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Clinical paper

Impact of the COVID-19 pandemic on in-hospital cardiac arrests in the UK

Julia M. Edwards[a,*], Jerry P. Nolan[b,c], Jasmeet Soar[d], Gary B. Smith[e], Emily Reynolds[f], Jane Carnall[g], Kathryn M. Rowan[a], David A. Harrison[a], James C. Doidge[a]

[a] Intensive Care National Audit & Research Centre (ICNARC), Napier House, 24 High Holborn, London WC1V 6AZ, UK
[b] Warwick Clinical Trials Unit, University of Warwick, Coventry CV4 7AL, UK
[c] Royal United Hospital, Bath BA1 3NG, UK
[d] Southmead Hospital, North Bristol NHS Trust, Bristol BS10 5NB, UK
[e] Centre of Postgraduate Medical Research & Education (CoPMRE), Faculty of Health & Social Sciences, Bournemouth University, Bournemouth, Dorset BH31 3LT, UK
[f] Liverpool Hospital, Elizabeth Street, Liverpool, NSW 2170, Australia
[g] Manchester University NHS Foundation Trust, Oxford Road Campus, Oxford Road, Manchester M13 9WL, UK

Abstract

Aims: To compare in-hospital cardiac arrest (IHCA) rates and patient outcomes during the first COVID-19 wave in the United Kingdom (UK) in 2020 with the same period in previous years.

Methods: A retrospective, multicentre cohort study of 154 UK hospitals that participate in the National Cardiac Arrest Audit and have intensive care units participating in the Case Mix Programme national audit of intensive care**.** Hospital burden of COVID-19 was defined by the number of patients with confirmed SARS-CoV2 infection admitted to critical care per 10,000 hospital admissions.

Results: 16,474 patients with IHCA where a resuscitation team attended were included. Patients admitted to hospital during 2020 were younger, more often male, and of non-white ethnicity compared with 2016–2019. A decreasing trend in IHCA rates between 2016 and 2019 was reversed in 2020. Hospitals with higher burden of COVID-19 had the greatest difference in IHCA rates (21.8 per 10,000 admissions in April 2020 vs 14.9 per 10,000 in April 2019). The proportions of patients achieving ROSC $\geq$ 20 min and surviving to hospital discharge were lower in 2020 compared with 2016–19 (46.2% vs 51.2%; and 21.9% vs 22.9%, respectively). Among patients with IHCA, higher hospital burden of COVID-19 was associated with reduced survival to hospital discharge (OR = 0.95; 95% CI 0.93 to 0.98; $p < 0.001$).

Conclusions: In comparison with 2016–2019, the first COVID-19 wave in 2020 was associated with a higher rate of IHCA and decreased survival among patients attended by resuscitation teams. These changes were greatest in hospitals with the highest COVID-19 burden.

Keywords: In hospital cardiac arrest, COVID-19, Cardiopulmonary resuscitation, National clinical audit

Introduction

Evidence suggests an impact of SARS-COV-2 infection on the risk of in-hospital cardiac arrest (IHCA) and the processes of care and patient outcomes following IHCA.[1,2] In the United Kingdom (UK), measures to help hospitals cope with the pandemic included cancelling elective surgery, discharging many hospital patients, and preparing for an increase in patients requiring respiratory support, all of which may have altered the case mix of the inpatient popula-

Abbreviations: IHCA, In-Hospital Cardiac Arrest, ROSC, Return of Spontaneous Circulation, ICU, Intensive Care Unit, NCAA, National Cardiac Arrest Audit, CMP, Case Mix Programme

* Corresponding author.
E-mail address: julia.edwards@icnarc.org (J.M. Edwards).

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tion. Additionally, hospital staff were deployed to more acute, and often less familiar, clinical areas. These changes may have impacted rates of IHCA, resuscitation processes, and patient outcomes. Although previous studies have reported the outcomes of IHCA among patients with SARS-COV-2 infection,[1,3] the impact of the COVID-19 pandemic on the incidence and outcome of IHCA in the UK has not been documented.

The primary objective was to compare rates of IHCA during the first COVID-19 wave in 2020 with the same period between 2016 and 2019, irrespective of the COVID-19 status of patients, and to compare these rates between hospitals participating in the UK National Cardiac Arrest Audit (NCAA) according to their level of COVID-19 burden. Secondary objectives were to compare characteristics of IHCA patients, resuscitation processes and patient outcomes following IHCA during the first COVID-19 wave in 2020 with previous years and between hospitals according to each hospital's burden of COVID-19.

Methods

Data

NCAA collects data from individuals aged over 28 days who receive at least one chest compression and/or defibrillation from a resuscitation event commencing in-hospital and where a hospital-based resuscitation team has attended in response to a 2222 call[4] (2222 is the number used by UK hospitals to call the resuscitation team in response to a cardiac arrest. (The term 'cardiac arrest call' is used henceforth). NCAA also collects hospital-level data on total monthly admissions to hospital, teaching status and geographical location. Intensive Care Unit (ICU) admissions of patients were identified through the Intensive Care National Audit and Research Centre's (ICNARC's) Case Mix Programme (CMP) database, the national audit of adult general ICUs. The COVID-19 status of patients admitted to ICU is captured by the ICNARC CMP database and this was used to define hospital level of COVID-19 burden because we do not have data on the COVID-19 status of patients not admitted to ICU.

We included data from hospitals participating in NCAA that reported at least five cardiac arrest team visit records between 1st March and 31st May 2020 and in 2016–19, and which housed at least one ICU participating in the CMP. The period 1st March–31st May 2020 was chosen to coincide with the first wave of ICU admissions to hospitals in the UK, and four comparator years (2016–19) was considered sufficient to establish the baseline. The analysis was restricted to hospitals in England, Wales and Northern Ireland as Scottish ICUs are served by a separate clinical audit. Data from all cardiac arrests in eligible hospitals were used, unless otherwise specified.

Admissions to ICUs with COVID-19 provide an indicator of hospital burden that is robust to variation in testing practices over time and between regions/hospitals, given mandated routine testing in UK ICUs since March 2020. In the primary analysis, hospital burden of COVID-19 is reported as the number of patients with confirmed COVID-19 admitted to any ICU within the hospital between 1st March 2020 and 31st May 2020 per 10,000 hospital admissions during the same period. Hospital burden of COVID-19 is reported on a continuous scale, and also categorised into three equally sized groups (tertiles) of hospitals reflecting lower, medium and higher hospital burden. Hospital burden of COVID-19 is set to zero for arrests occurring between 2016 and 2019.

Statistical Methods

Patient demographics, IHCA characteristics, resuscitation processes and outcomes were summarised by period (March to May 2020 vs March to May 2016–19). Differences in proportion or mean values between 2020 and 2016–19 were plotted against hospital burden of COVID-19. Multilevel logistic regression was used to model survival to hospital discharge using hospital burden of COVID-19 and year as continuous fixed effects and hospital as a random effect.

Rates of IHCA were calculated as the number of IHCA per 10,000 hospital admissions per calendar month and illustrated graphically using one line per year between 2016 and 2020. Multilevel negative binomial regression was used to estimate incidence rate ratios (IRR) for the number of arrests with hospital burden of COVID-19 category and year as continuous fixed effects, hospital as a random effect, and number of hospital admissions as the exposure variable.

A sensitivity analysis was conducted to explore the definition of hospital burden of COVID-19 by using total ICU admissions instead of total hospital admissions as the denominator.

All analyses were conducted using Stata 16.1 (StataCorp, Texas).

Ethical approval

ICNARC has approval to hold patient identifiable data under section 251 of the NHS Act 2006. Section 251 of the NHS Act 2006 makes provision for the use of patient identifiable information in the interests of improving patient care and in the public interest.

Results

A total of 17,341 eligible IHCAs in 16,474 patients across 154 hospitals were reported in NCAA between 1st March (00:00) and 31st May (23:59) in 2016–2020. Full details are provided in Fig. 1.

Rates of in-hospital cardiac arrests

Rates of IHCA are illustrated in Fig. 2, overall (2a) and by hospital level of COVID-19 burden (2b). Between 2016 and 2019, the overall rate decreases over time, starting at 16.8 per 10,000 hospital admissions in March 2016, dropping to 9.7 per 10,000 hospital admissions by May 2019 (Fig. 2a). Despite a decrease in the number of IHCAs, rates of IHCA per 10,000 hospital admissions were consistently higher in all three months in 2020 compared with 2019, with a sharp rise in rate of IHCA in April 2020 (14.3 per 10,000 admissions).

Hospitals with higher COVID-19 burden in 2020 also had higher rates of IHCA between 2016 and 2019 (Fig. 2b). In hospitals with lower hospital burden of COVID-19, rates remained similar between 2019 and 2020 in March and April but are slightly higher in May. Hospitals with higher burden of COVID-19 had the greatest difference in rates of IHCA, with 21.8 per 10,000 admissions in April 2020, compared with 14.9 per 10,000 admissions in April 2019.

Modelling using a multilevel negative binomial regression showed the underlying time trend from 2016 has been of decreasing rates of IHCA over time (IRR = 0.90 per year; 95% CI [0.88, 0.91]; $p < 0.001$). However, an increase in IHCA rates can be seen with increasing levels of hospital burden of COVID-19 (IRR = 1.05 for each additional patient admitted to ICU with COVID-19 per 100 hospital admissions; 95% CI [1.04, 1.07]; $p < 0.001$).

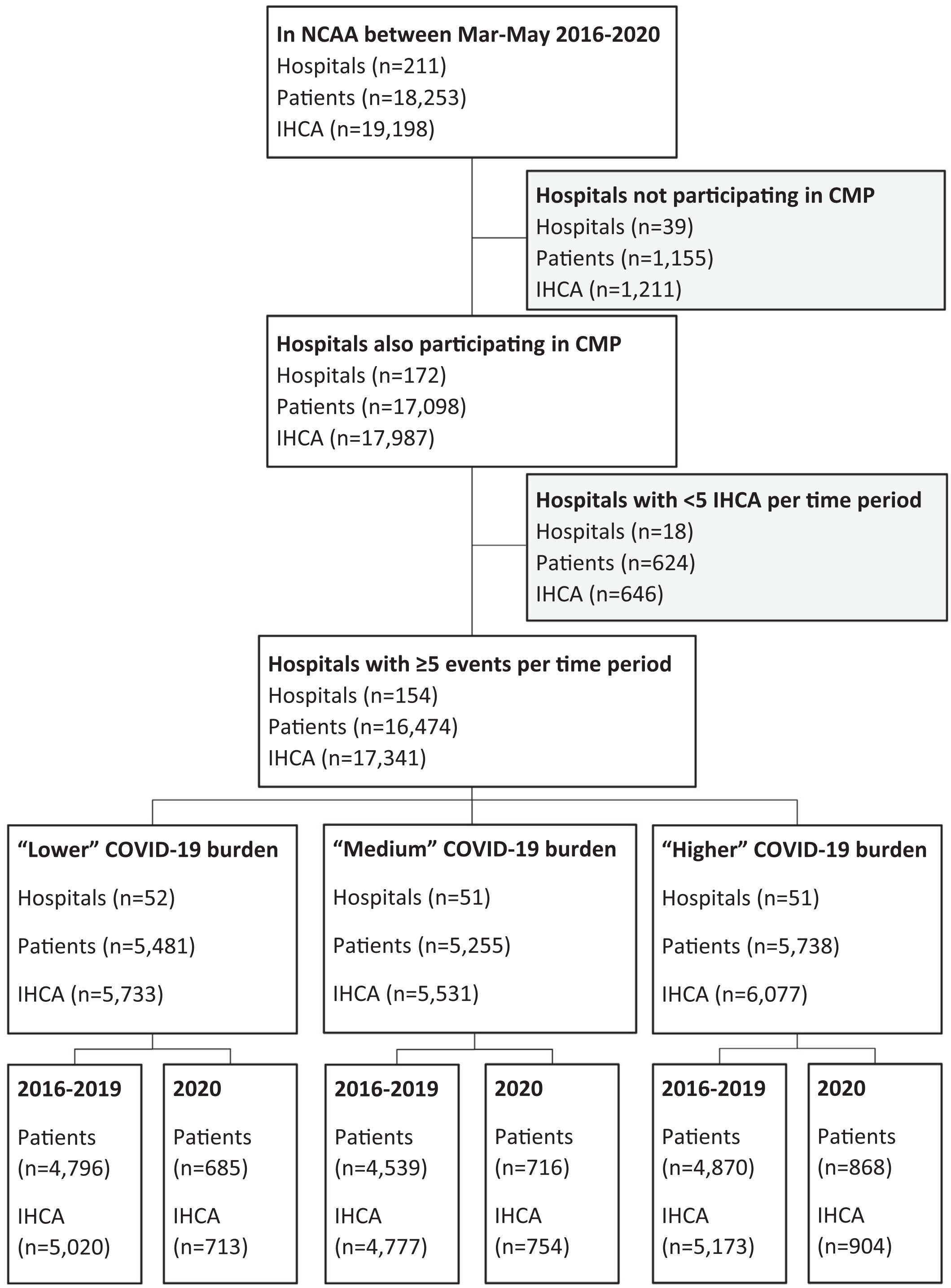

Fig. 1 – Flowchart of data selection for inclusion in the analysis. CMP = Case Mix Programme; NCAA = National Cardiac Arrest Audit; IHCA = In-hospital cardiac arrest.

Patient characteristics and cardiac arrest details

The characteristics of patients with IHCA are summarised by period in Table 1. Where applicable, only the first cardiac arrest for each patient is used. Patients were younger in 2020 compared with 2016–2019, and a slightly higher proportion were male (63.9% vs 60.1%). There was a decrease in White patients (74.0% vs 80.6%) and a small increase in all other ethnic groups. Reasons for hospital attendance remained similar between the two time periods.

Characteristics of the IHCAs are summarised in Table 2. Compared with 2016–2019, there was a small increase in percentage of arrests occurring in the emergency department, in a treatment area, or in a critical/coronary care unit in 2020. There was a decrease in percentage of arrests occurring on a ward. There were no differences between 2020 and 2016–19 in percentage of arrests occurring on weekdays or at weekends, and in the daytime or the night.

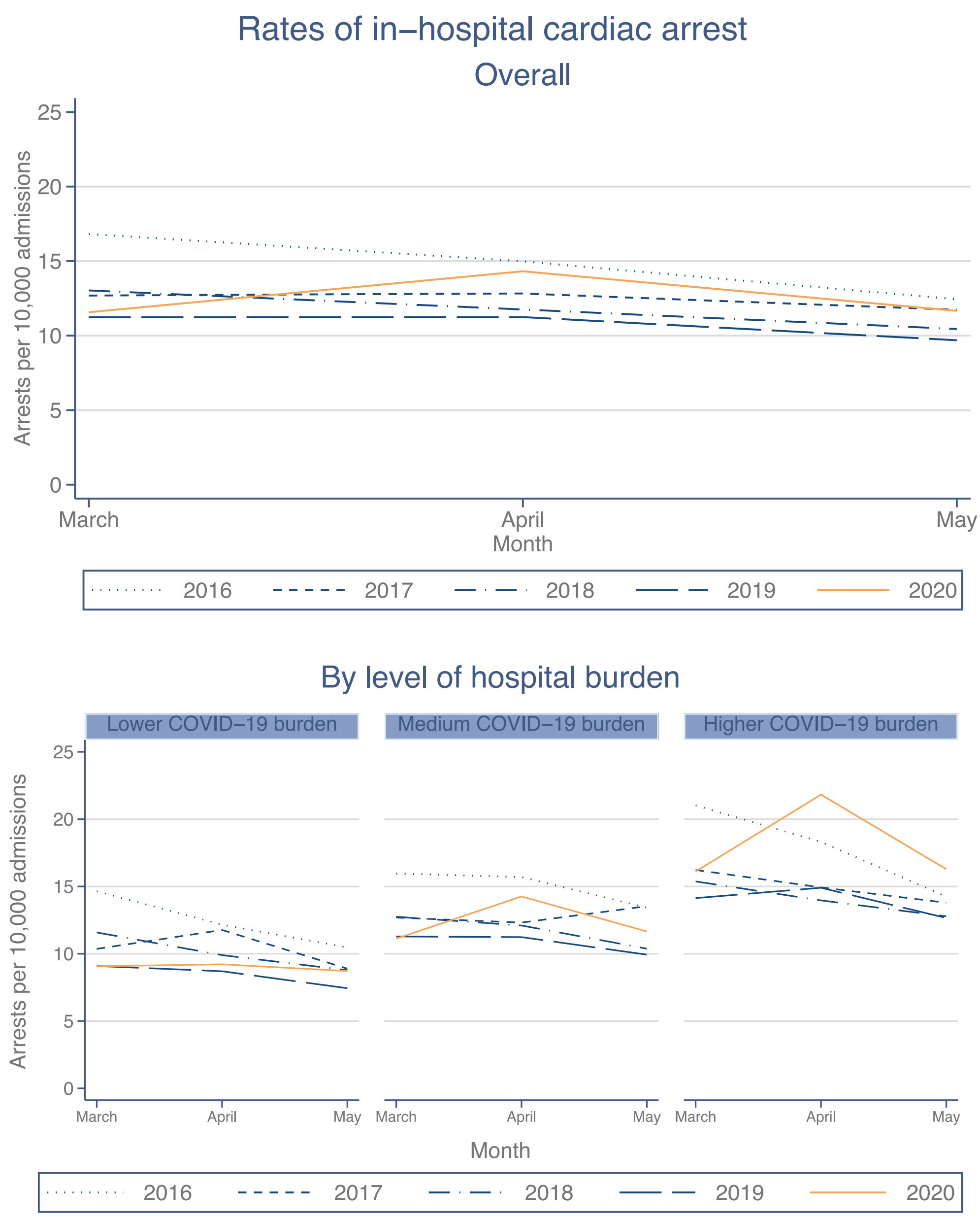

Fig. 2 – Rates of cardiac arrest per 10,000 hospital admissions between 2016 and 2020; (a) overall, and (b) by level of COVID-19 burden.

Patients in 2020 had a slightly shorter time between admission and first IHCA (median = 1 day (IQR: 0,5) compared with median = 2 days (IQR: 0,7) in 2016–19). There was a small increase in percentage of arrests having a shockable rhythm in 2020 (18.4% vs 17.7% in 2016–19).

Characteristics for the 154 hospitals included in the analysis are summarised by hospital burden of COVID-19 in Table 3. Hospitals with lower burden of COVID-burden were mainly non-university hospitals (55.8%) and had the highest mean number of hospital admissions per hospital per month in both 2016–19 and 2020. Almost half of the hospitals with higher hospital burden of COVID-19 were in London (49.0%) and were University or University-affiliated (66.7%). Higher burden hospitals also had the lowest mean number of hospital admissions per hospital per month in 2016–19 and in 2020.

Outcomes

Outcomes for patients and IHCAs are summarised by period in Tables 1 and 2 respectively. Mean duration of resuscitation attempt increased to 17.0 minutes in 2020, compared with 16.3 minutes in 2016–2019.

The proportions of patients achieving return of spontaneous circulation (ROSC) $\geq$ 20 min and survival to hospital discharge were lower in 2020 (46.2% and 21.9%, respectively) compared with 2016–19 (51.2% and 22.9%, respectively).

Hospital survival by year is presented in Fig. 3(a), and percentage difference in hospital survival between 2020 and 2016–19 is shown by hospital burden of COVID-19 in Fig. 3(b). The underlying linear time trend on hospital survival increased over time (OR = 1.07 per year; 95% CI [1.04, 1.11]; p < 0.001). However, increasing hospital burden of COVID-19 was associated with an adjusted decrease in

Table 1 – Patient details and outcomes- first cardiac arrest per patient.

Patient details	2016–2019 (N = 14,205)	2020 (N = 2,269)
Age, years *[N]*	*[N = 14203]*	*[N = 2268]*
Mean (SD)	71.4 (16.3)	66.5 (17.0)
Median (IQR)	75 (64, 83)	70 (57, 79)
Sex, n (%)	*[N = 14204]*	*[N = 2269]*
Male	8536 (60.1)	1449 (63.9)
Ethnicity, n (%)	*[N = 14205]*	*[N = 2269]*
White	11,444 (80.6)	1680 (74.0)
Mixed	118 (0.8)	29 (1.3)
Asian	865 (6.1)	165 (7.3)
Black	278 (2.0)	90 (4.0)
Other	230 (1.6)	61 (2.7)
Not stated	1270 (8.9)	244 (10.8)
Reason for hospital attendance, n (%)	*[N = 14203]*	*[N = 2269]*
Trauma	391 (2.8)	57 (2.5)
Medical	11,842 (83.4)	1921 (84.7)
Elective surgery	786 (5.5)	103 (4.5)
Emergency surgery	913 (6.4)	148 (6.5)
Other	271 (1.9)	40 (1.8)
Patient outcomes	**2016–2019 (N = 14,205)**	**2020 (N = 2,269)**
ROSC $\geq$ 20 mins following (first) IHCA? n (%)	7269 (51.2)	1048 (46.2)
Length of hospital stay following first arrest[†] (days)		
Mean (SD)	17.9 (26.0)	14.6 (20.9)
Median (IQR)	9 (3, 22)	8 (3, 17)
Additional cardiac arrest[†]? n (%)	594 (4.2)	82 (3.6)
Survived to hospital discharge? n (%)	3258 (22.9)	498 (21.9)

[†] Summary statistics displayed for patients who achieved ROSC > 20 minutes following their (first) cardiac arrest.

hospital survival (OR = 0.95 for each additional patient admitted to ICU with COVID-19 per 100 hospital admissions; 95% CI [0.93, 0.98]; p < 0.001).

Sensitivity analyses

When redefining hospital burden of COVID-19 level using total ICU admissions as the denominator, the category of burden increased for 41 hospitals, decreased for 29, and did not change for 81. Three hospitals had insufficient information and were excluded. Rates of IHCA by hospital burden of COVID-19 using the number of ICU admissions as the denominator, as opposed to total hospital admissions, are provided in the supplementary material. Whilst rates of IHCA decreased in the higher and medium COVID-19 burden groups, rates for lower burden level increased. The higher burden group retained the highest rate of IHCA of the three groups in 2020, with a sharp peak in April of 19.1 per 10,000 hospital admissions.

Of the 154 hospitals included in the primary analysis, 75 responded with an estimated number of missed IHCA per quarter. Of the 75 hospitals that responded, six hospitals reported having potentially unreported IHCA, ranging from 1-9 (mean = 5.1 events). While the highest number of missed events came from hospitals with the highest burden of COVID-19, the smallest number of missed events were reported in hospitals with medium burden of COVID-19.

Discussion

The first wave of the COVID-19 pandemic was associated with an altered case mix of patients with IHCA compared with previous years, with patients attended by resuscitation teams in 2020 being younger and more often male or of non-White ethnicity. There was also an increased rate of IHCA, which was most pronounced among hospitals with higher burden of COVID-19. Proportions of patients achieving ROSC $\geq$ 20 min and surviving to hospital discharge were lower in 2020 than in equivalent periods in 2016 to 2019. The greatest decrease in survival rates occurred in hospitals with a higher burden of COVID-19.

Although the rate of IHCA increased during the first wave of the pandemic, the total number of IHCAs decreased compared with previous years, possibly because there were fewer overall hospital admissions during the pandemic.

With increased pressure on hospitals in 2020 due to the pandemic and the redeployment of many staff, we were concerned that some IHCAs may not have been reported to NCAA. Hospitals were asked to provide an estimate of unreported IHCAs per month in 2020 (if any), although the impact was found to be minimal.

Before the COVID-19 pandemic, there was a decreasing trend in the rate of IHCA and increasing survival over time. Having accounted for this trend, our analysis has shown an adjusted association between hospital burden of COVID-19 and a decreased hospital survival during the first wave of the pandemic. Our findings support those of a recent publication using data from a U.S. registry[5] and one other single-centre study.[6] The reasons for poorer outcomes might include the impact of COVID-19 disease itself (i.e., worse outcomes associated with cardiac arrest caused by COVID-19) or delays caused by the need to put on enhanced personal protective equipment (PPE) before starting CPR (chest compressions and airway interventions are considered aerosol generating procedures).[7,8] Delays caused by the need to put on PPE potentially impact all inpatients during a pandemic because COVID-19 status is often unknown. Unfortunately, we do not have data on the time from cardiac arrest to the start of chest compressions.

There was no difference between 2016–2019 and 2020 in the distribution of cardiac arrest rhythms. This differs from data from a US

Table 2 – Cardiac arrest details and outcomes – all cardiac arrests.

Cardiac arrest details	2016–2019 (N = 14,970)	2020 (N = 2,371)
Location of arrest*, n (%)		
Emergency department	1347 (9.0)	288 (12.2)
Ward	9180 (61.4)	1312 (55.4)
Treatment area	1404 (9.4)	252 (10.6)
Critical/coronary care unit	2797 (18.7)	480 (20.3)
Other	222 (1.5)	38 (1.6)
Time between admission and (first) cardiac arrest, days [N]	*[N = 14203]*	*[N = 2269]*
Mean (SD)	6.1 (12.3)	5.2 (12.9)
Median (IQR)	2 (0, 7)	1 (0, 5)
Presenting first documented rhythm		
Shockable, n (%)	2645 (17.7)	436 (18.4)
VF, n (% of shockable)	*1775 (67.1)*	*285 (65.4)*
VT, n (% of shockable)	*792 (29.9)*	*143 (32.8)*
Shockable; unknown rhythm, n (% of shockable)	*78 (2.9)*	*8 (1.8)*
Non-shockable	11,176 (74.7)	1737 (73.3)
Asystole, n (% of non-shockable)	*2993 (26.8)*	*508 (29.2)*
PEA, n (% of non-shockable)	*7853 (70.3)*	*1179 (67.9)*
Bradycardia, n (% of non-shockable)	*57 (0.5)*	*7 (0.4)*
Non-shockable; unknown rhythm, n (% of non-shockable)	*273 (2.4)*	*43 (2.5)*
Unknown/Never determined	1149 (7.7)	198 (8.4)
Cardiac arrest outcomes	**2016–2019 (N = 14,970)**	**2020 (N = 2,371)**
Duration of resuscitation attempt [N]	*[N = 14819]*	*[N = 2362]*
Mean (SD)	16.3 (20.8)	17.0 (18.6)
Median (IQR)	10 (4, 21)	12 (4, 24)
Reason resuscitation ended, n (%)		
ROSC $\geq$ 20 min	7858 (52.5)	1116 (47.1)
Dead	7110 (47.5)	1255 (52.9)

ROSC = Return of Spontaneous Circulation; VF = Ventricular Fibrillation; VT = Ventricular Tachycardia; PEA = Pulseless Electrical Activity; DNAR = Do Not Attempt Resuscitation.

* Treatment area includes theatre & recovery, imaging department, cardiac catheter laboratory and other specialist treatment area; Critical/coronary care includes intensive care unit (adult or paediatric), high dependency unit (adult or paediatric), or coronary care unit; Other includes obstetrics area, clinic, non-clinical area and other intermediate care area.

Table 3 – Hospital characteristics by COVID-19 burden grouped in tertiles.

	Lower COVID-19 burden (N = 52)	Medium COVID-19 burden (N = 51)	Higher COVID-19 burden (N = 51)
Hospital type, n (%)			
University	12 (23.1)	13 (25.5)	21 (41.2)
University affiliated	11 (21.2)	3 (5.9)	13 (25.5)
Non University	29 (55.8)	35 (68.6)	17 (33.3)
Region, n (%)			
East of England	7 (13.5)	3 (5.9)	7 (13.7)
London	1 (1.9)	1 (2.0)	25 (49.0)
Midlands	8 (15.4)	10 (19.6)	7 (13.7)
North East and Yorkshire	11 (21.2)	16 (31.4)	2 (3.9)
North West	2 (3.8)	11 (21.6)	4 (7.8)
South East	8 (15.4)	10 (19.6)	4 (7.8)
South West	15 (28.8)	0 (0.0)	1 (2.0)
Wales	0 (0.0)	0 (0.0)	1 (2.0)
Admissions per hospital per month (2016–2019)			
Mean (SD)	7909 (3892)	6646 (2537)	5934 (2648)
Median (IQR)	6697 (5264, 9609)	6722 (4436, 8312)	5647 (4407, 7224)
Admissions per hospital per month (2020)			
Mean (SD)	5283 (2925)	4223 (1905)	3505 (1854)
Median (IQR)	4396 (3274, 6658)	3937 (2856, 5368)	3152 (2259, 4499)

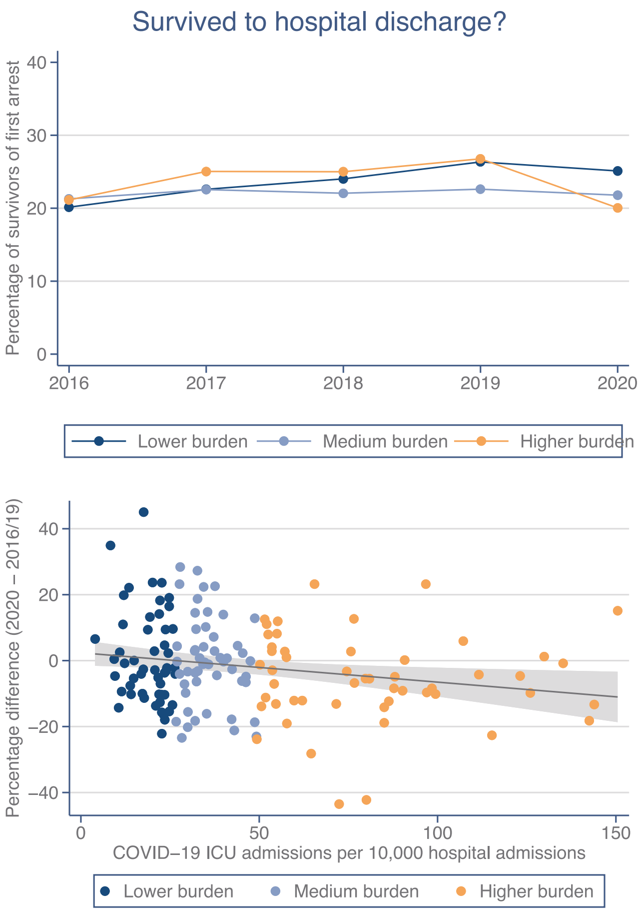

Fig. 3 – (a) Percentage of patients surviving to hospital discharge by year and level of COVID-19 burden (b) Percentage difference in hospital survival between 2016–19 and 2020 by level of COVID-19 burden, unadjusted regression line, and 95% confidence intervals (shaded region).

registry which indicate an increase in non-shockable rhythms during the pandemic period.[5] Other studies of IHCA during the COVID-19 pandemic have documented an increase in the proportion of non-shockable rhythms but are studies of patients with confirmed COVID-19 infection unlike our study which involved all patients with an IHCA.[1]

There is some evidence that use of do-not-attempt cardiopulmonary resuscitation (DNACPR) decisions during the COVID-19 pandemic has increased[9] but based on our data, this has not been associated with a decrease in the incidence of IHCA. A large UK study conducted during the first wave of the COVID-19 pandemic showed that most patients who had an early DNACPR decision did not actually have a cardiac arrest.[9]

NCAA includes most acute hospitals in the UK, increasing the generalisability of our findings. Several other studies have documented relatively low survival rates among COVID-19 patients with IHCAs[2,10–12] but our study provides greater insight into the impact of the COVID-19 pandemic in the UK on IHCA incidence and outcome in general.

We do not know the COVID-19 status of the patients in our study and have used hospital burden of COVID-19 as a surrogate to evaluate the impact of the COVID-19 pandemic on all IHCAs for which a cardiac arrest team was called.

Due to the scope of data collection in NCAA, we studied only those cases where a cardiac arrest call was made. This will have included nearly all IHCAs in ward areas but will have excluded many of the IHCAs in critical care areas where the sickest patients were cared for, because cardiac arrest calls are often not made from these areas.

NCAA does not capture data on the time between onset of cardiac arrest and the start of CPR, which makes it impossible to determine whether the requirement to put on enhanced PPE led to a delay in the onset of chest compressions during the COVID-19 pandemic in 2020. The impact of any potential delay in starting chest compressions because of the need to put on PPE is worthy of further study.

Conclusions

In comparison with the same period in 2016–2019, the first COVID-19 wave in 2020 was associated with a higher rate of IHCA and decreased rates of ROSC $\geq$ 20 min and survival to hospital discharge. The changes in rate of IHCA and survival were more pronounced in hospitals with the highest burden of COVID-19.

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Patient involvement

Patient representation in the NCAA and CMP steering groups.

Author contributions

Julia M.Edwards: Conceptualization, Formal Analysis, Methodology, Writing - original draft, Writing - review and editing. **Jerry P. Nolan:** Conceptualization, Writing - original draft, Writing - review and editing. **Jasmeet Soar:** Writing - original draft, Writing - review and editing. **Gary B.Smith:** Writing - original draft, Writing - review and editing. **Emily Reynolds:** Writing - original draft, Writing - review and editing. **Jane Carnall:** Writing - review and editing. **Kathryn M. Rowan:** Conceptualization, Writing - review and editing. **David A. Harrison:** Conceptualization, Formal Analysis, Methodology, Writing - review and editing. **James C.Doidge:** Conceptualization, Formal Analysis, Methodology, Writing - original draft, Writing - review and editing.

All authors critically reviewed the manuscript and approved the final version to be published and agree to be accountable for all aspects of the work.

Compliance with ethical standards

ICNARC has approval to hold patient identifiable data under section 251 of the NHS Act 2006. Approval is granted by the Confidentiality

Advisory Group (CAG) within the Health Research Authority (HRA). The approval number for NCAA is ECC 2–06(n)/2009. The approval number for the CMP is PIAG 2–10(f)/2005.

Section 251 of the NHS Act 2006 makes provision for the use of patient identifiable information in the interests of improving patient care and in the public interest. Section 251 support is reviewed annually by CAG within the HRA.

Availability of data and material

Access to the National Cardiac Arrest Audit data underlying this paper can be requested by following the guidance here: https://www.icnarc.org/Our-Audit/Audits/Ncaa/Reports/Access-Our-Data. Access to the Case Mix Programme data can be requested by following the guidance here: https://www.icnarc.org/Our-Audit/Audits/Cmp/Reports/Access-Our-Data.

Declaration of Competing Interest

JN is an executive committee member of Resuscitation Council UK, an editor of Resuscitation and receives payment from Elsevier.

JS is an executive committee member of Resuscitation Council UK, an editor of Resuscitation and receives payment from Elsevier.

No other authors declare any conflicts of interest.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2022.02.007.

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