four moments in time: Return of spontaneous circulation (ROSC), Emergency Department (ED), 24 hours and 30 days. The neurological outcome 30 days after OHCA was also investigated and stratified with the Cerebral Performance Category Score (CPC). *Results:* We selected 456 cases of OHCA with witnessed cardiac etiology. ROSC was achieved in 121 cases (26.5%), survival in the Emergency Departments in 110 patients (24.1%), after 24 hours in 86 (18.86%) and after 30 days in 72 (15.8%). Male sex was shown to improve OHCA survival. A shockable presentation rhythm, Cardiopulmonary Resuscitation (CPR) performed by bystanders and the activation of Public Access Defibrillation (PAD) positively influenced OHCA outcome. *Conclusions:* Males are more predisposed to incur an OHCA event than females, but they have greater chances of survival. Factors most related to survival are: shockable rhythm, bystanders CPR and the activation of a PAD. ([www.actabiomedica.it](http://www.actabiomedica.it))

**Key words:** OHCA, CPR, Shockable Rhythm, PAD, ROSC, CPC Score, Survival

### Introduction

Cardiocirculatory arrest (CA) is the cessation of mechanical cardiac activity resulting in the absence of blood circulation. CA interrupts the flow of blood to vital organs, depriving them of oxygen, and if left untreated, causes death. CA can be caused by multiple factors (trauma, poisoning, gastrointestinal bleeding, changes in respiratory function, etc.) but sudden cardiac death (SCD) is the leading cause of cardiac arrest

in the adult population. SCD is defined as "natural death due to cardiac causes, preceded by sudden loss of consciousness within 1 hour after the onset of symptomatology; a pre-existing heart disease may be known, but the time and manner of death are unforeseen<sup>1-2</sup>. An SCD event occurring out of hospital is referred to as "out-of-hospital-cardiac-arrest" (OHCA).

It is estimated that the incidence of OHCA is 1/1000 persons/year and that 80% of OHCA are based on ischemic heart disease. In the pre-Covid-19

era world, OHCA survival was 7-6% in Europe, 8-6% in North America, 3-0% in Asia and 9-7% in Australia<sup>3</sup>.

The data available in Italy are limited, and for this reason a Survey was considered appropriate, taking as a sample the population of the Lombardy Region that amounted to 10,078,012 people in 2019. Lombardy has a structured computerized system for the management of out-of-hospital emergencies enhanced by the implementation of the European Single Emergency Number 112, which allows the identification of the cases to be analyzed. Thanks to the coordination of regional and local authorities and Hospital Organizations, it was possible to obtain an accurate record of the events to be examined. The same study, previously carried out in 2014<sup>4</sup>, allowed us to have a term of comparison to evaluate the effectiveness of the actions undertaken locally, such as BLS training to the lay population and the diffusion of external semi-automatic defibrillators.

As of January 1, 2020 12,000 defibrillators were installed throughout the Lombardy region, while training and qualification for their use were provided through Public Access Defibrillators (PAD) projects. In the year 2019 alone 54,957 citizens were trained and 19,715 lay rescuers were retrained. The study aims to highlight the impact of the Chain of Survival steps on OHCA survival and supports the development of strategies and the planning of objectives intended to reduce the impact of OHCA on the population.

## Methods

The OHCA data on the population of Lombardy (10,060,574)<sup>5</sup> were collected in a single cohort prospective observational study by EmmaWeb system in 4 pre-established periods during the year 2019 (14-23 January; 15-24 April; 15-24 July; 14-23 October).

The EmmaWeb system is the management program that collects all the out of hospital assistance data.

Applying the Utstein method<sup>6</sup>, we selected the number of cases of witnessed OHCA from the total number of events analyzed and classified as OHCA, excluding the cases that did not have a cardiac etiology and those in which the OHCA was not witnessed.

The subsequent analysis of the data related to the events collected by the Dispatch Center, the extra-hospital rescue workers (EMS) and the hospital

medical records, allowed us to document the return of spontaneous circulation (ROSC), survival at 24h (in the Emergency Departments) and, through the hospital databases, after 30 days. In the witnessed OHCA group the outcome was described and stratified according to the "Standard definitions of Glasgow-Pittsburgh cerebral performance category" (CPC)<sup>7</sup>, with a score from 1 to 5. The chain of survival steps<sup>8</sup> performed out of hospital was subsequently analyzed by stratifying the selected cases according to the variables related to the single steps (early CPR, use of the AED, ACLS) to point out the impact of these steps on the OHCA survival and neurological outcome. Moreover, the cases were divided by EMS Call Center territories to describe local differences in OHCA survival.

The study and the processing of personal data was approved by the local Ethics Committee (nr 13641)

The statistical evaluation was carried out by chi-square test, ODDS Ratio, 95% confidence range and Student's t-test.

No patients or public involvement.

## Results

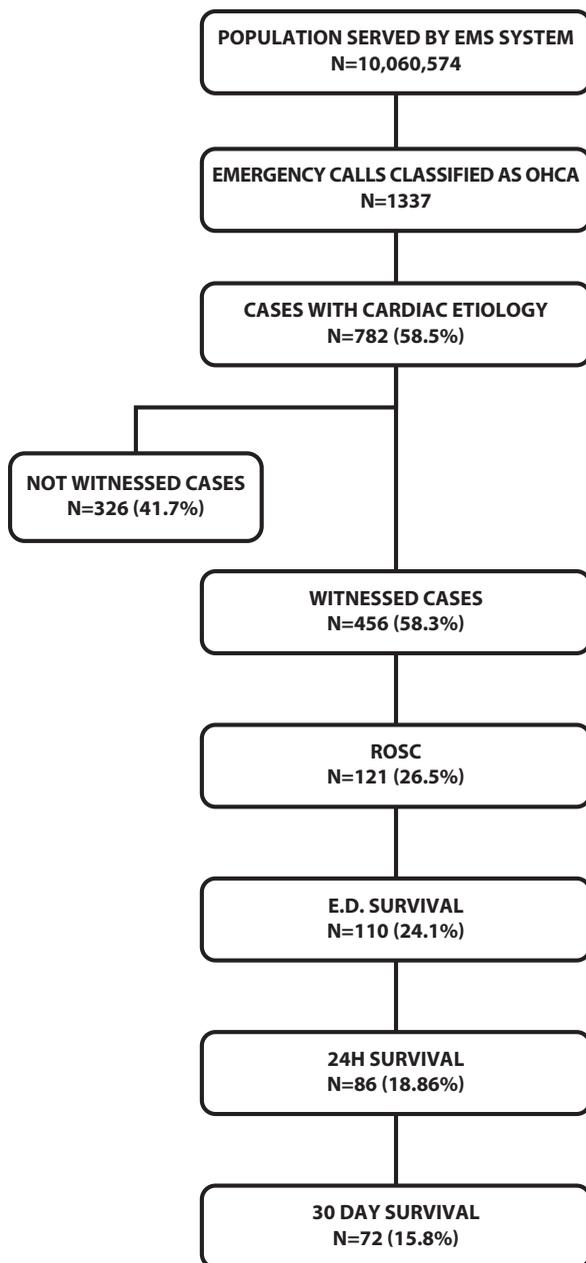
In our data the incidence of CA was found to be 1.2/1000 persons/year.

Applying the Utstein method<sup>6</sup> (Figure 1) 456 cases (58.3% of all events with a cardiac etiology) of witnessed OHCA were selected.

### *General survival*

Within the study group, ROSC was achieved in 121 cases (26.5%) [CI95 21.7 – 31.3], survival in the Emergency Departments in 110 patients (24.1%) [CI95 19,5 – 28,7], after 24 hours in 86 (18.86%) [CI95 15.0 – 22.2] and after 30 days in 72 subjects (15.8%)[CI95 11.8 – 19.8] (Table 1).

Comparing the 2019 data with those of 2014 (ROSC 25.0%; Emergency Departments 22.2%; 24H 25.0% 30 days 11.2%) showed an important increase in the number of survivors [p= 0.028, ODDS Ratio 1.56, CI95 1.05 – 2.31]. Also considering the cases characterized by shockable rhythms (19.9%), a 30-day survival of 46.7% [CI95 36.3 – 57.12] was found, with a significant increase compared to 2014 (32.5%) [p=0.015, ODDS Ratio 2.16, CI95 1.15 – 4.06].



**Figure 1.** Utstein template.

**Table 1.** OHCA Survey 2019 (Overall).

TOT	CE	WITN	RHYTHM	N	% WITN	ROSC	% RHY	ES ED	% RHY	ES 24H	% RHY	ES 30D	% RHY
1337	782	456	VF	90	19.74%	57	63.33%	52	57.78%	46	51.11%	42	46.67%
	58.59%	58.31%	PTV	1	0.22%	1	100.00%	1	100.00%	1	100.00%	1	100.00%
			PEA	54	11.84%	19	35.19%	16	29.63%	11	20.37%	8	14.81%
			ASY	199	43.64%	27	13.57%	25	12.56%	16	8.04%	11	5.53%
			NA	112	24.56%	17	15.18%	16	14.29%	12	10.71%	10	8.93%
<b>TOTAL</b>				<b>456</b>	<b>100%</b>	<b>121</b>	<b>26.54%</b>	<b>110</b>	<b>24.12%</b>	<b>86</b>	<b>18.86%</b>	<b>72</b>	<b>15.79%</b>

TOT: Total OHCA events; CE: Cardiocirculatory Etiology; WITN: Witnessed; ROSC: Return Of Spontaneous Circulation; RHY: Rhythm; ES ED: Event Survivors (Emergency Department); ES 24H: Event Survivors (24 Hours); ES 30D: Event Survivors (30 days); NA: Not Available

Regarding the neurological outcomes of the 30-day survivors, 80.6% [CI95 71,4 - 89,8] reached a high Cerebral Performance Category, CPC (1-2), while 18.1% [CI95 9,1 - 27,1] reached a medium low CPC (3-4); in one case (1.4%) it was not possible to retrieve information on the neurological performance (NA).

On this parameter there are no significant differences with the data relating to 2014 (29 cases CPC 1-2, 11 cases CPC 3-4) [p=0.26].

#### *Gender, age, territory survival*

Within the OHCA group with confirmed cardiac etiology 62.8% [CI95 59.4 - 66.2] of patients were males (491) while the remaining 32.2% [CI95 28.9 - 35.5] were females (291). An overall average age of 76.5 years [CI95 75.4 - 77.8] was found, 80.6 years [CI95 79.1 - 82.1] for the females and 73.1 years [CI95 73.1 - 75.5] for the males, respectively. Comparing the averages of the two groups through the Student's t-test 95, a statistically relevant difference [p = 1.09E-09] was observed, confirming that in males this event occurs on average earlier than in females.

In the witnessed OHCA group, the general average age was 75.7 years [CI95 74.4 - 77.0], that of the female population 80.0 [CI95 78.9 - 82.1] and that of the male population 73.1 [CI95 72.5 - 74.7]; also in this group, the Student's t-test showed significant differences between the average age of males and females [p = 7.62E-07]. Analyzing the deviations of the averages of this group compared to the one described above, no substantial differences were found.

With reference to the group of 30-day survivors 80.6% [CI95 71.4 - 89.8] were males, while the remaining 19.4% [CI95 10.2 - 28.6] were females. In both sexes respectively, survival was observed in 58 male patients, or 12.8% [CI95 9.7 - 15.9] of the

witnessed OHCA, and in 14 female patients, or 3.1% [CI95 1.5 - 4.7]. Between the two groups there was a significant difference [ $p = 0.0056$ ], with an ODDS Ratio M/F equal to 2.87 [CI95 1.54 - 5.32]. There was no difference between the sexes with respect to the neurological outcome [ $p=0.76$ ].

Taking age into account, the group of survivors had an average age of 64.7 years [CI95 62.7 - 66.5], the males of 63.7 years [CI95 61.6 - 65.8] (min. 28; max 96), the females of 67.7 [CI95 63.6 - 71.8] (min. 37; max 86). The Student's  $t$ -test 95 did not highlight significant differences between the averages of the two groups [ $p = 0.32$ ].

Therefore, the study group shows that in the male group, although OHCA occurs earlier on average, survival to the event has increased, but without significant differences in neurological outcome. This enriches the literature<sup>9</sup> on the subject and shows that these factors are not related to OHCA survival unlike other factors that will be discussed later.

By dividing the data according to the territory covered by the four SOREUs present in Lombardy there are no territory-based differences that affect survival [ $p=0.28$ ] suggesting a homogeneous approach to these events by the extra-hospital Emergency System in the macro-areas of the Region.

#### *BCPR, PAD and shockable rhythms survival*

In the group of witnessed events CPR was initiated by bystanders (BCPR) in 200 events (43.9%); 24.5% of patients (49) who received BCPR survived 30 days (Table 2). There are no statistically significant differences with the 2014 data (129 cases of CPR in progress, 20 of whom survived 30 days).

**Table 2.** Bystanders CPR Survey (BCPR).

BCPR	RHYTHM	N	% WITN	ROSC	% BCPR	ES ED	% RHY	ES 24H	% RHY	ES 30D	% RHY
200	VF	65	32.50%	46	70.77%	43	66.15%	38	58.46%	33	50.77%
43.86%	PTV	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
	PEA	29	14.50%	11	37.93%	10	34.48%	6	20.69%	6	20.69%
	ASY	83	41.50%	17	20.48%	14	16.87%	10	12.05%	7	8.43%
	NA	23	11.50%	5	21.74%	5	21.74%	3	13.04%	3	13.04%
<b>TOTAL</b>		<b>200</b>	<b>100.00%</b>	<b>79</b>	<b>39.50%</b>	<b>72</b>	<b>36.00%</b>	<b>57</b>	<b>28.50%</b>	<b>49</b>	<b>24.50%</b>

Comparing these data with those of the group where BCPR was not initiated (256 cases, 56.1%), a significant difference [ $p < 0.001$ ] was found with respect to 30-day survival (23 cases, 9.0%). The ODDS Ratio BCPR/no-BCPR showed a value of 3.28 [CI95 1.92 - 5.61], thus confirming how early CPR initiated by bystanders positively affects survival.

Regarding neurological outcomes, survivors who received an early BCPR (49) showed a high CPC in 83.7% of patients (41) [CI 73.3 - 94.1], a low average level in 14.3% (7) [CI 4.3 - 24.1] and in one case (2.0%) it was not possible to retrieve information on 30 days post-arrest neurological performance (Table 3).

In the group of patients who did not receive BRCP (23), a high level of CPC was found in 17 patients (73.9%) [CI 55.5 - 92.3], and a medium low level in 6 cases (26.1%) [CI 7.7 - 44.5].

Even considering the difference in survival in the two groups in question, there were no significant differences in neurological outcomes.

There were 29 cases in which defibrillation was performed by a bystander (Public Access Defibrillation) (6.2% of witnessed CAs) with a 30-day survival of 9 patients (31.0%) [CI95 13.9 - 48.1]; specifically, the survival of shockable rhythms within this group was 60.0% [CI95 28.0 - 92.0] (Table 4).

**Table 3.** BCPR: Cerebral Performance Category (CPC) of SURVIVORS.

CPC	n	% Aggregate
1 - 2	41	83.7 %
3 - 4	7	14.3 %
NA	1	2.0 %
<b>TOTAL</b>	<b>49</b>	<b>100.0 %</b>

A high level CPC was detected in 5 cases. In the 2014 Survey the percentage of PAD events detected was 1.6%, with a 4-fold increase of this incidence in 5 years<sup>4</sup>.

Regarding presentation rhythms, 91 patients (19.9%) showed a shockable rhythm (VF and PVT), 253 (55.5%) a non-shockable rhythm (ASY and PEA), and in 22 cases (24.6%) this information could not be retrieved. In the group of shockable rhythms a 30-day survival of 47.2% was found [CI95 45.2 - 65.8] (43 cases), while in the non-shockable group a 30-day survival was observed in 7.5% of patients [CI95 4.2 - 10.8] (19 cases). The two groups showed a statistically significant difference [ $p=1.26E-16$ ] with an ODDS Ratio of 11.03 [CI95 5.91 - 20.56].

In terms of neurological outcome, the group of shockable rhythms showed a high CPC in 86.0% of cases [CI95 75.5 - 96.5] (37) and the group of non-shockable rhythms in 68.4% of cases [CI95 46.9 - 89.9] (13), without statistically significant differences.

The incidence of shockable rhythms (excluding cases where the presentation rhythm could not be detected) in the BCPR group was 36.7% [CI95 29.6 - 43.8] (65 cases), while in the no BCPR group it was 14.4%, [CI95 9.1 - 19.7] (24) with a statistically

significant difference [ $p=2.23E-06$ , ODD R 3.46, CI95 2.04 - 5.87]. This confirms that BCPR prolongs the maintenance of a shockable rhythm until the arrival of EMS, thus increasing OHCA survival<sup>10</sup>.

#### *ACLS survival*

In 266 events (58.3%), a rescue vehicle for the application of the ACLS protocol by Emergency Physician (MSA2) or Intensive Care Nurse (MSA1) was sent. Considering the survival in this group (without dividing the cases with CPR initiation on site), 51 patients (19.2%) [CI95 14.5 - 23.9] survived for 30 days (Table 5).

By dividing the cases in which the ACLS protocol was applied to patients in which CPR was initiated by bystanders and the group in which it was not, we can observe a statistically significant difference between the two groups [ $p=0.0054$ , ODD R 2.07, 1.32 - 5.53] that suggests once again how the intervention of bystanders who witness an episode of OHCA is a fundamental step in the “survival chain” without which subsequent therapeutic strategies are less effective.

There were no differences between the two groups with regard to neurological outcome [ $p=0.164$ ].

**Table 4.** PAD Survey.

PAD	RHYTHM	N	% PAD	ROSC	% RHY	ES ED	% RHY	ES 24H	% RHY	ES 30D	% RHY
29	VF	10	34.48%	7	70.00%	7	70.00%	7	70.00%	6	60.00%
6.4%	PTV	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
	PEA	3	10.34%	1	33.33%	1	33.33%	1	33.33%	1	33.33%
	ASY	9	31.03%	2	22.22%	2	22.22%	0	0.00%	0	0.00%
	NA	7	24.14%	4	57.14%	4	57.14%	2	28.57%	2	28.57%
<b>TOTAL</b>		<b>29</b>	<b>100.00%</b>	<b>14</b>	<b>48.28%</b>	<b>14</b>	<b>48.28%</b>	<b>10</b>	<b>34.48%</b>	<b>9</b>	<b>31.03%</b>

**Table 5.** ACLS Survey.

ACLS	RHYTHM	N	% ACLS	ROSC	% RHY	ES ED	% RYH	ES 24H	% RHY	ES 30D	% RHY
266	VF	81	30.45%	49	60.49%	48	59.26%	38	46.91%	34	41.98%
58.33%	PTV	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
	PEA	46	17.29%	17	36.96%	17	36.96%	9	19.57%	7	15.22%
	ASY	134	50.38%	25	18.66%	25	18.66%	14	10.45%	10	7.46%
	NA	5	1.88%	1	20.00%	1	20.00%	0	0.00%	0	0.00%
<b>TOTAL</b>		<b>266</b>	<b>100.00%</b>	<b>92</b>	<b>34.59%</b>	<b>91</b>	<b>34.21%</b>	<b>61</b>	<b>22.93%</b>	<b>51</b>	<b>19.17%</b>

## Discussion

Our study compares the results of 2019 with those obtained in 2014. We find an increase in OHCA event survival and a control of neurological outcomes caused by the interruption of cerebral perfusion. This underlines the importance of continuing the programs for the training of citizens and the diffusion of defibrillators, as well as the implementation of systems, such as applications for smartphones, that allow users to find the AEDs and alert the trained lay rescuers as soon as possible. Equally important is the coordination among the citizens witnessing an OHCA and the emergency medical system, considering that throughout the Lombardy Region (city and rural areas) the median time of arrival of the first rescue vehicle at the event site is 11 minutes. The role of citizens in a “double first responder” scenario is essential as early resuscitation maneuvers are related to increased survival and maintaining an adequate rhythm of presentation that allows the use of targeted therapeutic protocols.

Despite the increase in the number of witnessed events in which CPR was initiated by bystanders compared to the data of 2014 (from 30.0% to 43.9%), this percentage is still far from the European average (47.8%)<sup>11</sup>. It is therefore necessary to plan strategies for BLS training to the lay population and for the activation of non-EMS first responders, based on the experiences of other European countries, such as the Netherlands, where the percentage of events in which BCPR is initiated is 72.0%<sup>12</sup> and an alert system through texting has been developed by local lay rescuers with AEDs<sup>13</sup>.

## Limitation

A potential bias could be represented by the number of “not available” presenting rhythms (24.6%). The implementation of a regional OHCA registry could increase the accuracy of this information.

In addition, the study does not take into account the intra-hospital treatment of the patient, which is heterogeneous in Lombardy, depending on the availability of different therapeutic options (H24 cardiac surgery, ECMO, etc.).

## Conclusion

Males are more predisposed to incur an OHCA event earlier than females, but they also have greater chances of survival. Among the factors analyzed, those most related to survival are the shockable presentation rhythm, CPR performed by bystanders and the activation of a PAD; this testifies to the importance of disseminating CPR training and knowledge on the use of defibrillators to the lay population, which play a key role in addressing OHCA in a functional and effective way. A more accurate analysis of the actual impact of OHCA will have to be subsequently carried out by increasing the number of cases in the study and verifying to what extent the Covid-19 pandemic has affected the intervention and survival data of OHCA.

**Acronyms:** OHCA: Out of Hospital Cardiac Arrest; CA: Cardiocirculatory arrest; SCD: Sudden Cardiac Death; BLS: Basic Life Support Defibrillation; PAD: Public Access Defibrillation; EMS: Emergency Medical System; ROSC: Return of Spontaneous Circulation; CPC: Cerebral Performance Category; CPR: Cardio Pulmonary Resuscitation; AED: Automatic External Defibrillator; ACLS: Advanced Cardiac Life Support; SOREU: Sala Operativa Regionale Emergenza Urgenza; BCPR: Bystanders Cardio Pulmonary Resuscitation; VF: Ventricular Fibrillation; PVT: Pulsless Ventricular Tachycardia; ASY: Asystolia; PEA: Pulseless Electrical Activity; MSA: Mezzo di Soccorso Avanzato; ECMO: Extra Corporeal Membrane Oxygenation

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