Clinical paper

Incidence and case ascertainment of treated in-hospital cardiac arrest events in a national quality registry – A comparison of reported and non-reported events

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Abstract

Background: Approximately 2500 in-hospital cardiac arrest (IHCA) events are reported annually to the Swedish Registry of Cardiopulmonary Resuscitation (SRCR) with an estimated incidence of 1.7/1000 hospital admissions. The aim of this study was to evaluate the compliance in reporting IHCA events to the SRCR and to compare reported IHCA events with possible non-reported events, and to estimate IHCA incidence.

Methods: Fifteen diagnose codes, eight Classification of Care Measure codes, and two perioperative complication codes were used to find all treated IHCA in 2018–2019 at six hospitals of varying sizes and resources. All identified IHCA events were cross-checked against the SRCR using personal identity numbers. All non-reported IHCA events were retrospectively reported and compared with the prospectively reported events.

Results: A total of 3638 hospital medical records were reviewed and 1109 IHCA events in 999 patients were identified, with 254 of the events not found in the SRCR. The case completeness was 77% (range 55–94%). IHCA incidence was 2.9/1000 hospital admissions and 12.4/1000 admissions to intensive care units. The retrospectively reported events were more often found on monitored wards, involved patients who were younger, had less comorbidity, were often found in shockable rhythm and more often achieved sustained spontaneous circulation, compared with in prospectively reported events.

Conclusion: IHCA case completeness in the SRCR was 77% and IHCA incidence was 2.9/1000 hospital admissions. The retrospectively reported IHCA events were found in monitored areas where the rapid response team was not alerted, which might have affected regular reporting procedures.

Keywords: Cardiac arrest, Cardiopulmonary resuscitation, Registries, Hospitals, Incidence, Do not resuscitate order

Introduction

The number of in-hospital cardiac arrest (IHCA) registries has increased in the last decades, but is still small compared with the number of out-of-hospital registries. 1 There are few studies that have evaluated the completeness of IHCA registries. The Danish In-hospital Cardiac Arrest Registry is estimated to cover 80% of all IHCA events. 2 In Norway, 32% of all events in 14 ICUs at Oslo University Hospital were reported to the Norwegian Cardiac Arrest Registry in 2013. 3 The case completeness of out-of-hospital cardiac arrest (OHCA) events in the Swedish Registry of Cardiopulmonary Resuscitation (SRCR) has been evaluated and 23–25% of such events were not reported. 4,5 These events involved patients who were older and did not get cardiopulmonary resuscitation (CPR) from bystanders at the same frequency, but had a higher survival rate, compared with prospectively reported OHCA events. 5

The SRCR is a national quality registry established in 1990. 6 The registry first covered OHCA only, but has included IHCA at the Sahlgrenska University Hospital since 1994. 7 From January 1, 2005, the SRCR has included national data from Swedish hospitals with a rapid response team (RRT) and an intensive care unit (ICU)
(n = 76). Currently, approximately 2500 IHCA events are reported annually. With an estimated incidence of 1.7/1000 hospital admissions. All patients that enter the hospital alive and are treated for a cardiac arrest inside a hospital, after the neonatal period, should be reported to the SRCR. Treated IHCA events in all in-hospital locations should be reported, including ICUs and operation theatres. Treatment is defined as the delivery of chest compressions and/or defibrillation and return of spontaneous circulation (ROSC) is defined as sustained circulation of 20 consecutive minutes. All subsequent IHCA events should result in new entries. Patients with a do-not-attempt CPR (DNACPR) decision should not be reported in the registry. The reporting procedure is web-based and is performed by healthcare professionals at three occasions: in connection to the cardiac arrest event, after 30 days, and after three to six months. In connection to the cardiac arrest event, data concerning date and time of collapse, witnessed status, initial rhythm, given treatment, and immediate patient outcome are noted on paper templates or reported digitally by the attending healthcare professionals at the scene. Data after 30 days concern patient outcome, comorbidity, probable etiology of arrest, and neurological function of surviving patients using the Cerebral Performance Category (CPC) score. After three to six months, patient-reported outcome measures are reported. Designated healthcare professionals at each hospital perform the data reporting after 30 days and after three to six months.

The case completeness of IHCA events in the SRCR has not been evaluated previously and is currently unknown. It is possible that there are non-reported events, which would affect the incidence of IHCA as well as the data validity. The aim of this study was to evaluate compliance in reporting IHCA events to the SRCR and to compare reported IHCA events with any non-reported events, and to estimate the incidence of IHCA.

Methods

Design and setting

This retrospective cross-sectional observation study included ten hospitals through purposeful sampling to capture a variation in geographic location, hospital size, hospital resources, and provided levels of care. However, four of the hospitals reported that they lacked resources for extractions and therefore had to be excluded. The remaining six hospitals provided 24/7 care, had ICUs, and had RRTs that responded to cardiac arrests calls. All but one had a percutaneous coronary intervention (PCI) unit. Three hospitals had medical emergency teams (METs) that responded to patients at risk of deterioration on general wards, Table 1.

Data collection

This study used data from hospital medical records and the SRCR from January 1, 2018, to December 31, 2019. Fifteen International Classification of Diseases 10th revision Swedish edition (ICD-10-SE) codes as secondary diagnosis, eight Classification of Care Measure codes, and two complication codes for cardiac arrest/CPR in the perioperative or postoperative period from the Swedish PeriOperative Registry (SPOR) were used to find all patients who had potentially been treated for an IHCA (Fig. 1). The codes were chosen by consensus among the authors. All hospital medical records that contained documentation of any of these codes, and hospital medical records of prospectively reported IHCA events during the study period, were extracted. All hospitals used electronic medical records and the extractions were either printed on paper, digital files or monitoring in hospital medical records. The hospital medical records were reviewed by the main author. All adults and children after the neonatal period who were treated for an IHCA were identified. Patients with an IHCA that was not treated and neonates were excluded. All identified IHCA events were cross-checked against the SRCR using the Swedish personal identity number (PIN). Designated healthcare professionals at each hospital reviewed all non-reported events (not found in the SRCR) and reported the events to the SRCR (retrospective reporting). The retrospectively reported data were then extracted from the SRCR. The numbers of hospital admissions, in-patient beds, and in-hospital deaths were collected from an administrative unit at each hospital and from the Swedish Intensive Care Registry. Information on IHCA reporting procedures were retrieved from local CPR coordinators. Methods and results are reported using the Utstein template and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for cross-sectional studies.

Table 1 – Description of included hospitals during the years 2018–2019.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Hospital 2</th>
<th>Hospital 3</th>
<th>Hospital 4</th>
<th>Hospital 5</th>
<th>Hospital 6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU admissions</td>
<td>78,480</td>
<td>84,803</td>
<td>48,169</td>
<td>51,800</td>
<td>57,665</td>
<td>20,667</td>
</tr>
<tr>
<td>Beds total</td>
<td>3596</td>
<td>4410</td>
<td>1648</td>
<td>1746</td>
<td>1345</td>
<td>1153</td>
</tr>
<tr>
<td>ICU beds</td>
<td>533</td>
<td>783</td>
<td>328</td>
<td>327</td>
<td>321</td>
<td>111</td>
</tr>
<tr>
<td>PCI unit</td>
<td>56</td>
<td>32</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>MET</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Hospital deaths</td>
<td>2250</td>
<td>2040</td>
<td>1400</td>
<td>831</td>
<td>1292</td>
<td>398</td>
</tr>
</tbody>
</table>

All numbers are presented as frequencies. ICU: intensive care unit, PCI: percutaneous coronary intervention. MET: medical emergency team (responds to patients at risk of deterioration on general wards).
and the number of patients who received treatment with immediate survival. The remaining proportion was considered DNACPR. Possible differences between prospectively and retrospectively reported events were analyzed using the chi-squared test for categorical variables and the Mann-Whitney U test for age. Chronic kidney disease was defined as an estimated glomerular filtration rate <60 ml/min/1.73 m², taking sex, age, and serum creatinine into account, using the Lund Malmo formula LMR18.16 The total proportion of missing items in the sample was 2%, though it was 18% in the variable regarding contact with a MET. Missingness was considered as missing at random. Multiple imputation by chained equations with 50 iterations in 50 datasets was used to obtain complete data for regression analysis. As some patients had more than one IHCA event, the analysis of potential predictors for non-reported IHCA events (not being found in the SRCR) was performed with generalized estimating equations using logistic regression with an independent correlation matrix. A pooled multiple regression model with all potentially important variables from 50 imputed datasets using Rubin’s rules was analyzed. Both univariate and multivariate estimates were presented and all independent variables with \( p < 0.05 \) in the multiple model were considered significant predictors. The independent variables survival at 30 days and CPC score at discharge had a strong correlation \( (r = 0.9) \) and CPC score at discharge was therefore excluded from the multiple model. Model performance was evaluated with the Hosmer-Lemeshow’s test and the area under the curve, where a value of >0.7 was considered acceptable. Eight variables regarding place of arrest, initial rhythm, date of arrest, witnessed status, cause of arrest, electrocardiogram (ECG) monitoring, defibrillation before arrival of the RRT, and mechanical chest compressions were validated regarding data completeness (proportion of completed items) and data correctness (proportion of items consistent with information in medical records). Analyses were performed with IBM SPSS Statistics, version 28, and R: A language and environment for statistical computing, using RStudio: Integrated Development for R.

**Ethical considerations**

The study was granted ethical approval by the Swedish Ethics Review Authority in Stockholm, dnr 2021-04102, with amendment dnr 2021-06339-02 and was registered at ClinicalTrialsGov, ID NCT05184972. The extraction of PINs was necessary to cross-check data in medical records and registries. After cross-checking, the data were coded and anonymized. Informed consent is obtained from all living patients by the registries, but it was deemed not feasible to obtain informed consent regarding the extraction of data from hospital medical records. The study was performed in accordance with the Declaration of Helsinki.17

**Results**

A total of 901 IHCA events were prospectively reported to the SRCR at the six hospitals during the study period. Seven events were found to be duplicates and 39 events were not IHCA events based on information in hospital medical records, which resulted in a total of 855 extracted events. A total of 3638 hospital medical records were reviewed and 1109 IHCA events in 999 patients were identified, with 254 of the events not found in the SRCR after cross-checking. This resulted in a total case completeness of 77%, range 55–94%. Of all identified IHCA events, 118 (11%) were found at emergency departments. The overall incidence of IHCA at the six hospitals during the study period was 2.9/1000 hospital admissions and the incidence at ICUs was 12.4/1000 ICU admissions. The proportion of DNACPR was 89% (Table 2) which are excluded from the registry. Seventy-five patients (8%) had two or more IHCA events during hospitalization (ranging from two to eight arrests).

A majority (87%) of the retrospectively reported events were found in monitored areas, mainly in ICUs, PCI units, and operating rooms, and a majority of those did not result in a RRT call.
The main finding of this study was that the case completeness of ambulance. Three large hospitals with a high number of admissions previously evaluated OHCA events in that a majority of the events were all IHCA events reported to the SRCR during the time period. The younger patients who had less documented history of comorbidity, reported IHCA events were found in monitored areas and involved 2.9/1000 hospital admissions. A majority of the retrospectively evaluated IHCA in the SRCR was 77% and the incidence of IHCA was reported (retrospectively reported) were no alert to the RRT, lower survival at 30 days, having no previous comorbidity, and the event occurring among the retrospectively reported vs. 73 years among the prospectively reported (\( p = 0.03 \)), with no significant difference in initial rhythm. The retrospectively reported events were more often related to a subsequent arrest than the prospectively reported events (23% vs. 6%, \( p < 0.001 \)). The predictors of a non-reported IHCA event (retrospectively reported) were no alert to the RRT, lower survival at 30 days, having no previous comorbidity, and the event occurring on a monitored ward, Table 4.

The overall data completeness and data correctness of all items of eight variables was high, 93% and 95%, (Table A.1). The reporting procedures differed between the hospitals. Hospitals with lower case completeness had digital reporting performed by the attending healthcare professional at the time of the IHCA (Table A.2). Table A.3 shows the initial sample of IHCA events extracted from the SRCR and the complete sample after the review.

**Discussion**

The main finding of this study was that the case completeness of IHCA in the SRCR was 77% and the incidence of IHCA was 2.9/1000 hospital admissions. A majority of the retrospectively reported IHCA events were found in monitored areas and involved younger patients who had less documented history of comorbidity, were more often found in VT/VF, and more often achieved ROSC.

The IHCA sample in this study represented approximately 20% of all IHCA events reported to the SRCR during the time period. The retrospectively reported IHCA events in this study resembled the previously evaluated OHCA events in that a majority of the events were witnessed and the patients were monitored in wards versus in an ambulance. Three large hospitals with a high number of admissions per year had the lowest case completeness. At these hospitals, reporting was performed online at the time of the arrest by the attending healthcare professionals. Some CPR coordinators reported recurring problems with signing in to the registry’s webpage, which could be a reason for low compliance and indicate the need for back-up routines. Despite all three hospitals reporting methods to ascertain case completeness, some IHCA events were missed. This could be due to a lack of documentation of diagnosis codes or classification of care measure codes in hospital medical records. Also, high workload can contribute to missing data or missed events in the SRCR. The RRT was usually not called, mainly because members of the RRT were already present. This could perhaps affect the usual reporting procedures. A malfunctioning hospital CPR organization and lack of knowledge or confusion regarding reporting procedures and guidelines could also contribute to missing cases.

To our knowledge, there is no previous similar study that evaluates the validity of a national IHCA registry and therefore there is no comparability at present. Other emergency care registries like the Swedish Trauma Registry have shown a case completeness of 44%, with overall data completeness of 88.5%. and two Swedish hospital-based stroke registries have shown case completeness of 82% and 91% of all identified cases, respectively. Other large trauma registries have reported varying case completeness of 60–97%. The national DANARREST registry in Denmark was evaluated in 2017 based on the number of cardiac arrest calls at all hospitals. It showed great variation in number of calls and should be interpreted with caution considering that a cardiac arrest call is not always made and not all calls pertain to true cardiac arrest events. The data completeness in the DANARREST was very high (97%), but – to our knowledge – data correctness has not been evaluated. The incidence of IHCA in Swedish ICUs has recently been estimated to 16.1/1000 admissions where admissions of patients without a PIN and admissions without information on the simplified acute physiology score were excluded. The number of hospital admissions relates to available hospital beds. Sweden is one of the countries with the lowest number of available hospital beds (2 per 1000 population) and ICU beds (5 per 100,000 population) in Europe, which may affect the admission rate, selection of patients, the proportion of DNACPR decisions, and IHCA incidence. The incidence of IHCA varies from 1.5–2.8/1000 hospital admissions in Europe to 9.7/1000 hospital admissions in the USA.
The observed variation in incidence is likely due to differences in DNACPR policies, definitions of IHCA, and data reporting and logistic difficulties. The probable cause of arrest had the lowest proportion of correctness of the validated variables in the SRCR. Before April 2018, the probable cause of arrest in the SRCR encompassed eight categories. Thereafter, the number of categories was expanded to twenty-two, which may initially have affected reporting and data correctness. There are no clear guidelines on how to uniformly categorize the cause of arrest in an IHCA registry. The cause was “unknown” or “other” in 27% of the cases in our sample and in a previous Swedish study regarding the etiology of IHCA. This may indicate a lack of appropriate categories for cause of arrest when reporting to the SRCR.

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**Clinical Implications**

A well-functioning CPR organization and clear reporting procedures and guidelines are important baseline conditions at any hospital. Nevertheless, there are IHCA events that are not reported to the SRCR. Online reporting may require a back-up system with paper templates. Documentation of ICD-10 codes and Classification of Care Measure codes related to cardiac arrest and CPR in hospital medical records is necessary, and regular reviews of previously admitted patients may be a way to discover non-reported events, especially in monitored areas of the hospital. This should preferably be done by designated healthcare professionals or CPR coordinators at each hospital. A national quality registry is a valuable source of

**Table 3 – Characteristics and factors of prospectively and retrospectively reported IHCA events.**

<table>
<thead>
<tr>
<th>Characteristics/factors</th>
<th>Prospectively reported events</th>
<th>Retrospectively reported events</th>
<th>P</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (median [IQR])</td>
<td>73 (65–80)</td>
<td>72 (64–79)</td>
<td>0.066</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>558 (65)</td>
<td>166 (67)</td>
<td>0.979</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Etiology (cardiac)</td>
<td>362 (42)</td>
<td>111 (44)</td>
<td>0.837</td>
<td>13 (1.2)</td>
</tr>
<tr>
<td>Heart failure</td>
<td>293 (34)</td>
<td>50 (22)</td>
<td>&lt;0.001</td>
<td>57 (5.1)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>238 (28)</td>
<td>51 (20)</td>
<td>0.054</td>
<td>32 (2.9)</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>437 (51)</td>
<td>85 (56)</td>
<td>0.903</td>
<td>189 (17)</td>
</tr>
<tr>
<td>Stroke</td>
<td>68 (8)</td>
<td>19 (7)</td>
<td>0.971</td>
<td>30 (2.7)</td>
</tr>
<tr>
<td>Respiratory insufficiency</td>
<td>154 (18)</td>
<td>21 (8)</td>
<td>&lt;0.001</td>
<td>43 (3.9)</td>
</tr>
<tr>
<td>Cancer</td>
<td>180 (21)</td>
<td>34 (13)</td>
<td>0.021</td>
<td>35 (3.2)</td>
</tr>
</tbody>
</table>

**Intensive care unit**

<table>
<thead>
<tr>
<th></th>
<th>Prospectively reported events</th>
<th>Retrospectively reported events</th>
<th>P</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>coronary unit</td>
<td>94 (11)</td>
<td>78 (31)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>intermediate unit</td>
<td>130 (15)</td>
<td>32 (13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>operating room</td>
<td>8 (1)</td>
<td>6 (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>emergency department</td>
<td>22 (3)</td>
<td>36 (14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCI unit</td>
<td>92 (11)</td>
<td>26 (10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>witnessed arrest</td>
<td>728 (85)</td>
<td>242 (95)</td>
<td>&lt;0.001</td>
<td>6 (0.5)</td>
</tr>
<tr>
<td>alert to the RRT</td>
<td>724 (85)</td>
<td>96 (38)</td>
<td>&lt;0.001</td>
<td>3 (0.2)</td>
</tr>
<tr>
<td>contact with MET *</td>
<td>109 (16)</td>
<td>58 (27)</td>
<td>&lt;0.001</td>
<td>199 (17.9)</td>
</tr>
<tr>
<td>ECG monitored</td>
<td>535 (63)</td>
<td>216 (85)</td>
<td>&lt;0.001</td>
<td>23 (2.1)</td>
</tr>
<tr>
<td>time of day (daytime)†</td>
<td>427 (50)</td>
<td>121 (48)</td>
<td>0.418</td>
<td>10 (0.9)</td>
</tr>
<tr>
<td>on-call hours‡</td>
<td>510 (60)</td>
<td>150 (59)</td>
<td>0.866</td>
<td>0 (0)</td>
</tr>
<tr>
<td>day of the week (weekday)§</td>
<td>648 (76)</td>
<td>200 (79)</td>
<td>0.330</td>
<td>0 (0)</td>
</tr>
<tr>
<td>holiday period (weekend)</td>
<td></td>
<td>146 (17)</td>
<td>54 (21)</td>
<td>0.128</td>
</tr>
<tr>
<td>hospital (university hospital)</td>
<td>443 (52)</td>
<td>161 (63)</td>
<td>0.001</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

**Missing**

ROSC: return of spontaneous circulation (alive at the termination of cardiopulmonary resuscitation), CPC: Cerebral Performance Classification, VT/VF: pulseless ventricular tachycardia/ventricular fibrillation (first advice from automated external defibrillator), RRT: rapid response team.

* Contact with a medical emergency team (MET) or anesthetist during the preceding 24 h,
† 07:00 a.m.–5:00 p.m.,
‡ Weekends and 5:01 p.m.–06:59 a.m. on weekdays,
§ Monday–Friday,
|| Weeks 51–1 and 26–32.
information which constitutes a base for research and treatment guidelines and is also an important indicator of guideline compliance.

Limitations
The quality and contents of the documentation in in-hospital medical records varied. In some cases, it was not possible to retrospectively report all variables to the SRCR due to lack of information. The resources for retrospective data reporting to the SRCR were limited at one of the hospitals; these IHCA events were therefore reviewed by the main author and a co-author. Access to the ICU documenting system is limited and it was not included in the search procedure at all hospitals, which may have impacted the identification of IHCA in ICUs in our study. Four of the ten included hospitals did not have the necessary resources to provide data extractions and were therefore excluded. This may be a source of selection bias. Also, the selection of codes and a lack of documented diagnose codes associated with cardiac arrest or CPR may have influenced our results. It is therefore reasonable to assume that there were some IHCA events that were not identified in this study which may have affected the estimated incidence and outcome.

Conclusions
The case completeness of the SRCR was 77% and the IHCA incidence was 2.9/1000 hospital admissions. A majority of the retrospectively reported IHCA events were found on monitored wards and the RRT was usually not alerted, which might have affected regular reporting procedures. Back-up systems for reporting, documentation of ICD-10 codes and Classification of Care Measure codes in hospital medical records, and regular reviews of previously admitted patients may improve case completeness.

CRediT authorship contribution statement
Jennie Silverplats: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. Björn Ång: Writing – review & editing, Methodology, Formal analysis, Conceptualization. Marie-Louise Södersved Källestedt: Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization. Anneli Strömsöe: Writing – review & editing, Supervision, Resources, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2024.110119.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2024.110119.

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