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Clinical paper

Did lockdown influence bystanders' willingness to perform cardiopulmonary resuscitation? A worldwide registry-based perspective

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Abstract

Aim: Bystander cardiopulmonary resuscitation (CPR) significantly increases the survival rate after out-of-hospital cardiac arrest. Using population-based registries, we investigated the impact of lockdown due to Covid-19 on the provision of bystander CPR, taking background changes over time into consideration.

Methods: Using a registry network, we invited all registries capable of delivering data from 1. January 2017 to 31. December 2020 to participate in this study. We used negative binominal regression for the analysis of the overall results. We also calculated the rates for bystander CPR. For every participating registry, we analysed the incidence per 100 000 inhabitants of bystander CPR and EMS-treated patients using Poisson regression, including time trends.

Results: Twenty-six established OHCA registries reported 742 923 cardiac arrest patients over a four-year period covering 1.3 billion person-years. We found large variations in the reported incidence between and within continents. There was an increase in the incidence of bystander CPR of almost 5% per year. The lockdown in March/April 2020 did not impact this trend. The increase in the rate of bystander CPR was also seen when analysing data on a continental level. We found large variations in incidence of bystander CPR before and after lockdown when analysing data on a registry level.

Conclusion: There was a steady increase in bystander CPR from 2017 to 2020, not associated with an increase in the number of ambulance-treated cardiac arrest patients. We did not find an association between lockdown and bystanders' willingness to start CPR before ambulance arrival, but we found inconsistent patterns of changes between registries.

Keywords: Covid-19, Corona, Cardiac arrest, Out-of-hospital cardiac arrest, Registries, Bystander cardiopulmonary resuscitation, CPR

Introduction

Recognising that a person is in cardiac arrest, calling for help, and starting bystander cardiopulmonary resuscitation (CPR) significantly increases the survival rate after out-of-hospital cardiac arrest (OHCA).[1] Findings from earlier research are summarised in the chain-of-survival concept, highlighting the time-sensitive nature of interventions and that high quality in all stages of treatment is necessary to increase survival.[2]

The purpose of CPR is to maintain circulation to vital organs, avoiding cell death.[1] Unconscious patients that cannot breathe normally need CPR as soon as possible. A person witnessing or finding a patient in cardiac arrest, who is not alerted by the dispatch centre, is called a bystander.[3] Bystander CPR has been advocated and taught since the 1960s, but the number of patients receiving this

Abbreviations: CPR, Cardiopulmonary Resuscitation, OHCA, Out-of-hospital cardiac arrest, EMS, Emergency Medical Services

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treatment varies. In a summary of data from registries worldwide, provision of bystander CPR ranged from 5.5 % to 70.5 %.[4] Several factors that inhibit or facilitate bystander CPR have been identified. Most commonly, barriers are grouped into psychological and physical, including knowledge and skill deficit and disagreeable physical characteristics. The most common facilitators are bystanders being trained in CPR and being given telephone instructions from the dispatch centre.[5] Early in 2020, due to the Covid-19 pandemic, many CPR courses were cancelled, and the guidelines for dispatch-assisted bystander CPR were changed.[6]

Several studies have reported a shift in bystander CPR due to Covid-19. However, the findings differ and were usually linked to waves of Covid-19-positive patients.[7,8] We expected government-initiated interventions, including large-scale physical distancing measures, stay-at-home orders, curfew, quarantines, and restrictions on the number of people with whom to socialise, often referred to as "Lockdown"[9], to make people wary and have a negative impact on the number of people willing to perform bystander CPR. Coincidingly, the pandemic could also change the number of critically ill patients in cardiac arrest. We hypothesised that the number of patients with OHCA that would receive bystander CPR would decline after the first lockdown and wanted to investigate this from a worldwide perspective.

Method

This before-after comparison study aimed to investigate the impact of lockdown on the incidence of bystander CPR per 100 000 inhabitants in a worldwide cohort study from established OHCA registries.

Selection and description of participants

Inclusion and exclusion criteria

We included all OHCAs registered between 1 January 2017 and 31 December 2020, not including newborns who needed resuscitation at birth and in-hospital cardiac arrest patients. The study protocol has previously been published.[10]

Participating registries

The invitation to participate was shared through a registry network, followed up by email and online meetings with interested registries that could deliver core data describes in the Utstein template of 2014[11]. A Memorandum of Understanding or standardised contract was signed by all participants, highlighting local data processors' responsibilities in quality control and data aggregation. (Supplement 1: Statistical analysis plan).

Ethical approval was obtained from Christian-Albrecht University of Kiel, Germany (D 452/22) and the Data Protection Officer at Oslo University Hospital approved this study (23/06995). In addition, all participating registries obtained ethical approval within their country or a documented waiver stating there was no requirement for ethical approval.

Study sites

We received aggregated data from five countries in Asia, four regions in Australia and New Zealand, twelve countries in Europe, and four regions in USA supplied by Cardiac Arrest Registry to Enhance Survival (CARES), resulting in 26 participating registries. Some registries reported data from the entire country, while others covered only parts of the population. Additional information about the registries is presented in Supplementary Table 1.

Division of the data set

Data from 2020 was divided into before and after lockdown for that region/country. Lockdown was defined as the official date when inhabitants were asked or ordered to stay at home by their government. Lockdown, rather than Covid-19 infection surge, was chosen to investigate if a governmental intervention would influence the population's willingness to perform CPR. For the first part of 2020, we included all patients suffering cardiac arrest from 1 January 2020 to the date of lockdown. For the second part of 2020, we included all patients suffering cardiac arrest from this date until 31 December. For example, a country that had lockdown on 11 March 2020 had 70 days before and 296 after lockdown.

Bystander CPR rates

The number of patients that may get CPR by a bystander, are all cardiac arrest patients except patients who have a cardiac arrest witnessed by Emergency Medical Services (EMS). When calculating bystander CPR rates for Asia, Australia and New Zealand, and Europe, we subtracted the number of EMS-witnessed cases per year from the "all resuscitation" group to get our denominator. When calculating bystander CPR rates for North America, the denominator was non-traumatic resuscitations attempted per year, that occurred in a non-medical location, not witnessed by a 911 Responder.

Population and incidence per 100 000 inhabitants

Each registry provided the population in their catchment area for each year of the study. Incidence was calculated per 100 000 inhabitants by dividing the number of patients in the relevant group by the total population in the catchment area for that year, and then multiplying by 100 000. The population for the two parts of 2020 was calculated using the total population of 2020 times the number of days before lockdown divided by 366 (leap year) and the number of days after lockdown divided by 366.

Statistical analysis

We calculated the incidences per 100 000 inhabitants of; bystander CPR, EMS-treated OHCAs, all resuscitations, males and cardiac arrest witnessed by EMS. We compared results from lockdown until 31 December 2020 with the time trends from 2017 to the first lockdown in 2020. We allowed for a linear time trend by the period midpoints for 2017 to 2019, i.e., setting 2017 to 0.5, 2018 to 1.5, 2019 to 2.5. For 2020 we set two time points, one early in the year (3.1) and one later in the year (3.6). The point of 3.1 was calculated because one month equals 1/12 (=0.08) of a year; and as most countries had lockdown mid-March (i.e., at 0.08 * 2.5 months = 0.2 years) the midpoint of this period equals 0.1 in year 3, i.e., 3.1.

We considered different registries (corresponding to different populations) as random samples from the world's target population. We used a mixed effects negative binomial or Poisson regression model for the outcome, depending on which method provided best fit, by Akaike's Information Criterion -AIC-, or Bayesian Information Criterion -BIC, employing the population covered as offsets, midpoints of the time periods as a continuous variable, and registries as random intercepts. We calculated the rates of cases receiving bystander CPR to examine if changes in incidence of cardiac arrests could explain differences in bystander CPR rates. The Chi-squared test was used to assess changes in bystander rates. We also calculated the incidence rate ratio, comparing the pre-and post-lockdown periods for each registry individually with time trends, using Poisson

regression. Stata version 17 was used for all analysis performed by authors Ingvild B. M. Tjelmeland, Jo Kramer-Johansen and Eirik Skogvoll.

Data management

Due to data protection requirements in each country/jurisdiction, each participating registry checked its data for completeness and plausibility. A statistical analysis plan was provided (Supplement 1: Statistical analysis plan). In cases of inconsistencies or relevant missing data, the problem was solved locally or in cooperation with the first and last author. The study did not receive specific funding, and registries conducted the data collection and analysis using local resources.

Results

The registries reported 747 167 cardiac arrest patients over 1.3 billion person-years. Data originated from four continents: Asia, Australia and New Zealand, Europe, and North America.

Incidence of bystander CPR and EMS-treated patients

Across our study sites, there was an increase in the incidence of bystander CPR of almost 5% per year from 2017 to 2020 ($p < 0.001$, CI 1.03–1.07). After lockdown, there was no statistically significant change compared to the time trend. There was no change over time in the overall incidence of cardiac arrests or the incidence of EMS-treated patients, and no significant change after lockdown. As for bystander CPR, there was an increase in the incidence of male patients per year, but no change after lockdown compared to the time trend (Table 1. To avoid a potential washout period, analyses were repeated without the data from January 2020 to lockdown and we found an average increase in bystander CPR of 4 % per year ($p = 0.002$, CI 1.02–1.07). After lockdown there was no statistically significant change compared to the time trend. For EMS treated patients there was no significant change over time, and no change after lockdown.

Rate of bystander CPR

There was an increase in bystander CPR rates every year from 2017 to 2020. When comparing 2017 to the period after lockdown, there was a statistically significant increase in bystander rates on all continents; Asia 51 % to 53 %, Australia and New Zealand 77 % to 82 %, Europe 58 % to 61 %, and North America 38 % to 40 %, as shown in Supplementary Fig. 1. The rates per registry are shown in Fig. 1.

Incidence of bystander CPR and EMS-treated patients in different regions

The variation in the incidence of bystander CPR is considerable both between and within the continents. Europe had the most extensive variation per 100 000 inhabitants, ranging from 2-62 per 100 000 in 2017 to 3–67 per 100 000 after lockdown in 2020. The smallest variation was seen in Australia and New Zealand, where the variation in 2017 was 34–44, and after lockdown it was 33–44 (Fig. 2).

We also found variation in incidence of EMS-treated patients per 100 000 inhabitants. The largest variation in the incidence of EMS-treated patients was seen in Europe, and the smallest was in Australia and New Zealand (Fig. 3).

Incidence rate ratio and time trends

The incidence rate ratio (IRR) for bystander CPR, showed large variations between registries when comparing the pre-and post-lockdown periods for each registry with time trends, IRR and varied from 0.11 to 2.18 for each country (Fig. 4).

Similarly, the IRR for EMS-treated patients comparing the pre- and post-lockdown periods varied widely from 0.14 to 1.71 (Fig. 5).

Discussion

Our study is probably the most extensive collection of OHCA-registry data ever published including data from 26 established registries, reporting 742 923 cardiac arrest patients for 1.3 billion person-years. The average incidence of EMS-treated cardiac arrest was 57 per 100 000 inhabitants per year but varied from 0.1 to 124. We found an increase in the incidence of bystander CPR over time but no significant change in the overall incidence of bystander CPR due to lockdown compared to the time trends for the entire period. The incidence of EMS-treated patients did not change significantly from 2017 to 2020. After lockdown, there was no change in the overall incidence of OHCA worldwide. Secondary analyses reveal heterogeneity between reporting registries in both incidences of bystander CPR and EMS-treated OHCA.

After the first wave of Covid-19, several studies reported changes in incidence of cardiac arrest and a decline in bystander CPR.[7,12] However, results from subsequent studies are conflicting. Even before the end of 2020, less than eight months after lockdown a meta-analysis on Covid-19 and OHCA[13] reported a decrease in bystander CPR rates. However, a new meta-analysis from 2021 showed no change in bystander CPR rates.[14]

OHCA is a relatively rare event in prehospital emergency care, with an incidence per 100 000 inhabitants of 57. However, the quality

Table 1 – Incidence rate ratio over time and the effect of lockdown on the results.

	IRR trends 2017–2020	P	95% CI	IRR after lockdown compared to time trend	P	95% CI
Bystander CPR	1.05	<0.001	1.03–1.07	0.95	0.06	0.90–1.00
EMS treated	1.02	0.30	0.98–1.05	0.94	0.20	0.86–1.03
All resuscitations	1.02	0.30	0.99–1.05	0.95	0.27	0.88–1.04
Sex male	1.03	0.03	1.00–1.05	0.96	0.25	0.90–1.03
Witnessed by EMS	1.02	0.26	0.99–1.05	1.02	0.61	0.94–1.10

Table 1. Incidence rate ratio (IRR) comparing changes over time and post-lockdown. IRR of more than one indicates an increasing incidence, and IRR of less than one indicates a decrease in incidence. IRRs were estimated by negative binominal regression analysis with the population covered as offsets, midpoints of the time periods as a continuous variable, and registries as random effects. CPR – cardiopulmonary resuscitation, EMS – emergency medical services.

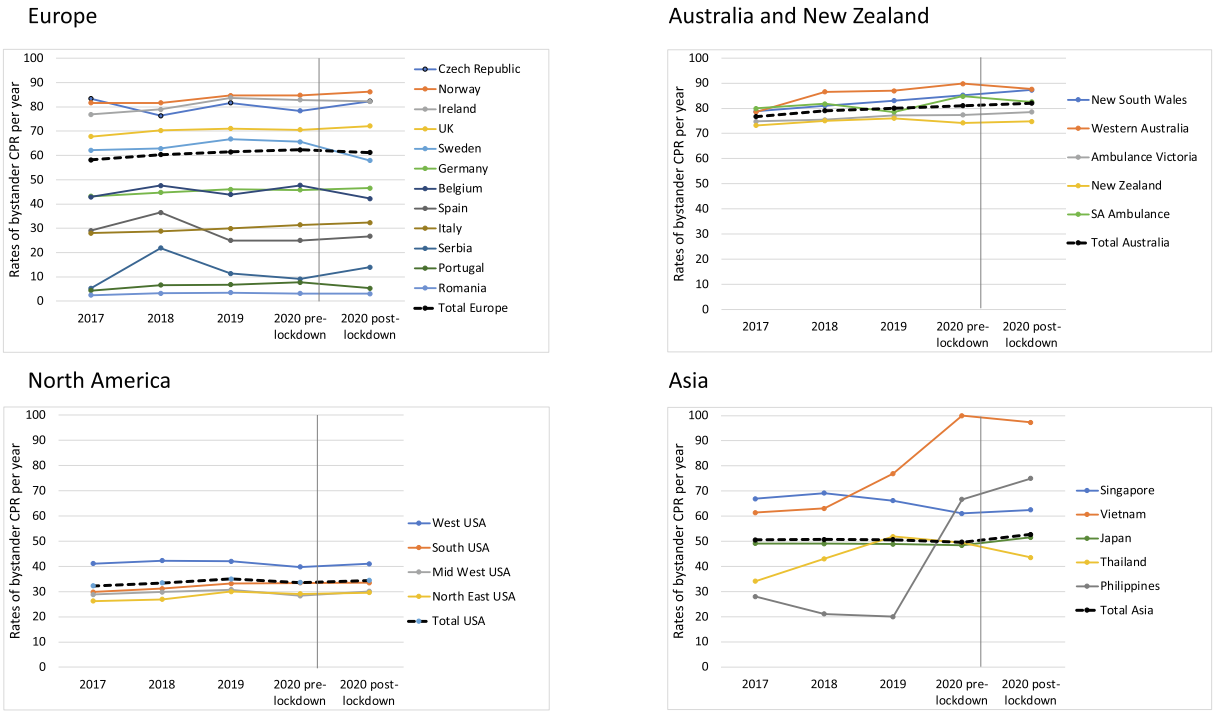

Fig. 1 – Rate of bystander cardiopulmonary resuscitation (BCPR) per registry from 2017 to 2020, where 2020 is divided into before and after lockdown. For Asia, Australia and New Zealand, and Europe, rates are calculated by dividing the number of patients receiving bystander CPR bythe number of cardiac arrests per year that are not witnessed by emergency medical services. For North America, the denominator is non-traumatic resuscitations attempted per year that happened in a non-medical location, not witnessed by 911 Responder.

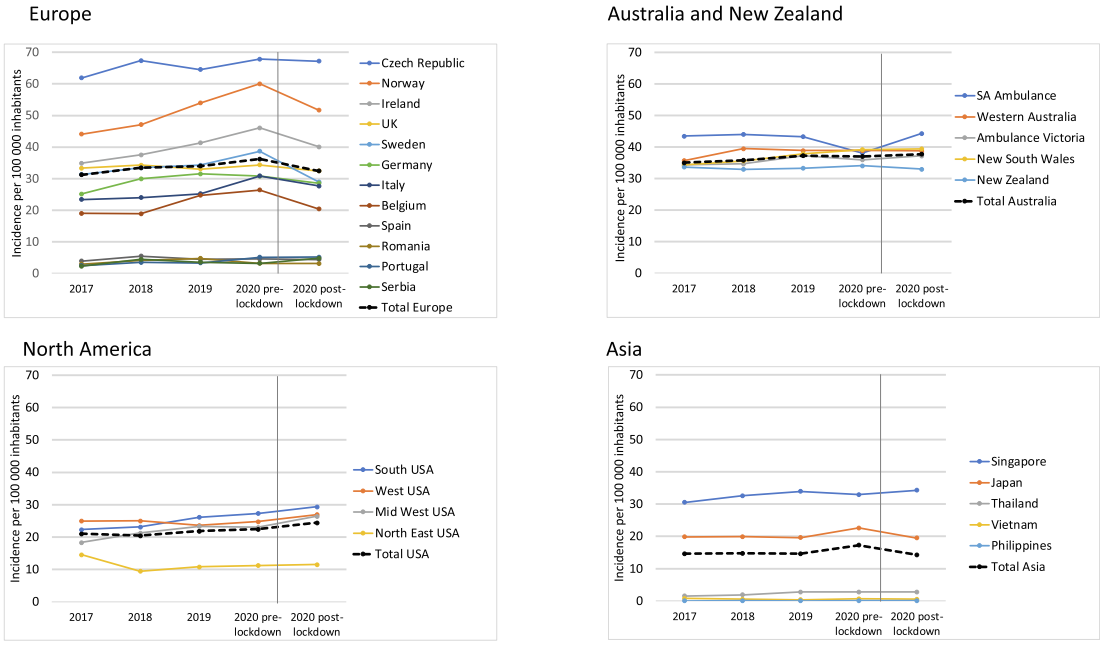

Fig. 2 – The incidence per 100 000 inhabitants of bystander cardiopulmonary resuscitation (BCPR) from 2017 to 2020. Data for 2020 was divided into before and after lockdown, as defined by the individual country or region. Results are grouped by continent.

of care given to OHCA patients by the EMS, is considered a good indicator of the overall quality of care provided by an EMS.[15] Because this is a rare event, there will be a natural variation in the number of cardiac arrests per month. The variance in absolute numbers is proportional to the population covered. At the beginning of the pandemic, most published studies covered small populations with

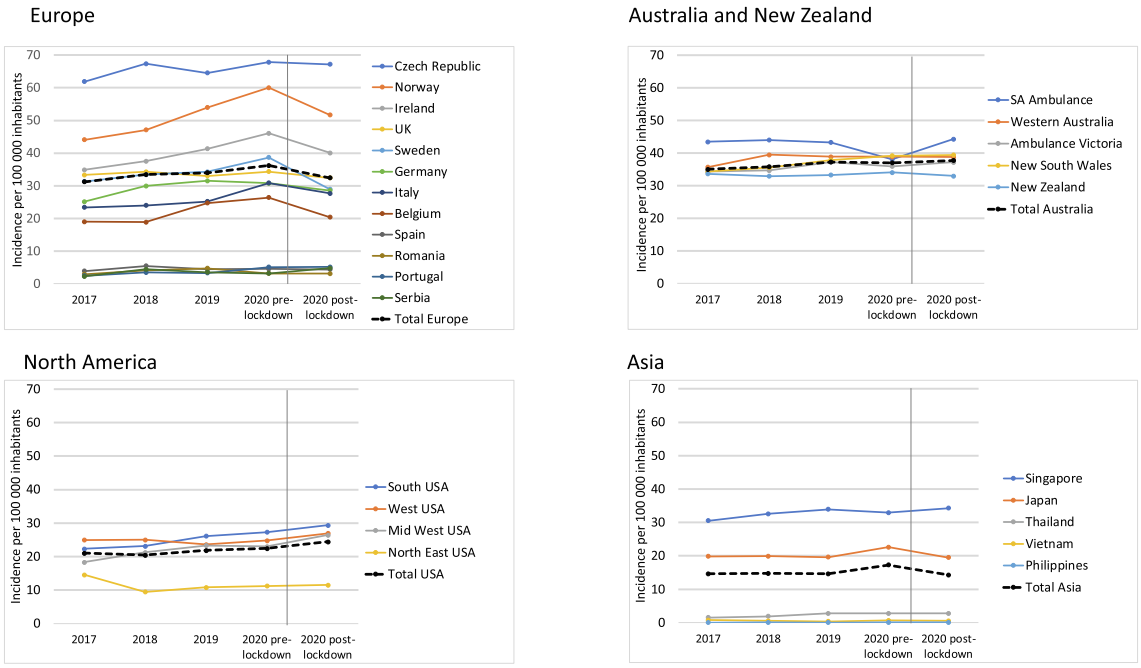

Fig. 3 – The incidence per 100 000 inhabitants of patients treated by the emergency medical services (EMS) from 2017 to 2020. Data for 2020 was divided into before and after lockdown, as defined by the individual country or region. Results are grouped by continent.

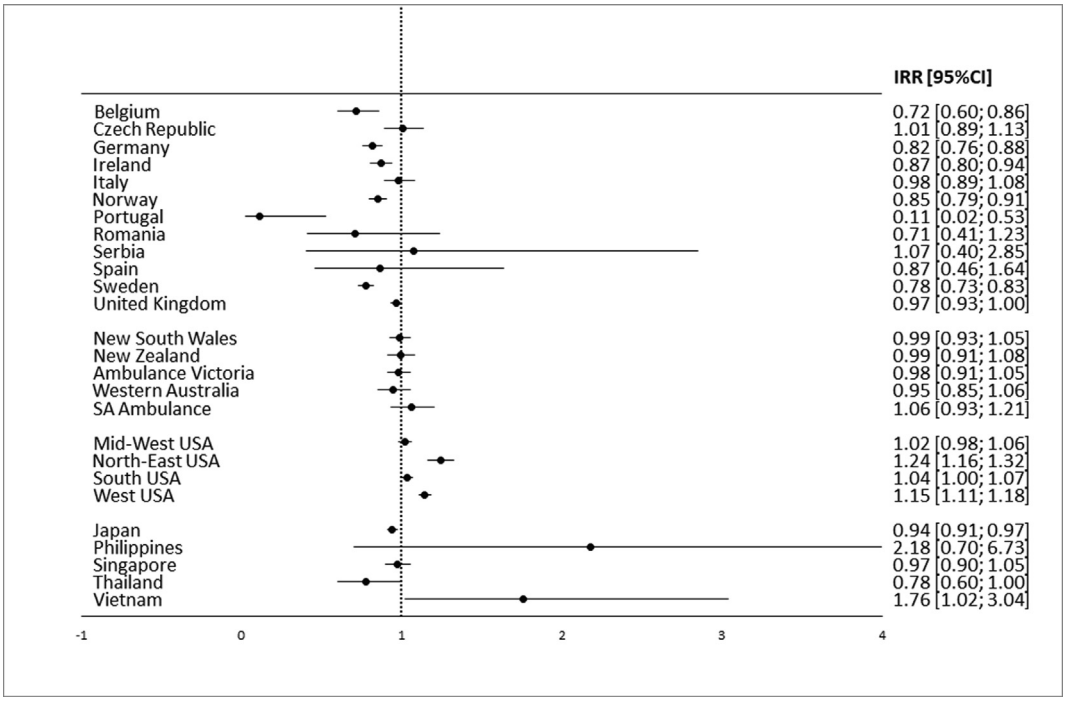

Fig. 4 – Incidence rate ratio (IRR) before and after lockdown per 100 000 inhabitants of bystander CPR before EMS arrival sorted by continent. We used a mixed effects Poisson regression for the outcome, employing the population covered as offsets, midpoints of the time periods as a continuous variable, and registries as random effects.

relatively few cardiac arrest patients.[7,16,17] As the pandemic progressed, larger studies were published, including data on OHCA incidence and outcomes from entire countries.[7,8,18–20] Our results do not contradict the previously published results from other studies, where changes in incidence, treatment, and survival after OHCA were found. However, our results show that from a worldwide perspective, there was no significant change in the incidence of bystander CPR or the overall incidence of EMS-treated OHCA patients.

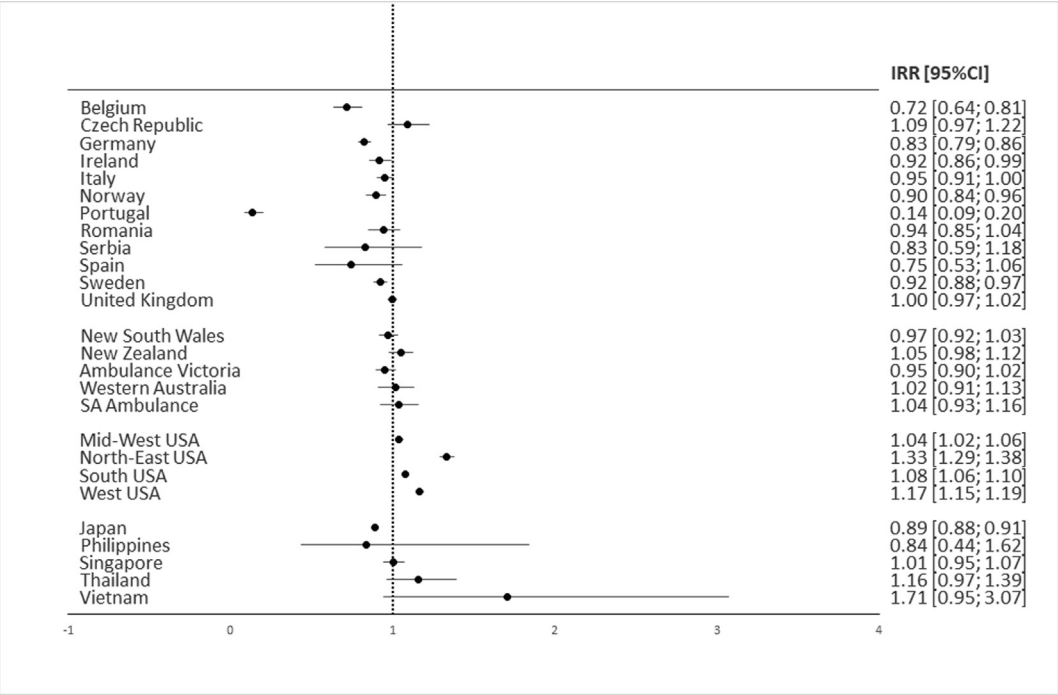

Fig. 5 – Incidence rate ratio (IRR) per 100 000 inhabitants for EMS-treated patients before and after lockdown, sorted by continent. We used a mixed effects Poisson regression for the outcome, employing the population covered as offsets, midpoints of the time periods as a continuous variable, and registries as random effects.

The lockdown may have affected many determinants of OHCA incidence and treatment. For example, the location of arrest changed as more people worked from home and public transport was reduced or restricted. Before the lockdown, around 70% of cardiac arrests occurred at home.[4] After lockdown, several studies report an increase in the rate of arrests occurring at home[7,20,21] and a decrease in the number of cardiac arrests in public places.[8,12] People also self-quarantined, even in their own homes, and avoided contact with people with respiratory disease symptoms, reducing the incidence of infectious diseases. However, having a cardiac arrest at home is likely to have increased the probability of the bystander being someone with a relationship to the patient. The lockdown may therefore have been less likely to change the willingness of the bystander to perform CPR on family and friends. Exposure to a potential virus is expected to have already occurred in a shared living space, which in turn means that the fear of exposure to the virus may be less likely to influence the decision to start CPR.

One factor influencing EMS personnel's decision to initiate CPR is whether a bystander has started CPR. In systems where dispatch-assisted CPR is not practised, bystanders are less likely to start CPR, decreasing the probability of the EMS starting resuscitation. The opposite scenario is also important to be aware of; if bystanders have started CPR, EMS personnel may find it difficult to declare the patient dead before they have at least tried basic resuscitation interventions. These complicated interactions between dispatch, bystander, and EMS may explain some of the changes in the incidence of bystander CPR reported in different studies. Our results show an increase in both the incidence of bystander CPR and the rate of bystander, meaning the increase cannot be explained by an increase in cardiac arrests alone.

Older people with prior illnesses have a higher risk of death from Covid-19.[22] Most studies, however, show no change in mean age or sex distribution in OHCA patients[16,17,20,23–25] even though there are reports of excess mortality for the same period.[26] In this study, we found that the incidence of male patients increased yearly but found no change after lockdown.

Limitations

The considerable heterogeneity we found in the incidence of cardiac arrest is consistent with previous reports.[4] Direct comparison between registries is probably not appropriate due to differences in the EMS setup, patient populations, and dispatch systems. Cultural aspects may also influence the reported incidence, such as healthcare access and the population expectations when contacting the EMS. These factors also impact bystander CPR, and between regions, there are different approaches to dispatch-assisted CPR, knowledge and training in CPR, and the willingness to get involved when someone is unconscious and not breathing normally. We speculate that these factors also interact with the responses to the pandemic in society, health care systems, and for individuals.

In addition, participating registries have slightly different inclusion criteria. The differences between registries and regions make it essential to consider registries as random samples from the world's target population in the statistical analysis.

This study does not adjust for the differences in the prevalence of Covid-19 in different areas, or how different regions and countries were affected at different times. The datasets were divided according to the first lockdown as reported by the registries, independent of the

incidence of Covid-19 cases and the strain on communities and hospitals. Healthcare professionals were redistributed, the workload increased in all areas of healthcare, and colleagues and friends were infected. The use of personal protection equipment became more common, causing longer response intervals.[7,8,23] The pandemic also caused uncertainty about the future, social isolation, and disruption of standardised care. At the same time, we saw communities coming together and the public showing up on terraces clapping for the nurses and doctors struggling to save the patients.

We collected aggregated data for this study on a registry level. Hence, our results are constrained in granularity, and possibilities for further analysis are limited. However, using data from established registries made it possible to compare data from after the lockdown to several years before. It allowed us to adjust for time trends, limiting the chances of observed changes being at random. Collecting information from established registries covering a substantial proportion of the world's population, provided information from areas with both high and low incidences of Covid-19.

The date of the first lockdown for all countries that participated in this study occurred within a relatively narrow time interval i.e. between 10 March and 7 April 2020. However, the first reported deaths in each country varied more widely and in Vietnam the first death was reported in July 2020. Following the first lockdown, there was variation in how long lockdowns were maintained and variations in the intensity of lockdown measures. Our analysis did not adjust for national differences in approach to managing the pandemic or to the severity of the pandemic impact in individual countries. Nevertheless, our results show that, at a global level, willingness to perform CPR did not change during the first year of the pandemic.

Conclusion

There has been a steady increase in bystander CPR from 2017 to 2020, but this is not associated with a similar increase in the number of EMS-treated cardiac arrest patients. We did not find an association between lockdown caused by the Covid-19 pandemic and bystanders' willingness to start CPR before EMS arrival. There are some variations between countries.

Conflict of Interest

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/disclosure-of-interest/ and declare: no support from any organisation for the submitted work; **IBMT** received unrestricted grant from Laerdal foundation for non-related research project, **JTG** received grant from German Resuscitation Registry and German ministry of health, consultant fee from Weinmann Emergency to institution, payment or honoraria from Weinmannn, Zoll, support for attending meetings from Zoll, participation on a Data Safety Monitoring Board or Advisory Board for Weinmann, project leader for the European Registry of Cardiac Arrest, project leader for the German Resuscitation Registry and Co-chair Utstein OHCA update, **JKJ** received unrestricted grant from Laerdal foundation for non-related research project, **SLL** received grant from Zoll foundation finances through National University Health Systems Singapore, **FJCMG** is a member of the Advisory Board, Philippine College Of Emergency Medicine, **MEHO** received support for the current study from National Medical Research Council Singapore, is a medical advisor in TIIM Healthcare and Global Healthcare SG, **VR** is President of the Serbian Resuscitation Council, ERC BLS Science and Education Committee Member, ILCOR BLS Task Force Member, **FS** is European Resuscitation Council Chair-Elect (unpaid), ILCOR Chair of Social Media Working Group (unpaid), ILCOR Member of BLS Working Group (unpaid), **AT** has Leadership or fiduciary roles in Czech Resuscitation Council, Chairman, Czech Society for Emergency and Disaster Medicine, Board Member, European Resuscitation Council, Science and Education Committee ALS Member, all unpaid, **JW** received support for attending meetings from German Resuscitation Registry – German Society of Anaesthesiology and Intensive Care Medicine and pean Resuscitation Council, has leadership or fiduciary role in the European Registry of Cardiac Arrest studies and German Resuscitation Registry. No other relationships or activities that could appear to have influenced the submitted work.

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Appendix A

Collaborators

We would like to thank Rabab Al-Araji and Brian McNally, who represented the CARES surveillance Group.

We also wish to thank the contributors of the Lockdown and bystander CPR group:

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Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2023.109764.

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