Clinical paper

Impact of holiday periods on survival following an in-hospital cardiac arrest

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Abstract

Introduction: Higher rates of mortality following an in-hospital cardiac arrest (IHCA) has been shown during nights and weekends, changes in staff density and composition has been suggested as a possible explanation. Changes in hospital staffing patterns are also common during holiday periods.

Aim: To investigate whether holiday periods are associated with decreased survival following an IHCA.

Material and methods: All patients ≥18 years who experienced an IHCA at Karolinska University Hospital between 2006 and 2019 were included. Patients were identified via and data was collected from the Swedish Registry for Cardiopulmonary Resuscitation. Holiday was defined as two periods, a seven-week summer period and an approximately two-week Christmas period. The primary outcome was return of spontaneous circulation (ROSC), secondary survival to hospital discharge. Logistic regression was performed to calculate odds ratio (OR) with 95% confidence intervals (CI), adjustment was done for known confounders.

Results: Out of 1936 registered cases, 264 (14%) occurred during holiday periods. Patient and event characteristics were similar on holidays compared to non-holidays. Both ratio for ROSC (45% and 55%, respectively) and survival (25% and 32% respectively) was poorer during holiday periods. Adjusted OR for ROSC and survival was poorer during holiday periods compared non-holiday periods (OR 0.69 [95% CI, 0.53–0.92] and OR 0.69 [95% CI, 0.49–0.96], respectively).

Conclusion: Outcomes after IHCA was poorer during holiday periods compared to non-holiday periods even if patient and event characteristics was similar. Further research is needed to better understand to what degree staffing patterns and other factors contribute to the observed difference.

Keywords: IHCA, Vacation, Cardiopulmonary Resuscitation, ROSC

Introduction

Development of resuscitative management systems have improved survival after cardiac arrest over the last decades, however survival is still low. 1 The quality of resuscitative care and survival depends in part on the development and implementation of treatment guidelines. 2 Previous research has found an association between the timing of an in-hospital cardiac arrest (IHCA) and survival, i.e. up to doubled odds for being discharged alive following an IHCA during office hours compared to outside office hours 3,4 and a similarly increased survival on weekdays compared to weekends. 5 Explanatory factors observed was more witnessed arrests and shorter interval between arrest and defibrillation during office hours. 3,6 Changes in staffing patterns between daytime and night-time are common in many hospitals, both in terms of staff density and staff expertise. 5,6 Thus, differences in survival might suggest that the quality of resuscitative care varies during different times of day, and different days of the week, and could therefore at least in part be affected by such hospital staffing factors.

A potentially similar situation, with regards to changes in hospital staffing patterns, are holiday periods. Within the Swedish healthcare system, the summer holiday period is characterized by staff shortages, overcrowded hospitals, and many junior doctors with lesser experience, annually generating extensive media coverage. In Sweden, holiday periods are by tradition relatively distinct in time. Swedish employee holiday leave benefits are regulated through the “Annual Leave Act” dated back to 1938 declaring that every employee shall be entitled to twenty-five days of annual leave in every annual leave year. Furthermore, unless otherwise agreed, annual leave dates shall be scheduled so that the employees have at least four weeks’ annual leave during the period June to August.
During the following decades, a period during which a large proportion of the workforce were industrial workers, it became customary for industries to close for the month of July hence this period became known as the “industrial holidays”. Although large companies and certainly hospitals no longer adhere to such practices, it is still highly customary for Swedish employees to schedule their summer holidays sometime from the end of June to early August. Moreover, Christmas time including New Year’s Eve is a major holiday season. Therefore, Sweden offers an ideal setting for studying the effects of holiday periods on survival following an IHCA.

To the best of the authors knowledge, it is not currently known whether there are differences in survival following an IHCA during holiday periods compared to the rest of the year. Therefore, the aim of this study was to investigate whether inpatient survival following a cardiac arrest is different during summer and Christmas vacation periods compared to the rest of the year.

Method

Study design
This hospital-based cohort study used the Swedish Registry for Cardiopulmonary Resuscitation (SRCR)8,9 as the main source to identify all IHCA at any of Karolinska University Hospitals between January 1, 2006 to December 31, 2019.

Karolinska University Hospital is located in Stockholm, which is home to approximately 2,000,000 people. Karolinska is one of five large hospitals and has two equally sized sites 30 km apart: Solna and Huddinge. The Solna site is a level one trauma unit, has neuro and thoracic surgery units and provides 24/7 angiography for ST-elevation myocardial infarctions. The Huddinge site includes a geriatric ward and relatively fewer intensive care unit (ICU) beds. Karolinska has about 1,300 beds, 108,000 admissions and 1.8 million patient visits yearly.

Study population
We defined IHCA according to the SRCR8,9 as “a hospitalised patient who is unresponsive with apnoea (or agonal, gasping respiration) where CPR and/or defibrillation have been initiated.” The inclusion criteria were all adult (18 years and older) patients who had an IHCA at Karolinska University Hospital. No patients or location of the IHCA were excluded. In the case of multiple IHCAs, only the first event per year was included.

Data collection
Registrations into the SRCR are completed in two steps online. In step one, data concerning date and time of event, age and sex of patient, time intervals from discovery to initiation of treatments, whether the event was witnessed, whether patient was monitored via electrocardiography (ECG) at time of event, place of cardiac arrest within hospital, registered first rhythm, types of treatments given, and whether the patient had return of spontaneous circulation (ROSC), is registered. In step two, data concerning co-morbidities, whether the patient was alive at hospital discharge and cerebral functioning, is registered using information from medical files.

Exposure
The study exposure was the timing of an IHCA within or outside holiday periods. Two holiday periods were considered. One including week 26–32 representing a 7-week summer holiday period. And one including December 20 to January 6 representing a Christmas holiday period. The choice of week numbers (according to the ISO8601 system) to define the summer holiday period is due to the fact that this system of time is widely spread in Sweden in general and used to schedule summer holidays in particular. Defining summer holidays in terms of week numbers offered higher validity compared to specific dates as these two do not correspond between different years. Defining the Christmas holiday period in terms of specific dates was arbitrary to approximate the period during which schools are closed as a proxy for potential changes in hospital staffing patterns. Data on the exposure were retrieved from the SRCR as the registered date of the event.

Outcome
The main outcome was ROSC, while survival to hospital discharge was the secondary outcome. The main outcome ROSC was defined as whether the patient had an own circulation with or without support when the acute resuscitative treatment ended. The secondary outcome was survival to hospital discharge, defined as whether the patient was alive when discharged from hospital. The reasoning behind these choices were that ROSC better reflects the circumstances immediately associated with the event, whereas survival to hospital discharge introduces more unknown factors as to the exact conditions surrounding an eventual death.

Ethics
All patients surviving their IHCA were asked six months afterwards for informed consent and agreed to participate in the SRCR and on-going studies based on it. The Regional Ethical Review Board in Stockholm, Sweden approved the study, Dnr 2013/1959-31.

Statistical analyses
Summary descriptive statistics were calculated for all patient and event variables.

Logistic regression modelling was performed to test for associations between exposure and outcomes and adjust for a priori decided potential confounders based on previous studies10,11 including age, sex, place of cardiac arrest and first documented heart rhythm. The presence of renal insufficiency was extracted using registry data on age, sex and pre-event, usually taken at admission to hospital, plasma creatinine levels from which estimated Glomerular Filtration Rate (eGFR) were estimated using the revised Lund-Malmö study equation.12 Renal insufficiency was defined as an eGFR < 80 ml/m21.73 m2 for patients aged 18–50 years, and eGFR < 60 ml/m21.73 m2 for patients aged > 51 years. Point estimation of odds ratios (OR) were presented with corresponding 95% confidence intervals. All model fitting was done on a complete-case basis meaning rows with missing values on any of the included variables were excluded from analysis. All statistical analyses were performed using R13 statistical software version, Foundation for Statistical Computing, Vienna, Austria.

Results
Of the 1936 events included, 1672 (86%) occurred during the non-holiday period and 264 (14%) occurred during the holiday period (Table 1). Fewer IHCA occurred during holiday periods than non-holiday periods since the ten weeks represent 19% of the time but only 14% of the IHCAs occurred in the holiday period. There were
only minor differences in patient and event characteristics between groups, diabetes was slightly more common (31% and 26%, respectively, Table 1), fewer arrests occurred daytime (34% and 39%, respectively, Table 1) during non-holiday. First documented rhythm was less often shockable during holidays (17% compared to 22%, Table 1). Fewer of the IHCA during non-holidays received antiarrhythmic drugs compared to holidays (10% and 16%, respectively, p-value 0.032, Table 1).

**Return of spontaneous circulation**
In all, fewer IHCA achieved ROSC during holidays compared to non-holidays (45% and 55%, respectively, Table 2). Both crude and adjusted OR for ROSC was poorer during holidays compared to non-holidays (0.69 [95% CI, 0.53–0.89] and 0.69 [95% CI, 0.53–0.92], respectively, Table 2). Amount of patients achieving ROSC per month was fewer during summer months and december (Supplementary Fig. 1).

**Survival**
Survival to discharge was poorer during holidays compared to non-holidays (25% and 32%, respectively, Table 2). Likewise, among patients achieving ROSC, survival to discharge was poorer during holidays compared to non-holidays (54% and 58%, respectively). Both crude and adjusted OR for survival was poorer during holidays.

### Table 1 – Characteristics of 1936 patients having a in-hospital cardiac arrest at Karolinska University Hospital 2006–2019.

|                      | Non-holiday Number (%) | Holiday Number (%) | p-value<sup>a</sup> |
|----------------------|-------------------------|--------------------|----------------------|
| **Age, years**       |                         |                    | 0.321                |
| Median (Q1, Q3)      | 72 (62, 80)             | 72 (63, 80)        |                      |
| **Sex**              |                         |                    | 0.068                |
| Female               | 558 (33)                | 102 (39)           |                      |
| Male                 | 1113 (66)               | 156 (60)           |                      |
| **Pre-existing comorbidities** |                |                    |                      |
| Congestive heart failure | 529 (32)   | 79 (30)           | 0.949                |
| Diabetes             | 444 (26)                | 81 (31)            | 0.216                |
| Myocardial infarction | 401 (24)              | 70 (27)            | 0.657                |
| Stroke               | 201 (12)                | 39 (15)            | 0.418                |
| Malignancy           | 472 (28)                | 63 (24)            | 0.267                |
| Respiratory insufficiency | 536 (32)  | 75 (29)           | 0.537                |
| Renal insufficiency  | 1042 (62)               | 166 (64)           | 0.809                |
| **Place of cardiac arrest** |                  |                    | 0.272                |
| Coronary Care Unit   | 199 (12)                | 40 (15)            |                      |
| Intensive Care Unit  | 172 (10)                | 23 (9)             |                      |
| Intermediate care unit | 30 (2)              | 4 (2)              |                      |
| Coronary laboratory  | 146 (9)                 | 14 (5)             |                      |
| Operating room       | 33 (2)                  | 3 (1)              |                      |
| Emergency department | 152 (9)                 | 29 (11)            |                      |
| General ward         | 849 (51)                | 128 (49)           |                      |
| Other incl Laboratory, Radiology department, etc. | 95 (6)    | 19 (7)            |                      |
| **Timing of cardiac arrest** |                  |                    | 0.207                |
| Mon–Fri 8 am–8 pm    | 647 (39)                | 88 (34)            |                      |
| Night/Weekend        | 881 (53)                | 145 (56)           |                      |
| Witnessed            | 1341 (80)               | 207 (80)           | 0.984                |
| ECG monitored        | 866 (52)                | 127 (49)           | 0.498                |
| Rapid Response Team (RRT) notified | 1472 (88) | 231 (89) | 0.573                |
| CPR initiated before RRT arrival | 1273 (76) | 201 (77) | 0.803                |
| Arrival of RRT delayed (i.e. after national goal, 4 minutes) | 54 (<1) | 2 (<1) |                      |
| **Defibrillation**   |                         |                    | 0.073                |
| Any attempt          | 557 (33)                | 79 (30)            |                      |
| Defibrillation performed before RRT arrival | 218 (13) | 28 (11) | 0.464                |
| Delayed (after national goal, 3 minutes) defibrillation among those with shockable first rhythm | 18 (5*) | 1 (2*) |                      |
| **First documented rhythm** |                  |                    | 0.308                |
| Ventricular fibrillation | 266 (16)         | 36 (14)           |                      |
| Ventricular tachycardia | 104 (6)              | 9 (3)             |                      |
| Pulseless electrical activity | 394 (24) | 66 (25) |                      |
| Asystole             | 576 (34)                | 91 (35)            |                      |
| **Pharmacologic intervention** |                  |                    |                      |
| Antiarrhythmic       | 275 (16)                | 26 (10)            | 0.032                |
| Epinephrine          | 1140 (68)               | 183 (70)           | 0.901                |
| Intubation           | 1027 (61)               | 161 (62)           | 0.820                |

<sup>a</sup> Percentage based on those with shockable first rhythm not the total number in column.

<sup>b</sup> p-value was calculated with chi² or Fishers exact if <5 patients per cell.

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The main findings of this study suggest that there is a decreased 
on an increased mortality following hospital admission in Taiwan dur-
formed during holiday periods. However, none of these have 
ified any possible differences in adherence to do not attempt cardiopul-
partly could explain the difference in incidence. We are not aware 
of fewer beds are open at the hospital during holiday periods, which 
19% of the time but only 14% of the IHCA occurred in the holiday 
periods than non-holiday periods since the ten weeks represent 
variations within the same hospital over time.

Discussion

The main findings of this study suggest that there is a decreased 
chance of ROSC and survival following an IHCA during holiday peri-
ods compared to the rest of the year. This was significant even 
though patient and event characteristics were similar among the 
two groups, indicating unknown or unmeasured factors.

There is a previously well-established “holiday-effect” of 
increased mortality during major holiday periods. For instance, an 
American study found an increase in mortality due to cardiovascular 
disease during the Christmas holiday period. In response, a study 
from Australia found a similar effect, presumably cancelling out any 
seasonal climactic factors since Christmas falls during summertime 
in the southern hemisphere. Similar reports have been published 
on an increased mortality following hospital admission in Taiwan dur-
ing the “Chinese New Year” and in Swedish cancer-surgery per-
formed during holiday periods. However, none of these have 
assessed whether the deaths were due to IHCA. Further, there is 
a known variation between hospitals, but none have assessed 
variations within the same hospital over time.

Interestingly, we noted that fewer IHCA occurred during holiday 
periods than non-holiday periods since the ten weeks represent 
19% of the time but only 14% of the IHCA occurred in the holiday 
period. Normally, fewer patients are admitted for planned care and 
fewer beds are open at the hospital during holiday periods, which 
partly could explain the difference in incidence. We are not aware 
of any possible differences in adherence to do not attempt cardiopul-
mory resuscitation (DNA CPR) orders between different time peri-
ods and unfortunately we lack such data. However, if staff density and/or 
experience is lower or individual workloads is higher during holi-
days there is a possibility that such differ.

In contrast to previous studies on night versus daytime, we 
found similar patient and event characteristics between holidays and 
non-holidays. Of certain interest was event characteristics such as 
witness status, ECG monitoring, start of CPR, defibrillation, and first 
documented rhythm. If staff during holiday periods have less experi-
ence and/or expertise it could result in less efficient management of 
ars. This could potentially be indicated by a lower proportion of 
cases were the rapid response team (RRT) were alerted, or lower 
rates of CPR and defibrillation attempts prior to arrival of the RRT. 
However, there was no difference in these variables between holiday 
and non-holiday, indicating an effective crucial first step in the chain 
of survival during holiday periods. Therefore, our observed difference 
ROSC and survival might relate to later steps in the chain of sur-
vival, such as availability and competence regarding intra- and post-
arrest diagnostics, interventions and treatments. Unfortunately, we 
lack such data and future studies would need to carefully a prior 
define these things before scrutinizing all medical files and clinical 
schedules for clinicians at the hospital. Within this dataset we lack 
information on duration of CPR, in order to at least screen for any dif-
ference we used data from a previous published study, this subset 
cluded 840 patients between 2007 and 2015 who received ROSC, 
among them median duration of resuscitation was 13 minutes during 
holidays compared to 10 minutes during non-holidays indicating 
longer time to ROSC which might affect the later outcome survival.

There were no major observed differences in the prevalence of 
pre-existing comorbidities of the patients between non-holiday and 
holiday periods. However, we did not have access to burden of dis-
ease. It is for example possible that patients within similar age 
groups with similar comorbidities that are less symptomatic and in 
better general physical health are more likely to be travelling or resid-
ing in holiday houses outside of the Stockholm area during the holi-
day period, and therefore not included in the current study.

Compared to the proportion of all IHCA occurring during nights 
and weekends, the proportion of IHCA occurring during the holiday 
periods is relatively smaller. Therefore, any effort to identify amen-
able factors associated with these periods would do best in focusing 
on nights and weekends. Limitations include the small number of 
cases during holiday periods, lack of information on post-ROSC care 
including intensive care and limitations in treatments, environmental 
factors such as temperature differences, which coincide with the 
defined holiday period and could affect outcomes. At least for the 
summer holiday period previous studies have found increased mor-
ality rates during heatwaves. Strengths of the study include a well-
established Utstein-based register for IHCA data as well as stable 
and regular holiday/vacation practice in Sweden, setting the study 
in a good position to study the effect of holiday leave and IHCA.

Since this was the first study on this topic, we firstly wanted to 
assess if there was an association, future studies need to assess 
the pathway better, such as change in patient mix and or staffing 
which might demand access to detailed clinical rotation schedules 
for the whole hospital.

In conclusion, this study found a decreased likelihood of survival 
following an IHCA during holiday periods compared to the rest of the 
year. Further research is needed to better understand to what degree 
staffing patterns and other factors contribute to the observed differ-
ence. These findings, if verified, might indicate a need for an educa-
tion or training of holiday staff.

CRediT authorship contribution statement

Canice Drea Persson: Conceptualization, Methodology, Data cura-
tion, Writing – original draft. Therese Djärn: Conceptualization, Writ-
ing – review & editing. Supervision. Maria Yglund Rödstrom: 
Conceptualization, Writing – review & editing, Supervision.
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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Data sharing statement

No additional data exists that is suitable for publication since data are based on medical records of individuals.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2022.100238.

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REFERENCES

1. Grasner JT, Herlitz J, Tjømeland IBM, et al. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe. Resuscitation 2021;161:61–79. https://doi.org/10.1016/j.resuscitation.2021.02.007 published Online First: 2021/03/29.
2. Hessulf F, Herlitz J, Rawshani A, et al. Adherence to guidelines is associated with improved survival following in-hospital cardiac arrest. Resuscitation 2020;155:13–21. https://doi.org/10.1016/j.resuscitation.2020.07.009 published Online First: 2020/07/25.
3. Herlitz J, Eek M, Holmberg M, et al. Characteristics and outcome among patients having out of hospital cardiac arrest at home compared with elsewhere. Heart 2002;88:579–82.
4. Peberdy MA, Ornato JP, Larkin GL, et al. Survival from in-hospital cardiac arrest during nights and weekends. JAMA 2008;299:785–92. https://doi.org/10.1001/jama.2008.202 published Online First: 2008/02/21.
5. Needleman J, Buerhaus P, Pankratz VS, et al. Nurse staffing and inpatient hospital mortality. N Engl J Med 2011;364:1037–45. https://doi.org/10.1056/NEJMsa101025 published Online First: 2011/03/18.
6. Wallace DJ, Angus DC, Barnato AE, et al. Nighttime intensivist staffing and mortality among critically ill patients. N Engl J Med 2012;366:2093–101. https://doi.org/10.1056/NEJMsa1201918 published Online First: 2012/05/23.
7. Adielsson A, Djur J, Rawshani A, et al. Changes over time in 30-day survival and the incidence of shockable rhythms after in-hospital cardiac arrest – A population-based registry study of nearly 24,000 cases. Resuscitation 2020;157:135–40. https://doi.org/10.1016/j.resuscitation.2020.10.015 published Online First: 2020/11/17.
8. Herlitz. Swedish Cardio- Pulmonary Registry- yearly report 2014. In Swedish. 2014.
9. Claesson A, Djavr T, Nordberg P, et al. Medical versus non medical etiology in out-of-hospital cardiac arrest-Changes in outcome in relation to the revised Utstein template. Resuscitation 2017;110:48–55. https://doi.org/10.1016/j.resuscitation.2016.10.019.
10. Hessulf F, Karlsson T, Lundgren P, et al. Factors of importance to 30-day survival after in-hospital cardiac arrest in Sweden – A population-based register study of more than 18,000 cases. Int J Cardiol 2018;255:237–42. https://doi.org/10.1016/j.ijcard.2017.12.068.
11. Andersson LW, Holmberg MJ, Berg KM, et al. In-Hospital Cardiac Arrest: A Review. JAMA 2019;321:1200–10. https://doi.org/10.1001/jama.2019.1696 published Online First: 2019/03/27.
12. Bjork J, Grubb A, Sterner G, et al. Revised equations for estimating glomerular filtration rate based on the Lund-Malmo Study cohort. Scand J Clin Lab Invest 2011;71:232–9. https://doi.org/10.3109/00365513.2011.557088 published Online First: 2011/03/12.
13. Statistical RCTRAfsCRIFF, Computing V, Austria. URL http://www.R-project.org/.
14. Phillips DP, Jarvinen JR, Abramson IS, et al. Cardiac mortality is higher around Christmas and New Year’s than at any other time: the holidays as a risk factor for death. Circulation 2004;110:3761–8. https://doi.org/10.1161/01.CIR.0000151424.02045.F2 published Online First: 2004/12/15.
15. Afoakwah C, Ngiem S, Scuffham P, et al. Weather Trumps Festivity? More Cardiovascular Disease Events Occur in Winter than in December Holidays in Queensland, Australia. Int J Environ Res Public Health 2021;18. https://doi.org/10.3390/ijerph181910158 published Online First: 2021/10/14.
16. Lin SM, Wang JH, Huang LK, et al. Does the 'Chinese New Year effect’ exist? Hospital mortality in patients admitted to internal medicine departments during official consecutive holidays: a nationwide population-based cohort study. BMJ Open 2019;9:e025762. https://doi.org/10.1136/bmjopen-2018-025762 published Online First: 2019/04/22.
17. Lagergren J, Mattsson F, Lagergren P. Prognosis following cancer surgery during holiday periods. Int J Cancer 2017;141:1971–80. https://doi.org/10.1002/ijc.30899 published Online First: 2017/07/22.
18. Stankovic N, Andersen LW, Granfeldt A, et al. Hospital-level variation in outcomes after in-hospital cardiac arrest in Denmark. Acta Anaesthesiol Scand 2022;66:273–81. https://doi.org/10.1111/aas.14008 published Online First: 2021/12/07.
19. Skrifvars MB, Castren M, Aune S, et al. Variability in survival after in-hospital cardiac arrest depending on the hospital level of care. Resuscitation 2007;73:73–81. https://doi.org/10.1016/j.resuscitation.2006.08.022 published Online First: 2007/01/26.
20. Herlitz J, Bang A, Aune S, et al. Characteristics and outcome among patients suffering in-hospital cardiac arrest in monitored and non-monitored areas. Resuscitation 2001;49:125–35.
21. Olomu UR, Basnet S, Berger A, et al. Trends in Survival After In-Hospital Cardiac Arrest During Nights and Weekends. J Am College Cardiol 2018;71:402–11. https://doi.org/10.1016/j.jacc.2017.11.043 published Online First: 2018/02/02.
22. Rohlin O, Taeri T, Netzer tribute A, et al. Duration of CPR and impact on 30-day survival after ROSC for in-hospital cardiac arrest-A Swedish cohort study. Resuscitation 2018;132:1–5. https://doi.org/10.1016/j.resuscitation.2018.08.017.
23. Astrom C, Bjelkmar P, Forsberg B. High mortality during the 2018 heatwave in Sweden. Lakartidningen 2019;116. published Online First: 2019/06/14.