Association between the COVID-19 pandemic in 2020 and out-of-hospital cardiac arrest outcomes and bystander resuscitation efforts for working-age individuals in Japan: a nationwide observational and epidemiological analysis

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ABSTRACT

Background Improving out-of-hospital cardiac arrest (OHCA) prognosis within the working-age population is important, but no studies have investigated the effects of COVID-19 pandemic specifically on the working-age population with OHCA. We aimed to determine the association between the 2020 COVID-19 pandemic and OHCA outcomes and bystander resuscitation efforts among the working-age population.

Methods Prospectively collected nationwide, population-based records concerning 166,538 working-age individuals (men, 20–68 years; women, 20–62 years) with OHCA between 2017 and 2020 were assessed. We compared characteristics and outcome differences of the arrests between three prepandemic years (2017–2019) and the pandemic year 2020. The primary outcome was neurologically favourable 1-month survival (cerebral performance category 1 or 2). Secondary outcomes were bystander cardiopulmonary resuscitation (BCPR), dispatcher-assisted instruction for cardiopulmonary resuscitation (DAI-CPR), bystander-provided defibrillation (public access defibrillation (PAD)) and 1-month survival. We examined variations in bystander resuscitation efforts and outcomes among pandemic phase and regional classifications.

Results Among 149,300 OHCA cases, 1-month survival (2020, 11.2%; 2017–2019, 11.1% (crude OR (cOR) 1.00, 95% CI 0.97 to 1.05)) and 1-month neurologically favourable survival (7.3%–7.3% (cOR 1.00, 95% CI 0.96 to 1.05)) were unchanged; however, the neurologically favourable 1-month survival rate decreased in 12 of the most COVID-19-affect ed prefectures (7.2%–7.8% (cOR 0.90, 95% CI 0.85 to 0.96)), whereas it increased in 35 other prefectures (7.5%–6.6% (cOR 1.15, 95% CI 1.07 to 1.23)). Favourable outcomes decreased for OHCA of presumed cardiac aetiology (10.3%–10.9% (cOR 0.94, 95% CI 0.90 to 0.99)) but increased for OHCA of non-cardiac aetiology (2.5%–2.0% (cOR 1.27, 95% CI 1.12 to 1.44)). BCPR provision increased from 50.7% of arrests pre-pandemic to 52.3% (cru de OR 1.07, 95% CI 1.04 to 1.09). Compared with 2017–2019, home-based OHCA in 2020 increased (64.8% vs 62.3% (crude OR 1.12, 95% CI 1.09 to 1.14)), along with DAI-CPR attempts (59.5% vs 56.6% (cOR 1.13, 95% CI 1.10 to 1.15)) and multiple calls to determine a destination hospital (16.4% vs 14.5% (cOR 1.16, 95% CI 1.12 to 1.20)). PAD use decreased from 4.0% to 3.7% but

WHAT IS ALREADY KNOWN ON THIS TOPIC

- Out-of-hospital cardiac arrest (OHCA) prognosis in working-age individuals tends to be more favourable than in other age groups.
- Systematic reviews have shown that neurologically favourable 1-month and 1-month overall survival rates in patients with OHCA worsened in areas heavily affected early in the COVID-19 pandemic.
- Improving OHCA prognosis within the working-age population is socially and economically important, but no studies have investigated the effects of the COVID-19 pandemic specifically on the working-age population with OHCA.

INTRODUCTION

National responses to the COVID-19 pandemic, including strict social containment measures, have differed among countries and have influenced citizens’ lifestyles and social activities. In Japan, the Ministry of Health, Labour and Welfare instructed the Japanese population to avoid the ‘3 Cs’ (closed spaces with poor ventilation, crowded places and close contact settings) and decided on a ‘basic policy for countermeasures against new coronavirus infectious diseases’. Many businesses introduced remote working and short and staggered working hours, restricted travel across prefectures and allowed non-essential workers to work from home. The after-work activities of workers were also reduced due to bar and restaurant closures, and social movements in non-essential businesses were repeatedly restricted in 2020. In prefectures declaring a state of emergency, the governors could order or request restaurants and amusement

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facilities to close or shorten their business hours and order or request that they refrain from holding events or reduce their scale. Therefore, residents and companies were subjected to many restrictions during the state of emergency in those areas.2

Previous studies have reported the overall effect of the COVID-19 pandemic on prehospital care for patients with out-of-hospital cardiac arrest (OHCA). However, observational study results concerning the association between the COVID-19 pandemic and bystander cardiopulmonary resuscitation (BCPR) rates are inconsistent. Recent systematic reviews have shown that OHCA outcomes (ie, neurologically favourable 1-month survival and 1-month overall survival) worsened and that BCPR and public access defibrillation (PAD) rates were reduced in countries with high infection rates.3 4 However, one recent Japanese study reported a positive association between the COVID-19 pandemic and BCPR rates in Tokyo.5

Lifestyle changes were most significant in the working-age population despite the small number of severe cases of COVID-19-related infections and deaths in this population during the first pandemic year in 2020.67 Under normal circumstances, OHCA are mostly witnessed in individuals of working age because such individuals are more likely to be surrounded by other people during commuting and working hours. This cohort is more likely to receive BCPR and to have a favourable prognosis.8

Improving the OHCA prognosis within the working-age population is socially and economically important. However, no studies have investigated the effects of the COVID-19 pandemic specifically on working-age adults with OHCA. This study aimed to determine the association between the COVID-19 pandemic in 2020 and OHCA outcomes and related prehospital factors (bystander resuscitation efforts and emergency medical services (EMS) factors) among working-age adults with OHCA in Japan.

WHAT THIS STUDY ADDS
⇐ In this analysis of registry data, we found that the association between the COVID-19 pandemic in 2020 and OHCA outcomes varied, depending on the state of emergency, region, OHCA aetiology and witness status.
⇐ Overall 1-month neurologically favourable survival remained unchanged during the COVID-19 pandemic, but the neurologically favourable 1-month survival rate decreased in the 12 prefectures in Japan significantly affected with COVID-19, as well as in those with OHCA of presumed cardiac aetiology, and survival increased in those with unwitnessed OHCA.
⇐ Bystander cardiopulmonary resuscitation (CPR) and dispatcher-assisted instruction for cardiopulmonary resuscitation (DAI-CPR) increased, but public access defibrillation (PAD) use decreased during the state of emergency and in the 12 prefectures most affected by COVID-19.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY
⇐ Despite increases in CPR, neurological survival in prefectures hardest hit by COVID-19 decreased. Notably, PAD use also decreased in these prefectures during the state of emergency. This suggests that placement of automated external defibrillators in areas that are unlikely to be restricted, as well as aggressive DAI-CPR, may improve survival rates during natural disasters or pandemics when people’s behaviour and movements are restricted.

METHODS
Study design
In this retrospective study, a comprehensive database was created through combining and reconciling two nationwide databases on OHCA and EMS transportation in Japan.

Population
We defined a working-age group as the age at which >50% of the population was employed (men, 20–68 years; women, 20–62 years). This working-age group represented 50.7% of the total population in Japan 2020.9

Setting
In Japan, ambulance crews determine the severity and type of injury and disease and select suitable emergency hospitals for transport. Hospitals can decline to take a patient when there is a justifiable reason based on each hospital’s resources and situation. Ambulance crews cannot start patient transportation until a receiving hospital has been determined.

For patients with OHCA, EMS personnel follow protocols established by the Regional Medical Control Council based on Japan Resuscitation Council guidelines.10 Authorised paramedics are permitted to insert tracheal tubes and administer intravenous epinephrine in adult OHCA. Termination of resuscitation rules do not exist in the prehospital setting in Japan. Unless a patient with OHCA is dead (such as in a decapitation scenario) or exhibits postmortem changes, EMS personnel continue resuscitation until arrival at the hospital.

Data collection
Data concerning working-age patients with OHCA recorded between 1 January 2017 and 31 December 2020 were extracted from the All-Japan Utstein-style Registry11 of the Japanese Fire and Disaster Management Agency (FDMA). A comprehensive database was created by combining and reconciling FDMA data with another FDMA transportation database comprising detailed location and in-hospital diagnosis information. After excluding EMS-witnessed cases and cases involving noprehospital resuscitation efforts, data for non-EMS-witnessed working-age patients with OHCA were analysed.

For all cases, we abstracted Utstein-style primary classifications: witnessed or unwitnessed, presumed cardiac or non-cardiac aetiology (based on the hospital’s attending physician’s clinical determination in collaboration with the EMS personnel), and shockable or non-shockable initial rhythm. In addition, pandemic-related factors were abstracted to examine interactions with the pandemic year, as follows:

⇒ Phase classification: state of emergency (7 April–25 May) versus other dates.
⇒ Regional classification: 12 significantly affected prefectures (number of COVID-19 cases/1000 populations/year >1.5: Hokkaido, Saitama, Chiba, Tokyo, Kanagawa, Aichi, Kyoto, Osaka, Hyogo, Nara, Fukuoka and Okinawa) vs 35 other prefectures.
⇒ Time-of-day classification: business hours (07:00–16:59 hours) versus others.
⇒ Location classification: OHCA at home versus other locations.
Outcome measures
The primary outcome was neurologically favourable 1-month survival (cerebral performance category 1 or 2). Secondary outcomes were BCPR, dispatcher-assisted instruction for cardiopulmonary resuscitation (DAI-CPR), bystander-provided defibrillation (PAD) and 1-month survival. In addition, we also examined variations in outcomes and bystander resuscitation efforts in terms of pandemic phase and regional classifications.

Statistical analysis
Differences in characteristics and outcomes between three prepandemic years (2017–2019) and the pandemic year 2020 were analysed using χ² tests and crude ORs (cORs) and 95% CIs, which were reported using the three prepandemic years as a reference. Univariate analyses for nominal variables were performed using χ² tests. Continuous variables did not show a normal distribution; therefore, a Wilcoxon rank-sum test was applied for univariate analyses of continuous variables. We screened for interactions between classifications for sex, location, aetiology, witness, region, time of day, initial ECG rhythm, and in terms of major characteristics and outcomes between the three prepandemic years and the pandemic year 2020, and reported these subgroups based on region, pandemic phase and aetiology. The significance level was set at α = 0.05.

Multivariable interaction tests were used to identify whether Utstein-style primary classifications, emergency phase, region, time of day and location of arrest were associated with OHCA outcomes. Multivariate logistic regression analysis, including
Factors found to be associated with OHCA outcomes, was performed to determine whether factors associated with neurologically favourable 1-month survival differed between the three prepandemic years (2017–2019) and the pandemic year 2020. All data were analysed using JMP Pro V.16 (SAS Institute, Cary, North Carolina, USA). Yearly analyses were performed using a Cochrane-Armitage trend test and multiple comparisons; results are presented in online supplemental figure 1.

**Patient and public involvement**

Patients or the public was not involved in our study’s design, conduct, reporting or dissemination plans.

**RESULTS**

**Data selection**

After excluding 16,592 EMS-witnessed cases and 646 cases without prehospital resuscitation efforts from a combined database of 166,538 cases, 149,300 non-EMS-witnessed working-age OHCA cases were selected for analysis (figure 1).

**Effects of the COVID-19 pandemic in 2020 on OHCA outcomes**

For the COVID-19 pandemic year overall in 2020, 1-month survival (cORs with three prepandemic years as the reference 1.00, 95% CI 0.96 to 1.06) and neurologically favourable 1-month survival (cOR 0.99, 95% CI 0.94 to 1.05) were unchanged compared with 2017–2019 (table 1). Cardiac aetiology was more likely to result in a favourable 1-month survival and neurologically favourable 1-month survival during the three prepandemic years than during 2020 (p<0.001, figure 2).

As changes in 2020 compared with prepandemic years, presumed cardiac aetiology was more likely than non-cardiac aetiology to reduce neurologically favourable 1-month survival rate (p<0.001) and to increase the incidence of multiple calls to determine the destination hospital (p=0.012). (online supplemental figure 1).

BCPR rates increased in both witnessed and unwitnessed OHCA during the pandemic year compared with the prepandemic period. Witnessed OHCAs were to be associated with increased BCPR rates (p=0.01) in 2020 compared with 2017–2019 (online supplemental figure 2).

Table 1 Differences in characteristics and outcomes in all working-age OHCA cases between three prepandemic years (2017–2019) and the pandemic year 2020

<table>
<thead>
<tr>
<th>Characteristics of OHCA</th>
<th>3 prepandemic years</th>
<th>Pandemic year (2020)</th>
<th>P value</th>
<th>Crude OR with 3 prepandemic years as the reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcomes, n (%)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-month survival</td>
<td>12,528 (11.1)</td>
<td>4174 (11.2)</td>
<td>0.684*</td>
<td>1.00 (0.97 to 1.05)</td>
</tr>
<tr>
<td>Neurologically favourable 1-month survival</td>
<td>8233 (7.3)</td>
<td>2712 (7.3)</td>
<td>0.832*</td>
<td>1.00 (0.96 to 1.05)</td>
</tr>
<tr>
<td>CPR, n (%)</td>
<td></td>
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</tr>
<tr>
<td>BCPR</td>
<td>56,830 (50.7)</td>
<td>19,425 (52.3)</td>
<td>&lt;0.001*</td>
<td>1.07 (1.04 to 1.09)</td>
</tr>
<tr>
<td>Compression-only BCPR†</td>
<td>16,812 (88.8)</td>
<td>17,756 (91.4)</td>
<td>1.34 (1.27 to 1.42)</td>
<td></td>
</tr>
<tr>
<td>DAI-CPR attempt</td>
<td>63,469 (56.6)</td>
<td>22,073 (59.5)</td>
<td>&lt;0.001*</td>
<td>1.13 (1.10 to 1.15)</td>
</tr>
<tr>
<td>Compliance with DAI-CPR†</td>
<td>44,391 (69.9)</td>
<td>15,617 (70.8)</td>
<td>1.04 (1.01 to 1.08)</td>
<td></td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>88,891 (79.2)</td>
<td>29,048 (78.3)</td>
<td>&lt;0.001*</td>
<td>0.94 (0.92 to 0.97)</td>
</tr>
<tr>
<td>Witnessed, n (%)</td>
<td>45,547 (40.6)</td>
<td>14,823 (39.9)</td>
<td>0.023*</td>
<td>0.97 (0.95 to 0.99)</td>
</tr>
<tr>
<td>Family-witnessed‡</td>
<td>23,056 (50.6)</td>
<td>7,935 (53.5)</td>
<td>1.05 (1.02 to 1.08)</td>
<td></td>
</tr>
<tr>
<td>Aetiology of OHCA, n (%)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Accidental§</td>
<td>5,894 (5.5)</td>
<td>1,763 (4.8)</td>
<td>&lt;0.001*</td>
<td>0.86 (0.81 to 0.91)</td>
</tr>
<tr>
<td>Presumed cardiac aetiology</td>
<td>67,730 (60.4)</td>
<td>22,816 (61.5)</td>
<td>&lt;0.001*</td>
<td>1.05 (1.02 to 1.07)</td>
</tr>
<tr>
<td>Shockable initial rhythm, n (%)</td>
<td>20,620 (18.4)</td>
<td>6674 (18.0)</td>
<td>0.083*</td>
<td>0.97 (0.94 to 1.00)</td>
</tr>
<tr>
<td>Public access defibrillation, n (%)</td>
<td>45,000 (4.0)</td>
<td>1,385 (3.7)</td>
<td>0.016*</td>
<td>0.93 (0.87 to 0.99)</td>
</tr>
<tr>
<td>Location, home, n (%)</td>
<td>69,901 (62.3)</td>
<td>24,068 (64.8)</td>
<td>&lt;0.001*</td>
<td>1.12 (1.09 to 1.14)</td>
</tr>
<tr>
<td>Business hours (07:00–16:59 hours), n (%)</td>
<td>67,838 (60.5)</td>
<td>22,771 (61.3)</td>
<td>0.003*</td>
<td>1.04 (1.01 to 1.06)</td>
</tr>
<tr>
<td>EMS time interval</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMS response time (min), ** median (IQR)</td>
<td>9 (8–12)</td>
<td>10 (8–12)</td>
<td>&lt;0.01††</td>
<td></td>
</tr>
<tr>
<td>Scene time (min), median (IQR)</td>
<td>8 (5–11)</td>
<td>8 (5–12)</td>
<td>&lt;0.01††</td>
<td></td>
</tr>
<tr>
<td>Transportation time (min),‡ median (IQR)</td>
<td>12 (8–18)</td>
<td>13 (9–19)</td>
<td>&lt;0.01††</td>
<td></td>
</tr>
<tr>
<td>Number of calls to determine the destination hospital ≥2, n (%)</td>
<td>16,227 (14.5)</td>
<td>6,080 (16.4)</td>
<td>&lt;0.001*</td>
<td>1.16 (1.12 to 1.20)</td>
</tr>
</tbody>
</table>

* P value using a z2 test.
† The proportion of compression-only bystander CPR in all cases receiving bystander CPR.
‡ The rate of bystander CPR in DAI-CPR-attempted cases.
§ The proportion of family-witnessed cases in all bystander-witnessed cases.
‖ Water, traffic and athletic accidents.
** Time interval between emergency call receipt and EMS contact to patient.
†† P value using Wilcoxon rank-sum test.
‡‡ Time interval between vehicle accommodation and EMS arrival at the hospital.
BCPR, bystander cardiopulmonary resuscitation; CPR, cardiopulmonary resuscitation; DAI-CPR, dispatcher-assisted instruction for cardiopulmonary resuscitation; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest.
Effects of the pandemic in 2020 on OHCA characteristics and bystander resuscitation efforts

The 2020 COVID-19 pandemic year was associated with slightly higher rates of BCPR compared with prepandemic years (cOR 1.07, 95% CI 1.04 to 1.09). Compared with prepandemic years, the 2020 COVID-19 pandemic year was associated with higher rates of compression-only BCPR (cOR 1.34, 95% CI 1.27 to 1.42), DAI-CPR (cOR 1.13, 95% CI 1.10 to 1.15), OHCA at home (cOR 1.12, 95% CI 1.01 to 1.06), prolonged EMS time intervals (p<0.01) and more cases requiring ≥2 calls to determine the destination hospital (cOR 1.16, 95% CI 1.12 to 1.20) (table 1). The 2020 COVID-19 pandemic year was associated with a lower incidence of PAD (cOR 0.93, 95% CI 0.87 to 0.99) and accidental (water, traffic and sports accidents) OHCA (cOR 0.86, 95% CI 0.81 to 0.91). Other minor but statistically significant differences in 2020 included a reduced percentage of male patients with OHCA and an increased percentage in OHCA during business hours (online supplemental figure 3).

OHCA characteristics and outcomes based on different time periods and prefectures

Although not statistically significant, favourable OHCA outcomes were lower during the emergency period than during the prepandemic years. However, the difference was not statistically significant, as shown in table 2 and figure 2. The 2020 COVID-19 pandemic year was associated with lower 1-month survival (11.8% vs 10.4%) and neurologically favourable 1-month survival (7.7% vs 7.0%).

Table 2 Differential effects of the 2020 pandemic on outcomes and characteristics of OHCA during the state of emergency days and other days

<table>
<thead>
<tr>
<th>Characteristics of OHCA</th>
<th>Period (date)</th>
<th>3 prepandemic years (2017–2019)</th>
<th>Pandemic year (2020)</th>
<th>Crude OR with 3 prepandemic years as the reference</th>
<th>P value by interaction test*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcomes, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-month survival</td>
<td></td>
<td>1669 (11.8)</td>
<td>478 (10.4)</td>
<td>0.87 (0.78 to 0.96)</td>
<td>10.859 (11.1)</td>
</tr>
<tr>
<td>Neurologically favourable 1-month survival</td>
<td>1094 (7.7)</td>
<td>321 (7.0)</td>
<td>0.89 (0.79 to 1.02)</td>
<td></td>
<td>7139 (7.3)</td>
</tr>
<tr>
<td>CPR, n (%)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>BCPR</td>
<td></td>
<td>7300 (51.6)</td>
<td>2394 (52.0)</td>
<td>1.02 (0.95 to 1.09)</td>
<td>48492 (49.3)</td>
</tr>
<tr>
<td>DAI-CPR attempt</td>
<td></td>
<td>4599 (56.0)</td>
<td>1617 (60.8)</td>
<td>1.22 (1.11 to 1.33)</td>
<td>58870 (56.6)</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td></td>
<td>11145 (78.7)</td>
<td>3674 (79.8)</td>
<td>1.07 (0.98 to 1.16)</td>
<td>77476 (79.3)</td>
</tr>
<tr>
<td>Witnessed, n (%)</td>
<td></td>
<td>5903 (41.7)</td>
<td>1838 (39.9)</td>
<td>0.93 (0.87 to 0.99)</td>
<td>39644 (40.4)</td>
</tr>
<tr>
<td>Of presumed cardiac aetiology, n (%)</td>
<td>8452 (59.7)</td>
<td>2880 (62.5)</td>
<td>1.13 (1.05 to 1.21)</td>
<td></td>
<td>59278 (60.5)</td>
</tr>
<tr>
<td>Shockable initial rhythm, n (%)</td>
<td>2616 (18.5)</td>
<td>808 (17.5)</td>
<td>0.94 (0.86 to 1.02)</td>
<td></td>
<td>18004 (18.4)</td>
</tr>
<tr>
<td>Public access defibrillation, n (%)</td>
<td>595 (4.2)</td>
<td>106 (2.3)</td>
<td>0.54 (0.44 to 0.66)</td>
<td></td>
<td>3905 (4.0)</td>
</tr>
<tr>
<td>Location, home, n (%)</td>
<td></td>
<td>8869 (62.6)</td>
<td>3114 (67.6)</td>
<td>1.27 (1.16 to 1.40)</td>
<td>61032 (62.3)</td>
</tr>
<tr>
<td>Number of calls to determine destination hospital ≥2, n (%)</td>
<td>1156 (14.1)</td>
<td>504 (18.9)</td>
<td>1.43 (1.27 to 1.60)</td>
<td></td>
<td>15071 (14.5)</td>
</tr>
</tbody>
</table>

*Comparison of the emergency period with other time periods.
BCPR, bystander cardiopulmonary resuscitation; CPR, cardiopulmonary resuscitation; DAI-CPR, dispatcher-assisted instruction for cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest.
the rest of the pandemic in 2020 and in prior years (Table 2). When comparing the pandemic year with the three prepandemic years, the state of emergency period (7 April–24 May) was more likely than other periods to show decreased PAD rates (p<0.001) and increased rates of multiple calls to determine the destination hospital (p<0.001).

When comparing the 2020 pandemic year with the 3 years prior to the pandemic, the 12 severely affected prefectures were more likely than other prefectures to have increased DAI-CPR rates (p<0.001), increased rates of multiple calls to determine destination hospital (p<0.001), decreased 1-month survival rates (p<0.001) and decreased neurologically favourable 1-month survival rates (p<0.001). The incidence of PAD decreased only in the 12 prefectures in the pandemic year compared with prepandemic rates (Table 3).

DISCUSSION

A strong chain of survival can augment the chances of recovery for cardiac arrest victims, but the COVID-19 pandemic disrupted this chain in many ways and was associated with changes in patient outcomes. Indeed, disasters and stress temporarily increase the incidence of cardiovascular events and other acute illnesses that can lead to OHCA. In this study, we analysed the association of the COVID-19 pandemic in 2020 with OHCA outcomes in working-age patients and bystander resuscitation efforts in consideration of interactions with pandemic phase, region and other prehospital factors that have previously been reported as associated with OHCA outcomes.

Overall, survival and neurologically favourable survival were not different in the pandemic year versus the prior 3 years. However, this was not true in the 12 prefectures that were most affected by COVID-19. We noted that in general BCPR and DAI-CPR increased, which should have improved prognosis. However, an increase in OHCA that occurred at home, a decline in use of PAD seen in the 12 most affected prefectures and all areas during the state of emergency, the increased need for multiple calls to determine hospital destination, and prolonged EMS response and transport times may have contributed to worse prognosis. These changes may have balanced each other out to result in no overall change in survival.

Notably, there were more OHCA with a presumed cardiac aetiology in 2020, and these were associated with a poorer neurologically favourable 1-month survival. A decrease in hospital visits for patients with cardiovascular disease, exacerbation of cardiovascular disease and increased cardiovascular mortality were found to have occurred due to the COVID-19 pandemic. Moreover, patients with cardiogenic OHCA are more likely to respond to automated external defibrillators (AEDs), and outcomes may have been affected by lower rates of PAD, longer ambulance travel times and delayed intervention due to a shortage of medical staff.

Although the COVID-19 pandemic reportedly discouraged bystander resuscitation efforts due to fear of infection, the BCPR rate, the DAI-CPR incidence rate and compliance with DAI-CPR among bystanders in Japan increased in the 2020 pandemic year. Moreover, an increased BCPR rate during the pandemic positively influenced OHCA outcomes. This may be a result of the fact that more arrests occurred at home, where the victim was known to the bystanders.

Following recommendations from the 2015 Japan Resuscitation Council Guidelines, dispatchers have adopted a more educational approach to DAI-CPR, actively asking emergency callers who may be unaware of cardiac arrest, about the possibility of cardiac arrest and repetition of instructions. Dispatchers instruct on compression-only cardiopulmonary resuscitation (CPR) to increase the BCPR rate over CPR using a combination of ventilations and chest compressions. These improvements may have contributed to maintaining stability in OHCA outcomes in 2020.

### Table 3  Differential effects of the 2020 pandemic on characteristics and outcomes of OHCA in 12 significantly affected prefectures and other prefectures

<table>
<thead>
<tr>
<th>Characteristics of OHCA</th>
<th>Regional classification</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>12 significantly affected prefectures</td>
<td>Other prefectures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcomes, n (%)</td>
<td>N=65,431</td>
<td>N=21,959</td>
<td></td>
<td></td>
<td>N=46,749</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-month survival</td>
<td>7931 (12.1)</td>
<td>2513 (11.4)</td>
<td>0.94 (0.89 to 0.98)</td>
<td>4597 (9.8)</td>
<td>1661 (11.0)</td>
<td>1.12 (1.06 to 1.20)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Neurologically favourable 1-month survival</td>
<td>5132 (7.8)</td>
<td>1569 (7.2)</td>
<td>0.90 (0.85 to 0.96)</td>
<td>3101 (6.6)</td>
<td>1143 (7.5)</td>
<td>1.15 (1.07 to 1.23)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CPR, n (%)</td>
<td>31,875 (48.7)</td>
<td>11,104 (50.6)</td>
<td>1.08 (1.04 to 1.11)</td>
<td>24,955 (53.4)</td>
<td>8321 (54.9)</td>
<td>1.06 (1.02 to 1.10)</td>
<td>0.580</td>
</tr>
<tr>
<td>DAI-CPR attempt</td>
<td>35,479 (54.2)</td>
<td>12,844 (58.5)</td>
<td>1.19 (1.15 to 1.23)</td>
<td>27,990 (59.9)</td>
<td>9229 (60.9)</td>
<td>1.04 (1.00 to 1.08)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>51,027 (78.0)</td>
<td>16,933 (77.1)</td>
<td>0.95 (0.92 to 0.99)</td>
<td>37,864 (81.0)</td>
<td>12,115 (80.0)</td>
<td>0.93 (0.89 to 0.98)</td>
<td>0.530</td>
</tr>
<tr>
<td>Witnessed, n (%)</td>
<td>27,289 (41.7)</td>
<td>8923 (40.6)</td>
<td>0.96 (0.93 to 0.99)</td>
<td>18,258 (39.1)</td>
<td>5900 (39.0)</td>
<td>0.99 (0.96 to 1.03)</td>
<td>0.123</td>
</tr>
<tr>
<td>Of presumed cardiac aetiology, n (%)</td>
<td>39,919 (61.0)</td>
<td>13,731 (62.5)</td>
<td>1.07 (1.03 to 1.10)</td>
<td>27,811 (59.5)</td>
<td>9085 (59.9)</td>
<td>1.02 (0.98 to 1.06)</td>
<td>0.063</td>
</tr>
<tr>
<td>Shockable initial rhythm, n (%)</td>
<td>12,217 (18.7)</td>
<td>4054 (18.5)</td>
<td>0.99 (0.95 to 1.03)</td>
<td>8403 (18.0)</td>
<td>2620 (17.3)</td>
<td>0.95 (0.90 to 1.00)</td>
<td>0.286</td>
</tr>
<tr>
<td>Public access defibrillation, n (%)</td>
<td>3001 (4.6)</td>
<td>897 (4.1)</td>
<td>0.89 (0.82 to 0.96)</td>
<td>1499 (2.2)</td>
<td>488 (2.2)</td>
<td>1.00 (0.90 to 1.10)</td>
<td>0.058</td>
</tr>
<tr>
<td>Location, home, n (%)</td>
<td>40,712 (62.2)</td>
<td>14,246 (64.9)</td>
<td>1.12 (1.09 to 1.16)</td>
<td>29,189 (62.4)</td>
<td>9822 (64.8)</td>
<td>1.11 (1.07 to 1.15)</td>
<td>0.603</td>
</tr>
<tr>
<td>Number of calls to determine destination hospital ≥2, n (%)</td>
<td>9348 (14.3)</td>
<td>3695 (16.8)</td>
<td>1.21 (1.16 to 1.27)</td>
<td>6879 (14.7)</td>
<td>2385 (15.7)</td>
<td>1.08 (1.03 to 1.14)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Comparison of 12 significantly affected prefectures with other prefectures.
BCPR, bystander cardiopulmonary resuscitation; CPR, cardiopulmonary resuscitation; DAI-CPR, dispatcher-assisted instruction for cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest.
For the working-age group, behavioural restrictions decreased the number of OHCAs occurring at workplaces and increased the number occurring at home. Due to the increased time spent at home, the family-witnessed rate increased in 2020. OHCAs at home affect prognosis because, unlike at the workplace, a delay in initial defibrillation occurs due to the absence of an AED. Family-witnessed OHCA has also been reported to be associated with lower rates of BCPR and PAD and a poorer prognosis than other-witnessed OHCA. An increase in OHCA at home and family-witnessed OHCA may have worsened OHCA outcomes.

The reason for the increased BCPR rate in unwitnessed OHCA is unknown, although increased altruistic behaviour, more typical during disaster periods, may have played a role. The extended time taken for an ambulance to arrive at the scene may have given the dispatcher sufficient time to persuade a bystander to perform CPR, which may also help explain this finding.

In Japan, restructuring the medical system for the anticipated surge in critically ill patients with COVID-19 resulted in a shortage of hospital beds and medical staff (especially those capable of dealing with severe cases). Consequently, the number of hospitals capable of accepting critically ill patients decreased. This led to an increase in the number of calls to determine destination hospitals and an increase in the number of long-distance transports to accepting hospitals prolonging transport times. These delays were particularly pronounced during the state of emergency (7 April–24 May) and in significantly affected prefectures and may have contributed to worse prognosis.

In Japan, each prefecture strives to secure a medical care provision system in accordance with the basic policy established by the Minister of Health, Labour, and Welfare and according to regional needs. The requirements for deciding which hospital to transport a patient to also differ, depending on the prefecture. During pandemics and natural disasters, it is difficult to maintain medical care delivery for everyday life-threatening diseases. In recent years, it has been reported that the number of cases nationwide involving ambulances not being accepted is increasing, which has generated discussions in relation to this matter.

In 2020, the PAD incidence rate decreased compared with that in the three prepandemic years. Although Japan is one of the countries with the world’s largest number of AEDs, most are installed indoors (workplaces, schools, commercial facilities and public transportation) and are only accessible at limited times; thus, access to AEDs was significantly reduced in 2020. This was particularly pronounced during the state of emergency period (7 April–24 May) and in the 12 significantly affected prefectures. Decreased AED access and increased incidence of OHCA at home may have contributed to the decline in PAD rates.

Early defibrillation is known to improve prognosis, and lower PAD rates may have contributed to worse prognosis.

During the pandemic, the rate of accidental (water, traffic and sports) OHCA decreased largely due to reduced movement and activity because of increased telecommuting, commercial facility closures, beach closures and large-scale event cancellations. Indeed, the number of deaths due to traffic accidents involving a low survival rate (a reported survival rate of approximately 1% in Japan over the last 20 years) was reported to be the lowest in 2020.

OHCA prognosis worsened during the state of emergency and in prefectures significantly affected by COVID-19, likely due to more significant activity restrictions. This likely resulted in the decrease in the PAD rate due to the decrease in AED access as more arrests occurred at home. Despite the increases in DAI-CPR and BCPR, these factors, as well as delays due to multiple calls to decide patient destination (due to hospital bed limitations and an increase in the number of patients with COVID-19) likely resulted in the less favourable outcomes observed.

This study had some limitations. First, detailed data on patients’ backgrounds were not available. Therefore, it was unclear whether the patients had different risk factors related to cardiac arrest or family medical history. Second, bystander-specific data, such as age, sex and training experience, were not included in the database and were, therefore, not included in the study. These data may have influenced the results. Third, the influence of rules in relation to deciding which hospital to transport a patient to and the fact that termination of resuscitation is not allowed in prehospital situations are likely to have contributed to differences in results compared with other countries. Fourth, given that the neurologically favourable 1-month survival was adopted as the outcome, we were unable to evaluate the long-term prognosis. Finally, as with other observational studies, the validity of the data represents a potential limitation.

In Japan, the COVID-19 pandemic in 2020 was not associated with overall changes in outcomes for working-age patients with OHCA. When comparing the 2020 pandemic year with the three prepandemic years, BCPR rates and DAI-CPR rates increased, and PAD rates decreased. Outcomes varied and appeared to be associated with the degree of lockdown, the prevalence of COVID-19, region, OHCA aetiology and witness status. Early responses following changes in working-age lifestyles owing to disasters and pandemics are likely to be challenging. However, planning AED placement in outdoor spaces that are accessible even during restricted movement and increasing BCPR through DAI-CPR may help prevent pandemic-associated decreases in survival rates for patients with cardiac OHCA. These measures are likely to provide greater preparedness in facing disasters and pandemics.

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Patient consent for publication Not applicable.

Ethics approval This study was approved by the research ethics committee of Kanazawa Medical University (I-729) and conducted in accordance with Declaration of Helsinki and the Ethical Guidelines for Medical and Health Research Involving Human Subjects issued by Japanese Ministry of Health, Labour and Welfare. Because the data analysed in this study were anonymised and secondary, the need for written informed consent was waived.

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REFERENCES