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Article

Cardiac Arrests of Non-Cardiac Origin in Slovenia: What Has Changed in 2022/2023 as Compared to 2010/2011?

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Abstract

Background: Cardiac arrest is the third leading cause of natural death in Europe and thus presents a growing burden on both our society and healthcare system. There has been very little research done on cardiac arrests of non-cardiac origin despite their increasing incidence, as they represent a heterogeneous group of patients in which the type and outcome of treatment vary depending on the underlying cause of the cardiac arrest. **Aim:** The aim of our study is to research how the Slovenian healthcare system has worked and currently works in the field of cardiac arrests of non-cardiac origin. **Methods:** Our study was descriptive and retrospective. We compared 2 time periods, 2010/2011 and 2022/2023. Our sample included all patients admitted to Centre for Intensive Internal Medicine (CIIM) during these periods after either out-of-hospital or in-hospital cardiac arrest of non-cardiac origin. **Results:** The incidence of all cardiac arrests of non-cardiac origin was higher in 2022/2023 (Hi-squared test, $p=0.021$), while the incidence of those that occurred in-hospital was lower in 2022/2023 (Hi-squared test, $p=0.007$). The number of male patients was higher in the second period (Hi-squared test, $p=0.013$). The age of the patients did not differ significantly between the two periods (Student's t-test, $p>0.05$). ICU stay was longer in the second period (Mann Whitney U test, $p=0.027$). The number of tests performed was higher and treatment was more aggressive in the second period than in the first period. Patient survival was higher in the second period in the in-hospital cardiac arrest of non-cardiac origin group (Student's t-test, $p=0.048$). **Conclusion:** The incidence of cardiac arrest of non-cardiac origin in Slovenia has been increasing through the years. Better hospital treatment results in better overall survival and a lower incidence of in-hospital cardiac arrests. More patients with out-of-hospital cardiac arrests are nowadays being resuscitated by lay bystanders in the field, so patients' survival to hospital admission is higher. The proportion of male patients is increasing, age is not changing significantly. Despite better diagnosis processes, new treatments and improved knowledge, the survival and neurological outcome of patients have not improved significantly.

Keywords: cardiac arrest; non-cardiac origin; treatment; survival

1. Introduction

Cardiac arrests are classified by location (out-of-hospital, OHCA; in-hospital, IHCA) and etiology (primary, cardiac origin; secondary, non-cardiac origin). This distinction is important because treatment, frequency, and survival differ. Primary cardiac arrests are more common and have better survival [1,2]. While primary cardiac arrest is well studied, secondary cardiac arrest (S-CA) is less frequently analyzed due to its heterogeneous etiologies. The most common causes of S-CA are infections (especially respiratory), major trauma, bleeding, poisoning and overdose, near-drowning, and central airway obstruction [3]. After primary cardiac arrest, brain damage is the main cause of death [4,5], whereas in S-CA, underlying diseases are usually decisive.

2. Aim of the study

There is a marked lack of studies focused specifically on S-CA. Most research examines primary cardiac arrest or compares primary and secondary types. Our retrospective study compared patients after S-CA admitted to the Center for Intensive Internal Medicine (CIIM), University Medical Center Ljubljana, in two time periods.

We aimed to determine whether the prevalence of cardiac arrests and the proportions of secondary OHCA and IHCA differ between 2010/2011 and 2022/2023. We also assessed whether the main causes of S-CA are similar in both intervals and whether they differ between OHCA and IHCA, and we compared patient age and survival in both periods.

3. Materials and Methods

This was a retrospective study of patients admitted to CIIM after S-CA in 2010/2011 and 2022/2023. The years 2010 and 2011 were chosen as the first two years from the CIIM cardiac arrest registry; 2022 and 2023 represent the most recent period, less affected by the COVID-19 epidemic.

We included all consecutive patients with confirmed S-CA; there were no exclusion criteria. We calculated the incidence of S-CA among all cardiac arrests. From medical records, we extracted data on the arrest (location, witness, BLS, delay to EMS arrival, ACLS duration), patient characteristics (age, sex), diagnostic tests and treatment (mechanical ventilation, vasopressors/inotropes, antibiotics, etc.), survival, and CPC score (Tables 1–3).

Table 1. Patients’ characteristics according to sex and location of CA.

	2010/2011		2022/2023		All male / all female
	OHCA	IHCA	OHCA	IHCA	
Male	23 (41,8%)	42 (50,6%)	54 (58,1%)	49 (65,3%)	168 (54,9%)
Female	32 (58,1%)	41 (49,4%)	39 (41,9%)	26 (34,7%)	138 (45,1%)
All	55	83	93	75	306

Table 2. Patients’ characteristics, data on OHCA, treatment and outcome.

	S-OHCA 2010/2011	S-OHCA 2022/2023	p value (significant: $p<0,05$)
No. Of pts (% all S-OHCA)	55 (39,9)	93 (55,4)	0,007
age (years) ± SD	68,8 ± 14,5	67,6 ± 16,2	0,707
Sex (%)			0,056
<i>male</i>	23 (41,8)	54 (58,1)	
<i>female</i>	32 (58,2)	39 (41,9)	
Data about S-OHCA			
witness (%);	46 (83,6)	75 (80,6)	0,649
<i>lay/none</i>	39 (84,7)	65 (86,7)	
EMS	7 (15,2)	10 (13,3)	
BLS (%)*	9 (23,1)	41 (63,1)	<0,001

Time to EMS arrival (mins)± SD	9,6 ± 5,5	9,7 ± 5,25	0,910
Initial rhythm (%)			0,125
PEA	28 (50,9)	53 (57,0)	
Asystole	23 (41,8)	39 (41,9)	
VF	4 (7,3)	1 (1,8)	
ACLS duration (mins) ± SD	15,7 ± 10,6	16,1 ± 12,4	0,878
Treatment			
TTM (%)			/
normothermia	0	52 (55,9)	
hypothermia	39 (70,9)	5 (5,4)	
no TTM	16 (29,1)	36 (38,7)	
Head CT (%)	26 (47,3)	74 (79,6)	<0,001
Chest and abdominal CT/CTA (%)	16 (29,1)	47 (50,5)	0,011
Coronary angiography (%)	4 (7,3)	6 (6,5)	0,548
Mechanical ventilation (%)	53 (96,4)	93 (100)	0,137
Inotropes/vasopressors (%)	49 (89,1)	83 (89,2)	0,976
Antibiotics (%)	34 (61,8)	62 (66,7)	0,550
Hemodialysis (%)	2 (3,6)	6 (6,5)	0,710
ICU stay (days) ± SD	4,4 ± 3,7	4,9 ± 4,4	0,513
Outcome			
Survival (%)	22 (40,0)	24 (25,8)	0,071
CPC (%)			/
CPC 1/2	9 (16,4)	11 (11,8)	
CPC 3	3 (5,5)	3 (3,2)	
CPC 4	14 (27,3)	53 (57,0)	
CPC 5	3 (5,5)	9 (9,7)	
missing data	26 (45,5)	17 (18,3)	
Survival CPC 1/2 (%)	9 (16,4)	11 (11,8)	0,435

Table 3. Patients’ characteristics, data on IHCA, treatment and outcome.

	S-IHCA 2010/2011	Se-IHCA 2022/2023	p value (significant p<0,05)
No. of pts (% all S-CA)	83 (60,1)	75 (44,6)	0,007

Age (years) ± SD	70,7 ± 13,0	67,8 ± 13,3	0,177
Sex (%)			0,061
<i>male</i>	42 (50,6)	49 (65,3)	
<i>female</i>	41 (49,4)	26 (34,7)	
Data about S-IHCA			
witness (%)	76 (91,6)	71 (94,7)	0,444
Initial rhythm (%)			0,562
<i>PEA</i>	52 (62,7)	51 (68,0)	
<i>Asystole</i>	26 (31,3)	18 (24,0)	
<i>VF</i>	5 (6,0)	6 (8,0)	
ACLS duration (mins) ± SD	10,4 ± 8,3	13,9 ± 13,1	0,228
Treatment			
TTM (%)			/
<i>normothermia</i>	0 (0,0)	46 (61,3)	
<i>hypothermia</i>	44 (53,0)	0 (0,00)	
<i>no TTM</i>	39 (47,0)	29 (38,7)	
Head CT (%)	13 (15,7)	41 (54,7)	<0,001
Chest and abdominal CT/CTA (%)	8 (9,6)	40 (53,3)	<0,001
Coronary angiography (%)	4 (4,8)	7 (9,3)	0,266
Mechanical ventilation (%)	83 (100,0)	75 (100,0)	/
Inotropes/vasopressors (%)	75 (90,4)	69 (92,0)	0,927
Antibiotics (%)	61 (73,5)	65 (86,7)	0,040
Hemodialysis (%)	6 (7,2)	13 (17,3)	0,051
ICU stay (days) ± SD	3,9 ± 3,8	5,6 ± 5,5	0,022
Outcome			
Survival (%)	25 (30,1)	34 (45,3)	0,048
CPC (%)			/
<i>CPC 1/2</i>	21 (25,3)	25 (33,3)	
<i>CPC 3</i>	0 (0,00)	6 (8,0)	
<i>CPC 4</i>	22 (25,3)	29 (38,7)	
<i>CPC 5</i>	0 (0,00)	0 (0,00)	
<i>Missing data</i>	40 (49,4)	15 (20,0)	
Survival CPC 1/2 (%)	18 (21,7)	25 (33,3)	0,100

In 2010/2011, hypothermia (32–34°C) was the standard method of temperature control. In 2022/2023, based on newer evidence and guidelines, normothermia with fever prevention (<37.5°C) was used; hypothermia was reserved for selected cases. Neurological outcome was assessed using the Glasgow–Pittsburgh Cerebral Performance Category (CPC) scale [6]. The study was approved by

the National Medical Ethics Committee of the Republic of Slovenia on June 21, 2024 (No. 0120-247/2024-2711-3).

STATISTICS

We analyzed three datasets: S-OHCA, S-IHCA, and combined S-CA (OHCA + IHCA). Nominal variables were compared using the chi-square test or Fisher’s exact test [6]. We did not statistically compare temperature management between periods because hypothermia was used in 2010/2011 and normothermia in 2022/2023, and neuroprognostication only became routine at CIIM at the end of 2017.

We assessed normality with QQ plots and presented normally distributed variables as mean ± SD. Outliers were assessed with box plots; homogeneity of variance was tested with Levene’s test. For variables without significant outliers, with approximately normal distribution and homogeneous variances, we used Student’s t-test. For variables with many outliers (age in all S-CA, duration of ACLS, ICU length of stay), we used the nonparametric Mann–Whitney U test.

A p-value < 0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics v29.0 (IBM Corp., Armonk, NY, USA, 2023).

4. Results

A total of 306 patients were included: 138 in 2010/2011 and 168 in 2022/2023.

1) S-OHCA

Data for S-OHCA are shown in Table 2. The proportion of S-OHCA among all secondary cardiac arrests (OHCA + IHCA) increased from 39.9% to 55.4% (p = 0.007).

In 2010/2011, 58.2% of S-OHCA patients were women and 41.8% men; in 2022/2023 this nearly reversed (58.1% men, 41.9% women), without a statistically significant difference.

Bystander CPR increased significantly from 23.1% to 63.1% (p < 0.001). CIIM performed more diagnostic tests in the later period; head CT and chest/abdominal CT/CTA increased significantly (p < 0.001 and p = 0.011, respectively).

Survival after S-OHCA was higher in 2010/2011 than in 2022/2023 (40.0% vs. 25.8%), but the difference was not statistically significant.

2) S-IHCA

Results for S-IHCA are shown in Table 3. The proportion of S-IHCA among all S-CA decreased from 60.1% in 2010/2011 to 44.6% in 2022/2023 (p = 0.007).

In both periods, most patients were male. The proportion of males rose from 50.6% to 65.3%, and females decreased from 49.4% to 34.7%, but this change was not statistically significant.

More diagnostic tests were performed in 2022/2023; head CT and chest/abdominal CT/CTA increased significantly (p < 0.001). Antibiotic use also rose from 73.5% to 86.7% (p = 0.040).

ICU length of stay after S-IHCA increased from 3.9 ± 3.8 to 5.6 ± 5.5 days (p = 0.022). Survival improved from 30.1% to 45.3% (p = 0.048).

3) All secondary OHCA and IHCA

For the combined analysis (Table 4), S-OHCA and S-IHCA were pooled within each period. The incidence of S-CA among all cardiac arrests increased from 35.0% in 2010/2011 to 43.1% in 2022/2023 (p = 0.021). The distribution by location changed significantly (p = 0.007): in 2010/2011, IHCA predominated, whereas in 2022/2023, OHCA was more frequent. The sex distribution also shifted significantly (p = 0.013), from a predominance of female patients in the first period to male patients in the second.

Table 4. Patients’ characteristics, data on OHCA/IHCA, treatment and outcome.

	S-CA 2010/2011	S-CA 2022/2023	p value (significant: p<0,05)
No. Of pts (% all CA)	138 (35,0)	168 (43,1)	0,021
Location (%)			0,007
<i>IHCA</i>	83 (60,1)	75 (44,6)	
<i>OHCA</i>	55 (39,9)	93 (55,4)	
Age (years)± SD	69,8 ± 13,6	67,7 ± 14,9	0,271
Sex (%)			0,013
<i>male</i>	65 (47,1)	103 (61,3)	
<i>female</i>	73 (52,9)	65 (38,7)	
Data about CA			
Witness (%)	122 (88,4)	146 (86,9)	0,692
Initial rhythm (%)			0,591
<i>PEA</i>	80 (58,0)	104 (61,9)	
<i>Asystole</i>	49 (35,5)	57 (33,9)	
<i>VF</i>	9 (6,5)	7 (4,2)	
ACLS duration (mins) ± SD	16,5 ± 21,8	12,5 ± 6,5	0,102
Treatment			
TTM (%)			/
<i>normothermia</i>	0 (0,00)	98 (58,3)	
<i>hypothermia</i>	83 (60,1)	5 (3,0)	
<i>no TTM</i>	55 (39,9)	65 (38,7)	
Head CT (%)	39 (28,3)	115 (68,5)	<0,001
Chest and abdominal CT/CTA (%)	24 (17,4)	87 (51,8)	<0,001
Coronary angiography (%)	8 (5,8)	13 (7,7)	0,504
Mechanical ventilation (%)	136 (98,6)	168 (100,0)	0,203
Inotropes/vasopressors (%)	124 (89,9)	152 (90,5)	0,856
Antibiotics (%)	95 (68,8)	127 (75,6)	0,188
Hemodialysis (%)	8 (5,8)	21 (12,5)	0,046
ICU stay (days) ± SD	4,1 ± 3,8	5,2 ± 4,9	0,027
Outcome			
Survival (%)	47 (34,1)	58 (34,5)	0,932
CPC (%)			/

CPC 1/2	30 (21,7)	36 (21,4)	
CPC 3	3 (2,2)	9 (5,4)	
CPC 4	36 (26,1)	82 (48,8)	
CPC 5	3 (2,2)	9 (5,4)	
Missing data	66 (47,8)	32 (19,0)	
Survival CPC 1/2 (%)	27 (19,6)	36 (21,4)	0,688

All diagnostic procedures increased in the later period, with a statistically significant rise in head CT and chest/abdominal CT/CTA ($p < 0.001$). The proportion of patients receiving hemodialysis at CIIM increased from 5.8% to 12.5% ($p = 0.046$).

Mean ICU stay after S-CA increased from 4.1 ± 3.8 to 5.2 ± 4.9 days ($p = 0.027$). Despite more extensive diagnostics and longer hospitalization, there were no significant differences in overall survival or survival with good neurological outcome (CPC 1/2).

4) Causes of S-CA

Respiratory causes were the leading etiology of S-CA. In S-OHCA, respiratory causes accounted for 67.3% of arrests in 2010/2011 and 55.9% in 2022/2023. In S-IHCA, respiratory causes contributed 45.8% and 46.7% in the first and second periods, respectively.

The second most common group of causes were infections, sepsis, and septic shock not originating in the respiratory system. Other causes were less frequent or varied between years. Notable among them were suicide attempts in OHCA in the second period (9.7%), hemorrhagic shock in IHCA in the first period (12.0%), and neurological causes in OHCA in the second period (8.6%).

5. Discussion

The main finding underlining the relevance of our research is the increasing incidence of secondary cardiac arrest (S-CA). We demonstrated this upward trend for out-of-hospital and overall secondary cardiac arrests, but not for in-hospital cardiac arrests. At the same time, the incidence of primary cardiac arrests is declining. Our results are in line with some foreign studies, such as Hess, Campbell, and White [7], while others, e.g. Kitamura et al. [1], did not confirm an increasing trend in secondary cardiac arrests. This discrepancy may be explained by the findings of Moriwaki et al., who retrospectively identified a higher incidence of secondary cardiac arrests than originally estimated, suggesting that some studies may have underestimated the true incidence [8].

The increasing proportion of secondary cardiac arrests is likely related to major advances in diagnostics and treatment. Severely ill patients with multiple comorbidities now survive longer than in the past, but their physiological reserves are often exhausted, making them more vulnerable to sudden events such as infections or bleeding and leading to higher risk of cardiac arrest and poorer outcomes. In parallel, the decline in primary cardiac arrests probably reflects better prevention and management of cardiovascular disease: greater awareness of healthy lifestyle, effective lipid-lowering therapies, new heart failure drugs and more accessible surgical procedures allow us to remove or mitigate causes of primary cardiac arrest before it occurs [7]. However, we cannot control the conditions leading to secondary cardiac arrest as efficiently as cardiovascular risk factors.

We did not observe significant differences in patient age between the two periods, although cardiac arrest occurred in slightly younger patients in 2022/2023. The sex distribution changed more clearly: in 2010/2011 there were more female patients, whereas in 2022/2023 males predominated, which is consistent with foreign data for both OHCA and IHCA [1,2,9–11].

In our study, the incidence of secondary OHCA increased significantly between 2010/2011 and 2022/2023 among all secondary cardiac arrests. In Ljubljana, more than half of OHCA patients do not survive and die at the scene [12]; those who survive resuscitation are admitted to hospital and enter the registry as OHCA. Survival in the field depends primarily on resuscitation. We showed that bystander CPR increased significantly, from 23% of cases in 2010/2011 to 63% in 2022/2023. This

improvement is closely linked to innovations in the dispatch system, in which dispatchers recognize cardiac arrest, give CPR instructions, and stay on the line until the emergency team arrives. Similar trends have been reported by Hess, Campbell, and White [7]. Greater public awareness of cardiac arrest signs, the chain of survival, and the importance of immediate resuscitation likely explains this increase in lay resuscitation and, consequently, the higher number of patients who survive OHCA and are admitted to hospital.

Despite this, the time from call to arrival of the emergency team in secondary OHCA did not change significantly and remains close to 10 minutes, which approaches the limit for irreversible brain damage in the absence of bystander CPR [13]. Earlier system limitations and geographic factors contribute to this. Although some organizational improvements were introduced, our results indicate that pre-hospital response time remains a critical weak point.

The proportion of secondary IHCA among all secondary cardiac arrests significantly decreased between 2010/2011 and 2022/2023. This suggests that, despite increasing hospital burden and staff shortages, the quality of in-hospital care and recognition of critically ill patients has improved. Hospitalized patients are older, more comorbid and hospitalized longer than before, yet secondary IHCA occurs less frequently, indicating successful prevention and better management of internal medical conditions.

The duration of ACLS to ROSC is on average shorter in secondary IHCA than in secondary OHCA, mainly because hospital staff can start ACLS immediately, whereas in the field recognition, the emergency call and lay CPR precede professional care. Lay CPR is less effective than ACLS, so ACLS in OHCA usually starts later and lasts longer.

The most common causes of secondary cardiac arrest in both periods were respiratory diseases (bacterial and viral infections) and pulmonary embolism, often accompanied by aspiration. Other causes (malignant tumors, bronchial obstruction, advanced lung disease, ventilator malfunction) were less frequent. Poisoning with drugs, alcohol, or narcotics occurred occasionally, mainly in suicide attempts. Electrolyte and volume disturbances were mainly observed in patients on chronic dialysis, and we recorded several iatrogenic complications. Most studies likewise identify respiratory diseases, pulmonary embolism, and overdose as leading causes of secondary cardiac arrest [1,2,7,14]. Trauma, drowning, and traffic accidents are underrepresented in our cohort because such patients are admitted to a different intensive care unit, so direct comparison with studies including these groups is limited. In general, comparisons are difficult due to the heterogeneity of secondary cardiac arrest and differences in inclusion criteria between healthcare systems.

Temperature management after cardiac arrest changed between the two periods. Following the pivotal hypothermia studies and the 2010 ERC guidelines, CIIM routinely implemented mild induced hypothermia (MIH), so 2010/2011 represent the "MIH period" [15,16]. Later evidence failed to confirm a clear advantage of hypothermia over strict normothermia [17–21], and the 2021 ERC and ESICM guidelines now recommend normothermia with active fever prevention as the preferred approach [22]. Accordingly, CIIM used normothermia with active fever prevention up to 37.5°C in 2022/2023, with hypothermia reserved for selected cases. Due to these changes, the two periods are not directly comparable with respect to temperature management.

We observed a statistically significant increase in the number of examinations performed after cardiac arrest (secondary OHCA, IHCA, and total S-CA), mainly due to more frequent head CT scans used in neuroprognostication and increased use of chest/abdominal CT/CTA and other imaging methods, reflecting both different etiologies and better availability. The proportion of coronary angiographies did not change significantly, as this examination is primarily relevant in primary cardiac arrests and only in selected secondary cases.

Findings on survival

Routine neuroprognostication at CIIM was introduced only in 2017. In 2010/2011 neurological outcomes were mostly assessed indirectly by awakening, which limits comparability between periods. From the data available, we did not find significant differences in neurological impairment; however, in 2022/2023 we recorded more CPC 4 outcomes. In the earlier period, more patients died

early due to lack of bystander CPR or severe brain damage already present at admission, so neurological outcome could not always be determined.

Despite more intensive treatment (more diagnostics, wider use of antibiotics and vasopressors, and a higher number of admitted patients), survival and survival with good neurological outcome (CPC 1/2) after secondary OHCA did not improve and were even poorer in the later period (40.0% in 2010/2011 vs. 25.8% in 2022/2023). These rates are not directly comparable to other studies, as we only included patients who survived resuscitation and were admitted to CIIM [1,2,7]. Our findings suggest that most physical and neurological damage occurs before hospital admission, mainly due to delays in bystander CPR and ACLS. In addition, patients—especially men—may present to hospital later in the course of their illness, a trend exacerbated by the COVID-19 pandemic and limited access to primary care.

In contrast, in secondary IHCA we observed longer treatment in 2022/2023 and a statistically significant improvement in survival ($p=0.048$) in patients receiving more aggressive and prolonged treatment compared with 2010/2011, although survival with good neurological outcome (CPC 1/2) did not differ significantly. Literature reports overall IHCA survival most commonly between 15% and 20%, but rarely differentiate primary from secondary causes and usually include all resuscitation attempts, making direct comparison with our data difficult [23,24]. The persistently modest survival after secondary IHCA is likely explained by the fact that these arrests occur in older, multimorbid, and severely ill patients whose reserves are limited and who tolerate the additional stress of cardiac arrest and hospitalization poorly.

To our knowledge, this is one of the first studies to systematically compare consecutive secondary out-of-hospital (S-OHCA) and in-hospital cardiac arrests (S-IHCA). Most foreign studies either focus only on S-OHCA or S-IHCA, or analyse primary and secondary cardiac arrests together [7,9–12,23–26]. It is also, to our knowledge, the first Slovenian study addressing both S-OHCA and S-IHCA, providing a unique picture of this growing problem in our healthcare system.

6. Conclusions

The incidence of cardiac arrest of non-cardiac origin in Slovenia has been increasing through the years. Better hospital treatment results in better overall survival and a lower incidence of in-hospital cardiac arrests. More patients with out-of-hospital cardiac arrests are nowadays being resuscitated by lay bystanders in the field, so patients' survival to hospital admission is higher. The proportion of male patients is increasing, age is not changing significantly. Despite better diagnosis processes, new treatments and improved knowledge, the survival and neurological outcome of patients have not improved significantly.

COMMENT ON OUR STUDY

Our design was retrospective, using data from the CIIM patient registry. This simplified planning and execution, as data were already collected, allowed comparison of two longer time periods with different treatment principles in the same department, and provided a relatively large sample with good statistical power. No additional questionnaires or patient contact were required.

However, the retrospective approach has limitations. Because all information was recorded previously, we could not verify its accuracy, and some variables were missing or estimated (e.g. ACLS duration). Times to emergency team arrival did not include the delay from collapse to the emergency call or the duration of dispatcher–witness communication. Although 306 patients were included, subdivision into groups reduced numbers for some comparisons (e.g. sex), so some trends were not statistically significant. A larger, multicentre Slovenian cohort including more years would likely reveal additional significant differences.

Further limitations are inherent to S-CA itself. These patients represent a highly heterogeneous population with almost individual aetiologies. Even when causes are grouped (e.g. respiratory vs. neurological), comparison is difficult. Many patients were polymorbid, making it hard to attribute cardiac arrest to a single factor. Some died shortly after admission, before diagnostics could be

completed, and in a few cases bloodstream infection was documented without an identifiable primary focus.

Comparison of the two periods is also influenced by changes in therapy. In 2010/2011, targeted temperature management relied on hypothermia, while in 2022/2023 normothermia with fever prevention was standard and hypothermia was rare. Neuroprognostication, now a key element of post-arrest care, was not routinely performed in the first period, limiting comparability of neurological outcomes beyond CPC 1/2.

Despite these limitations, our study offers an important overview of S-CA in the Slovenian healthcare system and shows a significantly increasing incidence, particularly of S-OHCA, with a decrease in S-IHCA. This pattern reflects spatial and staffing constraints in hospitals, leading to more critically ill patients deteriorating outside hospital. At the same time, the marked rise in bystander resuscitation highlights the success of public CPR education and has given more patients a chance to survive out-of-hospital cardiac arrest, potentially with a good neurological outcome.

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