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ORIGINAL RESEARCH

Impact of Coronavirus Disease 2019 Pandemic on the Incidence and Management of Out-of-Hospital Cardiac Arrest in Patients Presenting With Acute Myocardial Infarction in England

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BACKGROUND: Studies have reported significant reduction in acute myocardial infarction–related hospitalizations during the coronavirus disease 2019 (COVID-19) pandemic. However, whether these trends are associated with increased incidence of out-of-hospital cardiac arrest (OHCA) in this population is unknown.

METHODS AND RESULTS: Acute myocardial infarction hospitalizations with OHCA during the COVID-19 period (February 1–May 14, 2020) from the Myocardial Ischaemia National Audit Project and British Cardiovascular Intervention Society data sets were analyzed. Temporal trends were assessed using Poisson models with equivalent pre–COVID-19 period (February 1–May 14, 2019) as reference. Acute myocardial infarction hospitalizations during COVID-19 period were reduced by >50% (n=20 310 versus n=9325). OHCA was more prevalent during the COVID-19 period compared with the pre–COVID-19 period (5.6% versus 3.6%), with a 56% increase in the incidence of OHCA (incidence rate ratio, 1.56; 95% CI, 1.39–1.74). Patients experiencing OHCA during COVID-19 period were likely to be older, likely to be women, likely to be of Asian ethnicity, and more likely to present with ST-segment–elevation myocardial infarction. The overall rates of invasive coronary angiography (58.4% versus 71.6%; *P*<0.001) were significantly lower among the OHCA group during COVID-19 period with increased time to reperfusion (mean, 2.1 versus 1.1 hours; *P*=0.05) in those with ST-segment–elevation myocardial infarction. The adjusted in-hospital mortality probability increased from 27.7% in February 2020 to 35.8% in May 2020 in the COVID-19 group (*P*<.001).

CONCLUSIONS: In this national cohort of hospitalized patients with acute myocardial infarction, we observed a significant increase in incidence of OHCA during COVID-19 period paralleled with reduced access to guideline-recommended care and increased in-hospital mortality.

Key Words: acute myocardial infarction ■ coronavirus disease 2019 ■ incidence ■ mortality ■ out-of-hospital cardiac arrest

During the global pandemic of coronavirus disease 2019 (COVID-19), caused by the novel severe acute respiratory syndrome coronavirus 2, a significant reduction in acute myocardial infarction (AMI)–related hospitalizations has been observed.[1–4] It has been postulated that patients with AMI are not

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CLINICAL PERSPECTIVE

What Is New?

- This population-based cohort study provides important information about the incidence and clinical and procedural characteristics of patients presenting with acute myocardial infarction and prehospital cardiac arrest during the coronavirus disease 2019 (COVID-19) pandemic in England.
- There was a marked increase in the incidence of out-of-hospital cardiac arrest during the COVID-19 pandemic compared with the pre–COVID-19 period.
- Patients experiencing out-of-hospital cardiac arrest during COVID-19 were less likely to receive guideline-indicated care and had increased mortality compared with the pre–COVID-19 era.

What Are the Clinical Implications?

- Immediate countermeasures are required to increase patient awareness and improve cardiac care of this high-risk group during the ongoing COVID-19 pandemic.

Nonstandard Abbreviations and Acronyms

BCIS	British Cardiovascular Intervention Society
COVID-19	coronavirus disease 2019
IRR	incidence rate ratio
MINAP	Myocardial Ischaemia National Audit Project
OHCA	out-of-hospital cardiac arrest

seeking medical attention because of their concerns about the risk of nosocomial-acquired COVID-19 infection, as well as limitations to social movement attributable to government lockdowns.[3,5,6] Delays to timely reperfusion are associated with an increased risk of life-threatening arrhythmias, out-of-hospital cardiac arrest (OHCA), heart failure, and death among patients presenting with AMI.[7–9]

A recent multicenter observational report from Italy found that AMI-related hospitalizations were reduced by almost 50% during the COVID-19 period and accompanied by a 3-fold increase in mortality and complications.[2] Such significant changes to AMI-related hospitalizations may result in an increase in OHCA and death.[10,11] Data from the Lombardia CARe (Lombardia Cardiac Arrest Registry) reported a 58% increase in OHCA during the first 40 days of the COVID-19 outbreak.[12] It was thought that this may be related to the spread of the COVID-19 infection as there was no information about the incidence of AMI in this cohort. Similar observations were made by Lai et al from New York City emergency medical services system, where a 3-fold increase in incidence of OHCA was noted in those undergoing emergency medical services resuscitation during the COVID-19 period.[13] It remains unclear, however, whether reduced hospitalizations with AMI are associated with changes in incident OHCA. Equally, it is not known if the changes in service structure and delivery of healthcare emergency response during the COVID-19 pandemic have influenced the management of patients presenting with OHCA in the context of AMI. Using multisource nationwide data derived from UK national acute coronary syndrome and percutaneous coronary intervention (PCI) data sets, we studied the characteristics, care, and outcomes of admissions to hospital with AMI complicated by OHCA during the first wave of the COVID-19 outbreak in England.

METHODS

Study Data

Because of the sensitive nature of the data collected for this study, requests to access the data set from qualified researchers trained in human subject confidentiality protocols may be sent to National Institute of Cardiovascular Outcomes Research. Data for this study were drawn from 2 nationwide cardiovascular registries of National Institute of Cardiovascular Outcomes Research (namely, the MINAP [Myocardial Ischaemia National Audit Project] registry and the BCIS [British Cardiovascular Intervention Society] registry PCI data set).[14,15] Full details on the framework of these data sets and their utility in conducting research have been described previously.[16–18] Briefly, the MINAP registry is one of the largest single health system heart attack registries and collects information about baseline demographics, reperfusion treatment, and pharmacological and invasive management of patients admitted with AMI to 1 of the 195 acute National Health System hospitals in England.[19–21] The BCIS registry PCI database contains high-resolution information about the procedural aspects, periprocedural pharmacology, and in-hospital PCI-related complications of patients admitted with AMI.[16,22,23]

Ethics

The National Institute of Cardiovascular Outcomes Research databases, including MINAP and BCIS registries, are collected and used for research purposes without requiring informed patient consent, which fell under section 251 of National Health Service Act

2006,[24,25] and therefore institutional board review was not required for this study. Access to data required for this project has been fast tracked using a novel collaboration as part of a national drive for COVID-19–related research.

Study Population

We included all adult patients, aged 18 to 100 years, admitted with a diagnosis of AMI between February 1, 2019, and May 14, 2020 (the latest live data upload available), from the MINAP registry and BCIS registry PCI database. We only included patients with an index admission diagnosis of AMI or a PCI procedure during these dates. Further exclusions were made on the basis of missing record information on sex, cardiac arrest in hospital, and final diagnosis not being AMI (Figures S1 and S2). Given that first cases of COVID-19 in the United Kingdom were reported on January 29, 2020, we defined patients from February 1, 2020, to May 14, 2020, as the COVID-19 group. To further understand the temporal differences in the baseline characteristics, procedural profile, and outcomes, we generated an equivalent cohort of pre–COVID-19 patients from February 1, 2019, to May 14, 2019, from both data sets. Time to reperfusion treatment was calculated from time of symptom onset to time of the reperfusion treatment in the form of primary PCI or thrombolysis for ST-segment–elevation AMI.

Statistical Analysis

Continuous variables were presented as means and SDs, whereas categorical variables were reported as absolute numbers and percentages. The χ^2 and Student *t*-tests were used to examine differences across groups for categorical and continuous variables, respectively. All statistical comparisons were made between the pre–COVID-19 and COVID-19 groups only, whereas patients without OHCA were reported for total cohort comparison. All tests were 2 sided, and $P<0.05$ was considered statistically significant. Poisson regression models were used to estimate the unadjusted incidence rate ratio (IRR) of OHCA across each month of 2020, using the equivalent month in 2019 as the reference. We used multiple imputations with chained equations to account for missing data-related bias, creating 10 data sets.[26,27] Variables with complete information, such as age, sex, OHCA, month, and year, were registered as regular, whereas all other variables with missing information were imputed using logistic regression for binary, multinomial for nominal, and linear regression for continuous variables (Table S1). We used multivariable logistic regression with an interaction term between OHCA and the month variable to study the association between OHCA and in-hospital mortality in the pre–COVID-19 and COVID-19 periods. The margins command was using following the regression models, to obtain adjusted probability for in-hospital mortality.

To investigate whether the lag in the data uploads may be associated with inflated incidence of OHCA because of different hospital reporting pre–COVID-19 and post–COVID-19 period, we performed a sensitivity analysis. We only included the 88 “rapid reporting” hospitals that have consistently provided data on a weekly basis during the COVID-19 and pre–COVID-19 period across 2019 and 2020. All analyses were performed using Stata v16.0.

RESULTS

Clinical Characteristics

Five hundred twenty-four patients (5.6%) were admitted with OHCA from a total of 9325 AMI admissions the during the COVID-19 period from February 1, 2020, to May 14, 2020, compared with 731 (3.6%) patients of 20 310 during the equivalent pre–COVID-19 period from February 1, 2019, to May 14, 2019. Patients presenting with OHCA during the COVID-19 period were older (mean age, 67.1 versus 63.1 years; $P<0.001$), were more often women (28.8% versus 20.5%; $P<0.001$), and were more often of Asian ethnicity (10.0% versus 4.6%; $P<0.001$). There was an increased prevalence of insulin-treated diabetes mellitus (6.4% versus 3.0%; $P<0.001$) and hypertension (47.9% versus 41.2%; $P<0.001$) in the COVID-19 OHCA group compared with the pre–COVID-19 OHCA group. In-hospital pharmacological treatments were comparable between the pre–COVID-19 and COVID-19 groups, with similar use of glycoprotein IIb/IIIa inhibitors, angiotensin-converting enzyme inhibitors, P2Y12 inhibitors, and dual antiplatelet therapy (Table 1). An increasing proportion of patients with OHCA during the COVID-19 period had ST-segment–elevation myocardial infarction compared with patients experiencing OHCA in the pre–COVID-19 period (Figure S3).

Trends in Incidence of OHCA

During the COVID-19 period, the monthly proportions of OHCA increased from 5.4% in February 2020 to 6.9% in May 2020 (Figure 1), whereas there was a significant decrease in the total number of patients presenting with AMI. There was a 56% increase in the overall incidence of OHCA during the COVID-19 period (5.6% versus 3.6%; IRR, 1.56; 95% CI, 1.39–1.74) compared with pre–COVID-19 period (Figure 2). The IRR of OHCA also increased from 1.55 (95% CI, 1.29–1.87) in February 2020 to 1.96 (95% CI, 1.31–2.86) in May 2020 compared with equivalent monthly periods in 2019 (Figure 2). In the sensitivity analysis

Table 1. Baseline Characteristics of All Patients Presenting With OHCA Admitted With AMI Before and During the COVID-19 Pandemic in England

Variables	Total Admissions With AMI (N=29 635)	Pre–COVID-19 OHCA Group (N=731)	COVID-19 Period Group (N=524)	*P* Value*
Age, mean (SD), y	68.2 (13.6)	63.1 (12.2)	67.1 (13.2)	<0.001
Men, n (%)	19 295 (68.0)	581 (79.5)	373 (71.2)	<0.001
Race, n (%)				0.008
White	20 039 (86.7)	530 (89.4)	350 (83.7)	
Black	368 (1.6)	7 (1.2)	5 (1.2)	
Asian	1930 (8.3)	27 (4.6)	42 (10.0)	
Mixed	787 (3.4)	29 (4.9)	21 (5.0)	
Presenting characteristics				
BMI, mean (SD), kg/m^2	28.2 (5.9)	27.6 (4.9)	28.1 (5.7)	0.15
Heart rate, mean (SD), bpm	78.8 (19.4)	86.3 (24.2)	84.6 (24.2)	0.22
Systolic blood pressure, mean (SD), mm Hg	140.2 (27.5)	124.5 (30.4)	125.7 (29.4)	0.51
Clinical syndrome				0.62
STEMI, n (%)	8867 (31.2)	538 (73.6)	379 (72.3)	
NSTEMI, n (%)	19 513 (68.8)	193 (26.4)	145 (27.7)	
Creatinine (μmol/L), mean (SD)	97.1 (64.9)	102.5 (49.3)	107.8 (69.9)	0.13
Peak troponin level (ng/l), median (IQR)	266 (43–1771)	596 (40–4722)	380 (23–4081)	<0.001
Killip class, n (%)				0.17
No heart failure	21 946 (84.6)	410 (65.8)	301 (66.2)	
Basal crepitation	2599 (10.0)	70 (11.2)	44 (9.7)	
Pulmonary edema	1037 (4.0)	27 (4.3)	33 (7.3)	
Cardiogenic shock	371 (1.4)	116 (18.6)	77 (16.9)	
LV systolic function, n (%)				0.007
Good	10 499 (45.7)	182 (30.1)	121 (28.9)	
Moderate	5785 (25.2)	233 (38.5)	141 (33.7)	
Poor	1795 (7.8)	108 (17.9)	66 (15.8)	
Not assessed	4894 (21.3)	82 (13.6)	91 (21.7)	
Medical history, n (%)				
Percutaneous coronary intervention	4187 (16.8)	66 (10.6)	49 (11.4)	0.68
Coronary artery bypass grafting	1740 (7.0)	28 (4.5)	29 (6.7)	0.12
Heart failure	1833 (7.3)	34 (5.5)	30 (7.0)	0.33
Hypercholesterolemia	8147 (32.6)	151 (24.6)	107 (24.9)	0.90
Angina	5193 (20.8)	53 (8.6)	55 (12.9)	0.02
Cerebrovascular disease	2042 (8.4)	86 (7.8)	25 (6.1)	0.14
Myocardial infarction	6015 (23.8)	94 (15.1)	83 (19.2)	0.07
Peripheral vascular disease	1100 (4.4)	16 (2.6)	14 (3.2)	0.54
Chronic kidney disease	3027 (11.9)	91 (14.4)	73 (16.4)	0.37
Diabetes mellitus, n (%)				<0.001
Not diabetic	20 019 (72.6)	575 (85.3)	361 (76.6)	
Diet controlled	1208 (4.4)	12 (1.8)	26 (5.5)	
Oral medications	4112 (14.9)	67 (9.9)	54 (11.5)	
Insulin therapy	2234 (8.1)	20 (3.0)	30 (6.4)	
Hypertension	13 850 (54.5)	254 (41.2)	209 (47.9)	0.02
Smoking status, n (%)				0.25
Never smoked	8264 (35.6)	156 (31.1)	130 (36.4)	
Previous smoker	8475 (36.5)	148 (29.5)	94 (26.3)	

(*Continued*)

Table 1. Continued

Variables	Total Admissions With AMI (N=29 635)	Pre–COVID-19 OHCA Group (N=731)	COVID-19 Period Group (N=524)	*P* Value*
Current smoker	6503 (28.0)	198 (39.4)	133 (37.3)	
Asthma/COPD	4444 (17.8)	88 (14.3)	71 (16.6)	0.31
Family history of CHD, n (%)	6067 (28.5)	87 (16.6)	60 (17.0)	0.87
In-hospital pharmacology, n (%)				
Low-molecular-weight heparin	9130 (42.4)	340 (60.7)	184 (50.8)	0.003
Unfractionated heparin	7001 (32.3)	286 (50.9)	153 (41.5)	0.005
Warfarin	718 (3.3)	20 (3.6)	11 (3.0)	0.63
Loop diuretic	5054 (23.4)	162 (29.2)	118 (32.2)	0.35
Glycoprotein IIb/IIIa inhibitor use	1435 (6.6)	93 (16.5)	69 (18.7)	0.38
Processes of care				
Seen by cardiologist, n (%)	27 381 (97.7)	690 (96.8)	457 (91.0)	<0.001
Coronary angiography, n (%)	16 918 (77.9)	305 (71.6)	177 (58.4)	<0.001
Percutaneous coronary intervention, n (%)	9635 (56.3)	176 (43.7)	102 (42.9)	0.84
Time to reperfusion, mean (SD), h	3.0 (14.6)	1.1 (1.4)	2.1 (11.5)	0.05
P2Y12 use, n (%)	25 629 (90.3)	553 (75.6)	378 (72.1)	0.16
Dual-antiplatelet therapy, n (%)	24 936 (87.9)	525 (71.8)	364 (69.5)	0.37
ACE inhibitors, n (%)	15 702 (70.7)	338 (58.8)	197 (52.4)	0.26
In-hospital mortality, n (%)	778 (2.8)	201 (27.8)	192 (37.7)	<0.001

The COVID-19 period was from February 1, 2020, to May 14, 2020; and the pre–COVID-19 period was from February 1, 2019, to May 14, 2019. The UK lockdown was on March 22, 2020. ACE indicates angiotensin-converting enzyme; AMI, acute myocardial infarction; BMI, body mass index; bpm, beats per minute; CHD, coronary heart disease; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; IQR, interquartile range; LV, left ventricle; NSTEMI, non–ST-segment–elevation myocardial infarction; OHCA, out-of-hospital cardiac arrest; and STEMI, ST-segment–elevation myocardial infarction.

*All statistical comparisons were made between pre–COVID-19 period and COVID-19 period groups only.

of "rapid reporting," hospitals that consistently reported data in all months during pre–COVID-19 and COVID-19 periods, we found a similar increase in the incidence of OHCA in patients presenting with AMI during the COVID-19 period (IRR, 1.36 [95% CI, 1.08–1.72] in February 2020, increasing to IRR, 1.80 [95% CI, 1.20–2.99] in May 2020) compared with the pre–COVID-19 period (Figures S4 and S5).

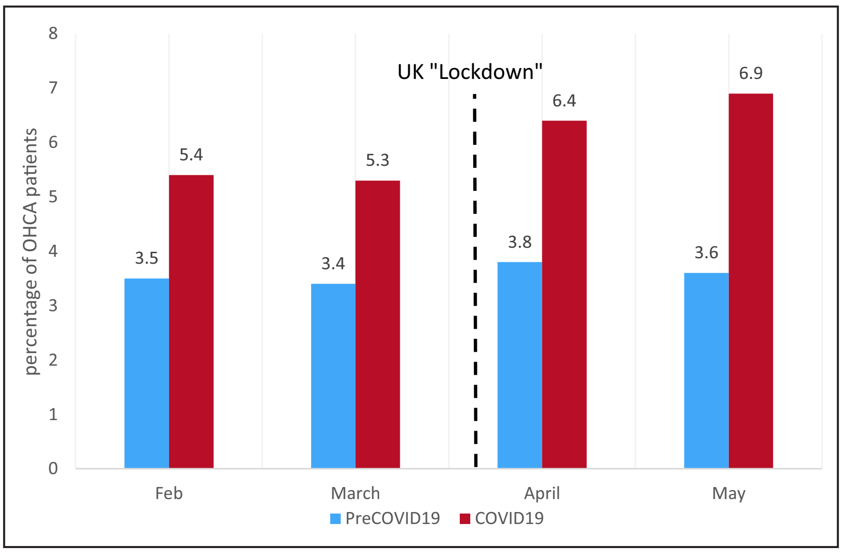

Figure 1. Temporal trends of monthly proportions of patients with acute myocardial infarction presenting with out-of-hospital cardiac arrest (OHCA) before and during coronavirus disease 2019 (COVID-19) pandemic in England. COVID-19 period indicates February 1, 2020, to May 14, 2020; pre–COVID-19 period, February 1, 2019, to May 14, 2019; and UK lockdown, March 22, 2020.

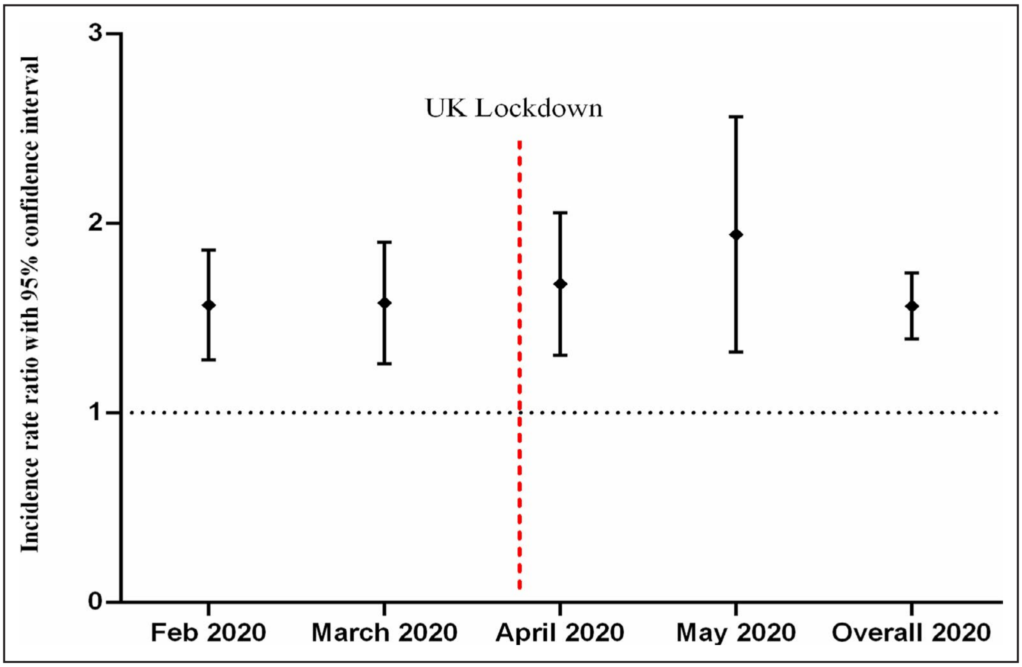

Figure 2. Monthly incidence of out-of-hospital cardiac arrest related hospitalizations during the coronavirus disease 2019 (COVID-19) period compared with pre–COVID-19 period in England. COVID-19 period indicates February 1, 2020, to May 14, 2020; pre–COVID-19 period, February 1, 2019, to May 14, 2019; and UK lockdown, March 22, 2020.

Processes of Care

Patients admitted with OHCA during the COVID-19 period were slightly less likely to be seen by a cardiologist (91.0% versus 96.8%; P<0.001), less likely to be investigated with invasive coronary angiography (58.4% versus 71.6%; P<0.001), and, for those with ST-segment–elevation myocardial infarction, had increased time to reperfusion treatment (mean, 2.1 versus 1.1 hour; P=0.05) (Table 1). Temporal analysis of use of invasive coronary angiography revealed a consistent lower use of an invasive strategy across all months in the COVID-19 period, with almost a 50% reduction in May 2020 compared with May 2019 (Figure 3). The use of PCI was also lower across COVID-19 months in 2020 compared with pre–COVID-19 months in 2019 (Figure S6). In-hospital mortality was higher in the OHCA group during the COVID-19 period compared with pre–COVID-19 (37.7% versus 27.8%; P<0.001). In the multivariable analysis, the adjusted probability of mortality also increased from 27.7% to 35.8% in the COVID-19 cohort compared with 16.9% to 29.8% in the pre–COVID-19 cohort (P<0.001) (Figure S7).

Clinical and Angiographic Characteristics From BCIS Registry

In the BCIS registry, of 15 114 PCI procedures, 674 (4.5%) were undertaken for OHCA in the pre–COVID-19 period compared with 270 (3.4%) of 7856 during the COVID-19 period. The baseline demographics and clinical characteristics were similar between the pre–COVID-19 and COVID-19 periods (Table 2). Patients with OHCA who received PCI during the COVID-19 period more frequently had complex coronary disease, such as left main stem (3.8% versus 1.2%; P<0.001) and multivessel PCI (21.2% versus 12.6%; P<0.001). There was similar use of periprocedural pharmacology, hemodynamic support in the form of pharmacological inotropes, intra-aortic balloon pump, and Impella device across the pre–COVID-19 and COVID-19 groups (Table S2). The procedural success was similar in both groups, with no difference in the in-hospital mortality, major adverse cerebrovascular events, bleeding, and other periprocedural complications (Table S2).

DISCUSSION

In this national prospective cohort of patients hospitalized with AMI during the COVID-19 outbreak, there was an increase in the incidence of OHCA accompanied with a substantial decline in AMI-related hospitalizations during the same time period. In fact, following announcement of lockdown and implementation of social distancing measures in England, the incidence of OHCA among those presenting with AMI almost

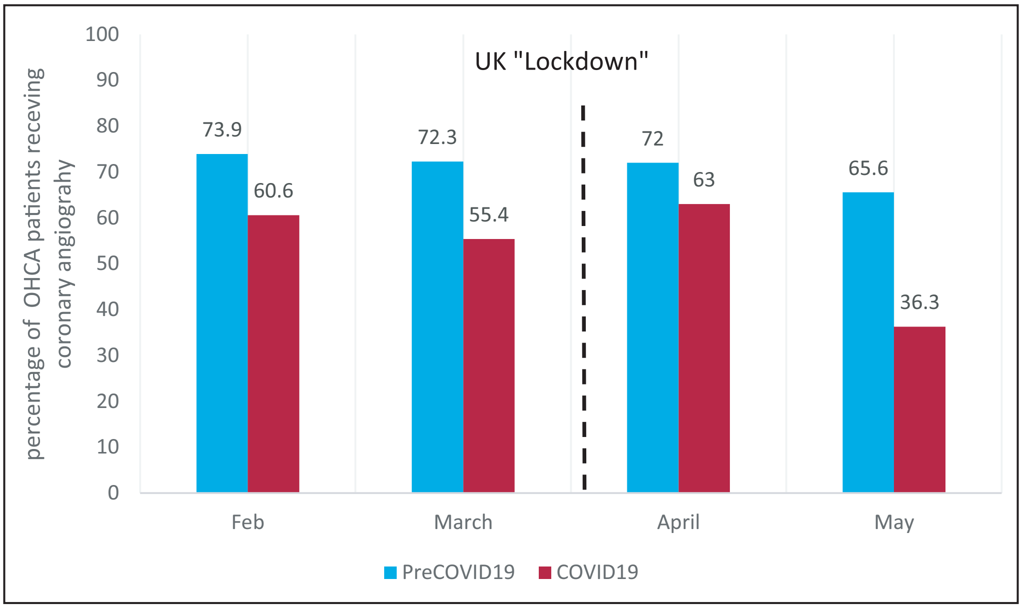

Figure 3. Temporal trends in rates of coronary angiography use in management of patients with out-of-hospital cardiac arrest (OHCA) before and during coronavirus disease 2019 (COVID-19) pandemic in England.
COVID-19 period indicates February 1, 2020, to May 14, 2020; pre–COVID-19 period, February 1, 2019, to May 14, 2019; and UK lockdown, March 22, 2020.

doubled in the late phase of COVID-19 pandemic compared with an equivalent period in the previous year. More frequently, patients presenting with OHCA during the COVID-19 period were older, women, and of Asian ethnicity. Although the pharmacological management strategies were not changed, during the COVID-19 pandemic, patients hospitalized with AMI after OHCA had longer delays to emergency reperfusion, less frequently received invasive coronary angiography, were less likely to receive specialist care, and had a higher risk of in-hospital death.

Many studies have noticed a decrease in AMI-related admissions during COVID-19 pandemic.[2–4,28] Data from 15 hospitals in the northern Italy revealed >30% reduction in the incidence of AMI-related hospitalizations during the COVID-19 pandemic.[29] Similar observations were made by Mafham et al from England, reporting 40% reduction in AMI-related hospitalizations during the COVID-19 pandemic.[28] The slight difference between the incidence of AMI-related hospitalizations in this study may be related to differences in data sets and coding differences in the Secondary Uses Service Admitted Patient Care data set that was used.[28] These findings have raised concerns that the decrease in AMI admissions may have resulted in an increased risk of OHCA, mortality, or both. Our study substantiates these concerns by showing reduced AMI admissions paralleled an increased incidence of OHCA among those presenting with AMI during the COVID-19 pandemic in England. These results are consistent with those of Baldi et al, who reported a 58% increase in the incidence of OHCA among COVID-19–positive patients in Italy.[12] However, there were no data about the concurrent history of coronary heart disease or AMI diagnosis in these patients, and the authors concluded that these findings may be related to actual viral infection.

Our data provide important information about the characteristics and in-hospital management of patients experiencing OHCA during the COVID-19 pandemic. The demographic differences in the prepandemic and during COVID-19 period are of particular interest. It is possible that older patients with increased comorbidities may have refrained from seeking early help because of fears of being exposed to infection, breaking their shielding and social confinement. Our observation about the ethnic origin of patients experiencing OHCA may be linked to increased risk of COVID-19–related mortality in ethnic minorities, such as south Asians, that has been widely reported.[30,31] It is probable that media coverage, cultural and social beliefs, and a lack of awareness may have prompted many to delay contact with the emergency medical services, thus presenting with OHCA.

There were also differences in in-hospital management and outcomes of patients experiencing OHCA during the COVID-19 period. Patients with OHCA during the COVID-19 period experienced an increase in time to reperfusion therapy and slightly

Table 2. Baseline Characteristics of All Patients Presenting With OHCA Undergoing PCI Before and During the COVID-19 Pandemic in England

Variables	Total Patients With AMI (N=22 026)	Pre–COVID-19 OHCA (N=674)	COVID-19 OHCA (N=270)	*P* Value*
Age, mean (SD), y	65.3 (12.2)	62.3 (12.2)	63.0 (11.7)	0.41
Men, n (%)	16 273 (73.9)	534 (79.2)	212 (78.5)	0.81
Race				*0.49*
White	14 849 (83.9)	471 (89.0)	201 (91.0)	
Black	235 (1.3)	5 (0.9)	0 (0.0)	
Asian	1767 (10.0)	26 (4.9)	9 (4.1)	
Others	854 (4.8)	27 (5.1)	11 (5.0)	
BMI, mean (SD), kg/m^2	28.4 (5.4)	27.9 (4.9)	27.7 (5.3)	0.61
Previous PCI, n (%)	5150 (23.7)	90 (13.7)	35 (13.5)	0.95
Previous CABG, n (%)	1134 (5.2)	18 (2.7)	5 (1.9)	0.47
Previous AMI, n (%)	5032 (23.1)	96 (15.1)	36 (14.0)	
CVA, n (%)	887 (4.2)	27 (4.5)	0 (0.0)	<0.001
Renal disease, n (%)	4711 (21.7)	163 (25.3)	114 (43.2)	<0.001
Hypercholesterolemia, n (%)	9403 (44.6)	207 (34.3)	48 (20.8)	<0.001
PVD, n (%)	754 (3.6)	23 (3.8)	9 (3.9)	0.96
Smoking history, n (%)				0.19
Never smoked	8118 (40.4)	208 (40.5)	92 (47.9)	
Ex-smoker	6823 (33.9)	135 (26.3)	42 (21.9)	
Current smoker	5163 (25.7)	171 (33.3)	58 (30.2)	
Diabetes mellitus, n (%)	5292 (24.4)	91 (14.6)	29 (11.8)	0.28
Hypertension, n (%)	11 527 (54.7)	230 (38.1)	85 (36.8)	0.72
LV systolic function, n (%)				0.12
Good	18 188 (82.6)	452 (67.1)	195 (72.2)	
Moderate	3073 (14.0)	145 (21.5)	42 (15.6)	
Severe	746 (3.4)	77 (11.4)	33 (12.2)	
Indication for intervention, n (%)				0.63
STEMI	13 257 (63.4)	122 (18.3)	52 (19.7)	
NSTEMI/ACS	7647 (36.6)	543 (81.7)	212 (80.3)	
Arterial blood gas PH, mean (SD)	7.22 (0.16)	7.19 (0.15)	7.23 (0.13)	0.07
Base excess, mean (SD)	−3.72 (7.8)	−3.74 (8.0)	−3.45 (8.3)	0.72
Cardiogenic shock, n (%)	1475 (6.7)	233 (34.6)	89 (33.0)	0.64
Glasgow Come Scale score, n (%)				0.55
15	1011 (95.1)	148 (36.7)	70 (39.3)	
<8	52 (4.9)	255 (63.3)	108 (60.7)	
Mechanical ventilation, n (%)	26 (1.3)	338 (56.6)	132 (55.5)	0.76

The COVID-19 period was from February 1, 2020, to May 14, 2020; and the pre–COVID-19 period was from February 1, 2019, to May 14, 2019. The UK lockdown was on March 22, 2020. ACS indicates acute coronary syndrome; AMI, acute myocardial infarction; BMI, body mass index; CABG, coronary artery bypass grafting; COVID-19, coronavirus disease 2019; CVA, cerebrovascular accident; LV, left ventricle; NSTEMI, non–ST-segment–elevation myocardial infarction; OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; and STEMI, ST-segment–elevation myocardial infarction.

*All statistical comparisons were made between pre–COVID-19 period and COVID-19 period groups only.

less specialist care and use of invasive coronary strategy, whereas the demographics of those selected for PCI seem to have been unchanged. Following government directives and a declaration of a healthcare emergency in the United Kingdom, hospitals undertook major reconfigurations of their services in preparation for COVID-19–related admissions. It is possible that the restructuring of emergency services, redeployment of specialist physicians to COVID-19 wards to focus on the care of COVID-19–positive patients, and conflicting and evolving guidance on how and when to resuscite in the context of OHCA, specifically with concerns about the aerosol generation, may have contributed to these differences in management.[32,33] Indeed, we noted a significant reduction in invasive coronary strategy for OHCA in this study, which is associated with improved survival and more favorable neurological outcomes, particularly in those presenting with ST-segment elevation on the ECG.[34] Reassuringly, we observed no substantial differences in procedural characteristics and outcomes for patients with OHCA who received PCI during the COVID-19 period.

To the best of our knowledge, this is first national report of impact of COVID-19 pandemic on the care and outcomes of patients with OHCA presenting to hospitals in the setting of AMI. We acknowledge the limitation of our study. The MINAP registry collects data only for hospitalized cases of acute coronary syndrome, and we were therefore unable to investigate the incidence, care, and outcomes of those with OHCA occurring in patients in whom OHCA was not related to an acute coronary syndrome or who did not survive to hospital admission. Therefore, our data are likely to have underestimated the overall incidence of OHCA. Nevertheless, a recent report from a community cardiac arrest registry suggested a similar increase in OHCA incidence, reaffirming our findings.[12] Finally, the observational nature of our study precludes inferences about causation.

CONCLUSIONS

Our study provides important insight into admissions, care, and outcomes for patients with AMI complicated by OHCA during the COVID-19 pandemic. These data suggest that a decline in AMI-related hospitalization in England was accompanied by an increase in the number of cases of OHCA, particularly after the implementation of social confinement measures during the COVID-19 outbreak in England. It appears that elderly people, women, and ethnic minorities may have refrained from seeking early help after developing cardiac symptoms of AMI. The reorganization of hospital services and staff in preparation for the COVID-19 pandemic may inadvertently have affected the care of this high-risk group. Urgent interventions to improve public awareness and treatment pathway to allow timely access to specialist care will be required to minimize the collateral cardiac damage of COVID-19 for patients with AMI.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Material

Tables S1–S2
Figures S1–S7

REFERENCES

1. Solomon MD, McNulty EJ, Rana JS, Leong TK, Lee C, Sung S, Ambrosy AP, Sidney S, Go AS. The Covid-19 pandemic and the incidence of acute myocardial infarction. *N Engl J Med.* 2020;383:691–693.
2. De Rosa S, Spaccarotella C, Basso C, Calabrò MP, Curcio A, Filardi PP, Mancone M, Mercuro G, Muscoli S, Nodari S. Reduction of hospitalizations for myocardial infarction in Italy in the COVID-19 era. *Eur Heart J.* 2020;41:2083–2088.
3. Garcia S, Albaghdadi MS, Meraj PM, Schmidt C, Garberich R, Jaffer FA, Dixon S, Rade JJ, Tannenbaum M, Chambers J. Reduction in ST-segment elevation cardiac catheterization laboratory activations in the United States during COVID-19 pandemic. *J Am Coll Cardiol.* 2020;75:2871–2872.
4. Metzler B, Siostrzonek P, Binder RK, Bauer A, Reinstadler SJ. Decline of acute coronary syndrome admissions in Austria since the outbreak of COVID-19: the pandemic response causes cardiac collateral damage. *Eur Heart J.* 2020;41:1852–1853.

5. Abdelaziz HK, Abdelrahman A, Nabi A, Debski M, Mentias A, Choudhury T, Patel B, Saad M. Impact of COVID-19 pandemic on patients with ST-segment elevation myocardial infarction: insights from a British cardiac center. *Am Heart J*. 2020;226:45–48.
6. Huet F, Prieur C, Schurtz G, Gerbaud E, Manzo-Silberman S, Vanzetto G, Elbaz M, Tea V, Mercier G, Lattuca B. One train may hide another: acute cardiovascular diseases could be neglected because of the COVID-19 pandemic. *Arch Cardiovasc Dis*. 2020;113:303–307.
7. Puymirat E, Simon T, Cayla G, Cottin Y, Elbaz M, Coste P, Lemesle G, Motreff P, Popovic B, Khalife K, et al. Acute myocardial infarction: changes in patient characteristics, management, and 6-month outcomes over a period of 20 years in the FAST-MI Program (French Registry of Acute ST-Elevation or Non-ST-Elevation Myocardial Infarction) 1995 to 2015. *Circulation*. 2017;136:1908–1919.
8. Borgia F, Goodman SG, Halvorsen S, Cantor WJ, Piscione F, Le May MR, Fernandez-Aviles F, Sanchez PL, Dimopoulos K, et al. Early routine percutaneous coronary intervention after fibrinolysis vs. standard therapy in ST-segment elevation myocardial infarction: a meta-analysis. *Eur Heart J*. 2010;31:2156–2169.
9. Danchin N, Puymirat E, Steg PG, Goldstein P, Schiele F, Belle L, Cottin Y, Fajadet J, Khalife K, Coste P, Ferrieres J, et al. Five-year survival in patients with ST-segment-elevation myocardial infarction according to modalities of reperfusion therapy: the French Registry on Acute ST-Elevation and Non-ST-Elevation Myocardial Infarction (FAST-MI) 2005 Cohort. *Circulation*. 2014;129:1629–1636.
10. Chieffo A, Stefanini GG, Price S, Barbato E, Tarantini G, Karam N, Moreno R, Buchanan GL, Gilard M, Halvorsen S, Huber K, James S, et al. EAPCI position statement on invasive management of acute coronary syndromes during the COVID-19 pandemic. *EuroIntervention*. 2020;16:233–246.
11. Mahmud E, Dauerman HL, Welt FG, Messenger JC, Rao SV, Grines C, Mattu A, Kirtane AJ, Jauhar R, Meraj P. Management of acute myocardial infarction during the COVID-19 pandemic. *J Am Coll Cardiol*. 2020;76:1375–1384.
12. Baldi E, Sechi GM, Mare C, Canevari F, Brancaglione A, Primi R, Klersy C, Palo A, Contri E, Ronchi V, Beretta G, Reali F, Parogni P, et al. Out-of-hospital cardiac arrest during the Covid-19 outbreak in Italy. *N Engl J Med*. 2020;383:496–498.
13. Lai PH, Lancet EA, Weiden MD, Webber MP, Zeig-Owens R, Hall CB, Prezant DJ. Characteristics associated with out-of-hospital cardiac arrests and resuscitations during the novel coronavirus disease 2019 pandemic in New York city. *JAMA Cardiol*. 2020. https://doi.org/10.1001/jamac ardio.2020.2488. [Epub ahead of print].
14. Gale CP, Weston C, Denaxas S, Cunningham D, de Belder MA, Gray HH, Boyle R, Deanfield JE; Executive NICOR. Engaging with the clinical data transparency initiative: a view from the National Institute for Cardiovascular Outcomes Research (NICOR). *Heart*. 2012;98:1040–1043.
15. Noman A, Balasubramaniam K, Alhous MHA, Lee K, Jesudason P, Rashid M, Mamas MA, Zaman AG. Mortality after percutaneous coronary revascularization: prior cardiovascular risk factor control and improved outcomes in patients with diabetes mellitus. *Catheter Cardiovasc Interv*. 2017;89:1195–1204.
16. Rashid M, Ludman PF, Mamas MA. British Cardiovascular Intervention Society registry framework: a quality improvement initiative on behalf of the National Institute of Cardiovascular Outcomes Research (NICOR). *Eur Heart J Qual Care Clin Outcomes*. 2019;5:292–297.
17. Herrett E, Smeeth L, Walker L, Weston C. The Myocardial Ischaemia National Audit Project (MINAP). *Heart*. 2010;96:1264–1267.
18. Wilkinson C, Weston C, Timmis A, Quinn T, Keys A, Gale CP. The Myocardial Ischaemia National Audit Project (MINAP). *Eur Heart J Qual Care Clin Outcomes*. 2020;6:19–22.
19. Mohamed MO, Kinnaird T, Anderson R, Rashid M, Martin GP, Freeman P, Kwok CS, Myint PK, Zaman AG, Mamas MA. Combinations of bleeding and ischemic risk and their association with clinical outcomes in acute coronary syndrome. *Int J Cardiol*. 2019;290:7–14.
20. Rashid M, Kontopantelis E, Kinnaird T, Curzen N, Gale CP, Mohamed MO, Shoaib A, Kwok CS, Myint PK, et al. Association between hospital cardiac catheter laboratory status, use of an invasive strategy, and outcomes after NSTEMI. *Can J Cardiol*. 2020;36:868–877.
21. Rashid M, Curzen N, Kinnaird T, Lawson CA, Myint PK, Kontopantelis E, Mohamed MO, Shoaib A, Gale CP, Timmis A, et al. Baseline risk, timing of invasive strategy and guideline compliance in NSTEMI: nationwide analysis from MINAP. *Int J Cardiol*. 2020;301:7–13.
22. Kwok CS, Kontopantelis E, Kinnaird T, Potts J, Rashid M, Shoaib A, Nolan J, Bagur R, de Belder MA, Ludman P, et al. Retroperitoneal Hemorrhage After Percutaneous Coronary Intervention: Incidence, Determinants, and Outcomes as Recorded by the British Cardiovascular Intervention Society. *Circ Cardiovasc Interv*. 2018;11:e005866. https://doi.org/10.1161/CIRCINTERVENTIONS.117.005866.
23. Taxiarchi P, Kontopantelis E, Martin GP, Kinnaird T, Curzen N, Banning AP, Ludman P, De Belder M, Rashid M, et al. Same-day discharge after elective percutaneous coronary intervention: insights from the British Cardiovascular Intervention Society. *JACC Cardiovasc Interv*. 2019;12:1479–1494.
24. Bebb O, Hall M, Fox KAA, Dondo TB, Timmis A, Bueno H, Schiele F, Gale CP. Performance of hospitals according to the ESC ACCA quality indicators and 30-day mortality for acute myocardial infarction: national cohort study using the United Kingdom Myocardial Ischaemia National Audit Project (MINAP) register. *Eur Heart J*. 2017;38:974–982.
25. Hall M, Dondo TB, Yan AT, Goodman SG, Bueno H, Chew DP, Brieger D, Timmis A, Batin PD, Deanfield JE, et al. Association of clinical factors and therapeutic strategies with improvements in survival following non-ST-elevation myocardial infarction, 2003–2013. *JAMA*. 2016;316:1073–1082.
26. Rubin DB. Multiple imputation after 18 years. *J Am Stat Assoc*. 1996;91:473–489.
27. Cattle BA, Baxter PD, Greenwood DC, Gale CP, West RM. Multiple imputation for completion of a national clinical audit dataset. *Stat Med*. 2011;30:2736–2753.
28. Mafham MM, Spata E, Goldacre R, Gair D, Curnow P, Bray M, Hollings S, Roebuck C, Gale CP, Mamas MA. COVID-19 pandemic and admission rates for and management of acute coronary syndromes in England. *Lancet*. 2020;396:381–389.
29. De Filippo O, D'Ascenzo F, Angelini F, Bocchino PP, Conrotto F, Saglietto A, Secco GG, Campo G, Gallone G, Verardi R. Reduced rate of hospital admissions for ACS during Covid-19 outbreak in Northern Italy. *N Engl J Med*. 2020;383:88–89.
30. Aldridge R. Dataset: black, Asian and minority ethnic groups in England are at increased risk of death from COVID-19. *Wellcome Open Res*. 2020;5:88.
31. Pareek M, Bangash MN, Pareek N, Pan D, Sze S, Minhas JS, Hanif W, Khunti K. Ethnicity and COVID-19: an urgent public health research priority. *Lancet*. 2020;395:1421–1422.
32. DeFilippis EM, Ranard LS, Berg DD. Cardiopulmonary resuscitation during the COVID-19 pandemic: a view from trainees on the frontline. *Circulation*. 2020;141:1833–1835.
33. Edelson DP, Sasson C, Chan PS, Atkins DL, Aziz K, Becker LB, Berg RA, Bradley SM, Brooks SC, Cheng A. Interim guidance for basic and advanced life support in adults, children, and neonates with suspected or confirmed COVID-19: from the emergency cardiovascular care committee and Get With The Guidelines®-Resuscitation Adult and Pediatric Task Forces of the American Heart Association in collaboration with the American Academy of Pediatrics, American Association for Respiratory Care, American College of Emergency Physicians, The Society of Critical Care Anesthesiologists, and American Society of Anesthesiologists: supporting organizations: American Association of Critical Care Nurses and National EMS Physicians. *Circulation*. 2020;141:e933–e943.
34. Khera R, CarlLee S, Blevins A, Schweizer M, Girotra S. Early coronary angiography and survival after out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Open Heart*. 2018;5:e000809.

SUPPLEMENTAL MATERIAL

Table S1. Percentage of missing information for each variable from MINAP registry.

Variables	Number (percentage)
Age	0
Sex	0
Race	5,500 (18.5%)
BMI	0
Heart rate	0
Systolic blood pressure	0
Clinical syndrome	0
Creatinine	0
Kilip Class	2,604 (8.8%)
LV systolic function	5,638 (19.0%)
Percutaneous coronary intervention	3,702 (12.5%)
Coronary artery bypass graft	3,705 (12.5%)
Heart failure	3,568 (12.0%)
Hypercholesterolemia	3,574 (12.0%)
Angina	3,641 (12.3%)
Cerebrovascular disease	3,643 (12.3%)
Myocardial infarction	3,333 (11.3%)
Peripheral vascular disease	3,692 (12.5%)
Chronic kidney disease	3,204 (10.8%)
Diabetes	917 (3.0%)
Hypertension	3,168 (10.7%)
Smoking status	5,534 (18.7%)
Asthma / COPD	3,557 (12.0%)
Family history of CHD	7,462 (25.2%)
Low molecular weight heparin	7,177 (24.2%)
Unfractionated heparin	7,045 (23.8%)
Warfarin	7,270 (24.5%)
Loop Diuretic	7,085 (23.9%)
Glycoprotein use	6,891 (23.2%)
Seen by cardiologist	381 (1.3%)
Coronary angiography	3,523 (11.9%)
Percutaneous coronary intervention	9,677 (32.6%)
P2Y12 use	0
Dual antiplatelet therapy	0
ACE inhibitors	6,480 (21.9%)
In-hospital mortality	0

CHD= coronary heart disease, COPD= chronic obstructive pulmonary disease, LV= left ventricle, bpm= beats per minute, BMI= body mass index, OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020

Table S2. Procedural characteristic of patients presenting with OHCA undergoing PCI before and during COVID-19 pandemic.

Variables	Total AMI patients N=22,026	Pre-COVID-19 OHCA N= 674	COVID-19 OHCA N=270	P value*
Lesion attempted				0.26
1	14,965(68.9%)	480 (71.8%)	216 (81.2%)	
2	4171 (19.2%)	129 (19.3%)	31 (11.6%)	
3 or more	1442 (6.6%)	50 (7.5%)	16 (6.2%)	
Call to Balloon time	8.8 (18.9)	2.5 (4.5)	3.2 (5.9)	0.12
Vessel attempted				0.05
Grafts	357 (1.7%)	7 (1.1%)	2 (0.8%)	
LMS	485 (2.3%)	8 (1.2%)	10 (3.8%)	
RCA	9314 (45.0%)	367 (55.8%)	145 (54.5%)	
LAD	3925 (19.0%)	113 (17.2%)	35 (13.2%)	
LCX	6608 (31.9%)	163 (24.8%)	74 (27.8%)	
Multi-vessel PCI	4200 (19.1%)	85 (12.6%)	44 (21.2%)	<0.001
Number of stents				0.26
0	3221 (14.9%)	72 (10.8%)	37 (14.1%)	
1	11301 (52.4%)	376 (56.6%)	153 (58.4%)	
2	4755 (22.1%)	138 (20.8%)	50 (19.1%)	
3 or more	2278 (10.6%)	78 (11.7%)	22 (8.4%)	
Inotropic support	334 (1.6%)	113 (17.4%)	37 (14.2%)	0.23
Intra-aortic balloon pump	127 (0.6%)	49 (7.6%)	16 (6.1%)	0.45
Impella	16 (0.1%)	1 (0.2%)	1 (0.4%)	0.50
Glyoprotein IIb/IIIa inhibitor use	3075 (16.2%)	243 (40.7%)	99 (42.1%)	0.71
TIMI flow post PCI				**0.64**
0	431 (3.0%)	34 (6.5%)	15 (7.3%)	
1	120 (0.8%)	5 (1.0%)	3 (1.5%)	
2	419 (2.9%)	25 (4.8%)	6 (2.9%)	
3	13529 (93.3%)	460 (87.8%)	182 (88.3%)	
IVUS use	1946 (9.8%)	44 (7.4%)	24 (10.0%)	0.22
OCT use	726 (3.7%)	21 (3.5%)	11 (4.6%)	0.48
FFR/iFR use	2236 (11.3%)	15 (2.5%)	5 (2.1%)	0.71
Aspirin	17585 (93.6%)	442 (78.4%)	175 (76.4%)	0.55
Clopidogrel	7451 (40.9%)	130 (24.2%)	47 (21.2%)	0.37
Ticagrelor	8079 (44.3%)	186 (34.6%)	80 (36.0%)	0.70
Heparin	4502 (24.7%)	142 (26.4%)	64 (28.8%)	0.49
Procedural outcomes				
MACCE	615 (2.9%)	151 (23.2%)	42 (17.0%)	<0.001
In-hospital bleeding	92 (0.4%)	10 (2.0%)	2 (1.0%)	0.34
In-hospital death	316(1.4%)	136 (20.2%)	40 (14.8%)	0.05

*All statistical comparisons were made between pre-COVID19 and COVID-19 period group only, LMS= left main stem, RCA= Right coronary artery, LAD= left anterior descending artery, LCX= left circumflex artery, IVUS= intravascular ultrasound, OCT= optical coherence tomography, FFR= fractional flow reserve, iFR= instantaneous flow reserve, MACCE= major adverse cerebrovascular events.

Figure S1. Cohort selection from MINAP registry.

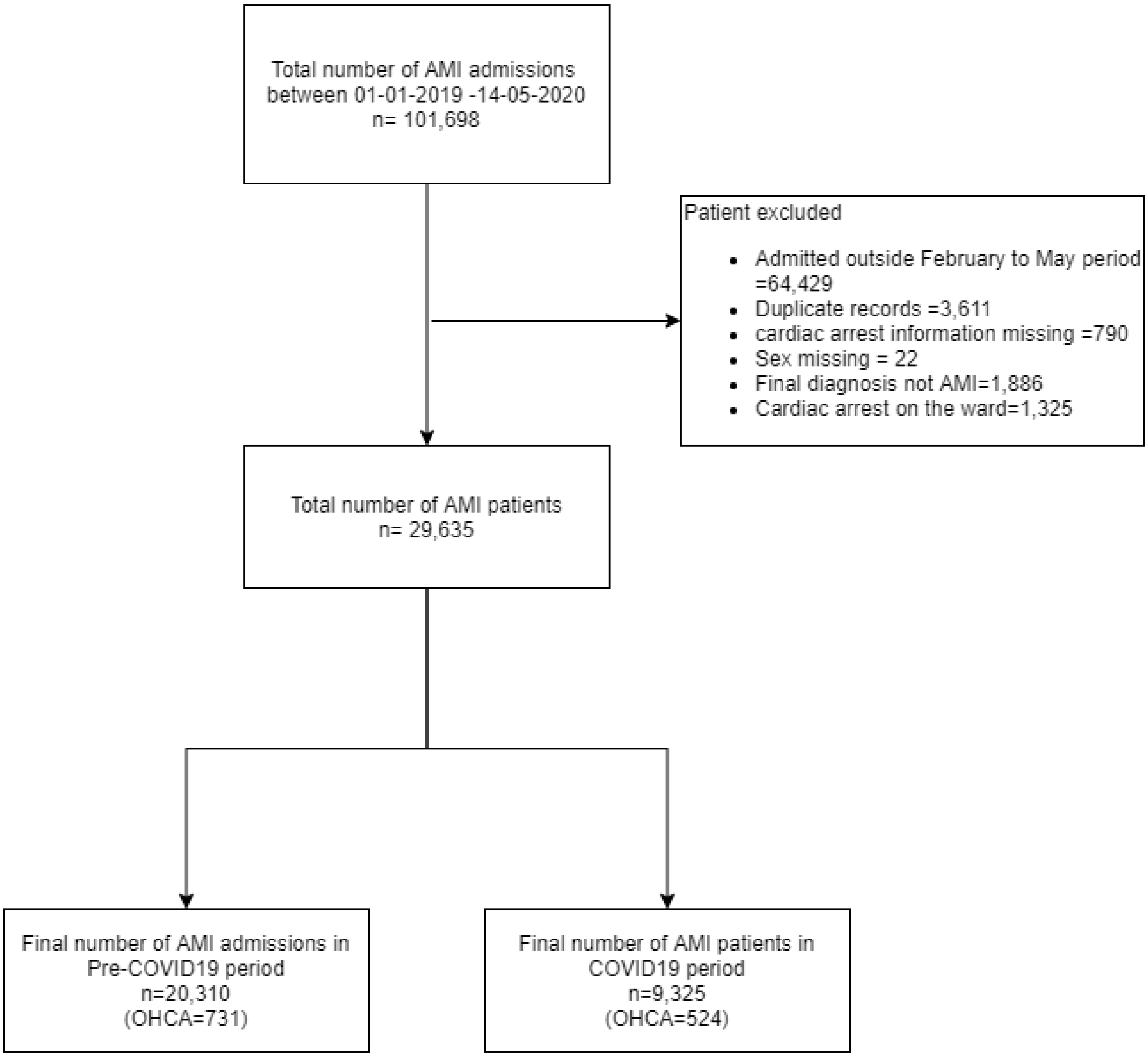


Figure S2. Cohort selection from BCIS registry.

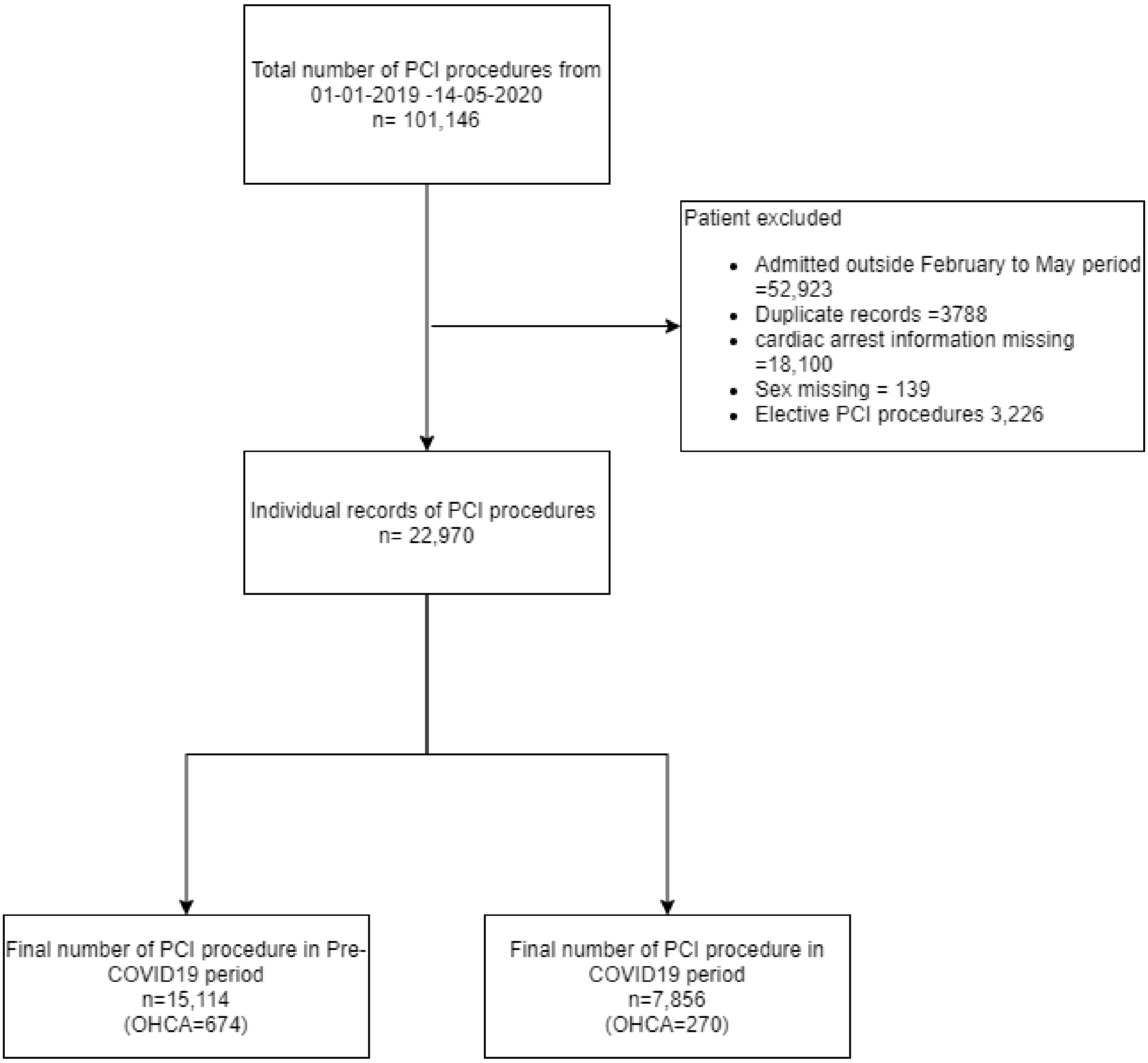
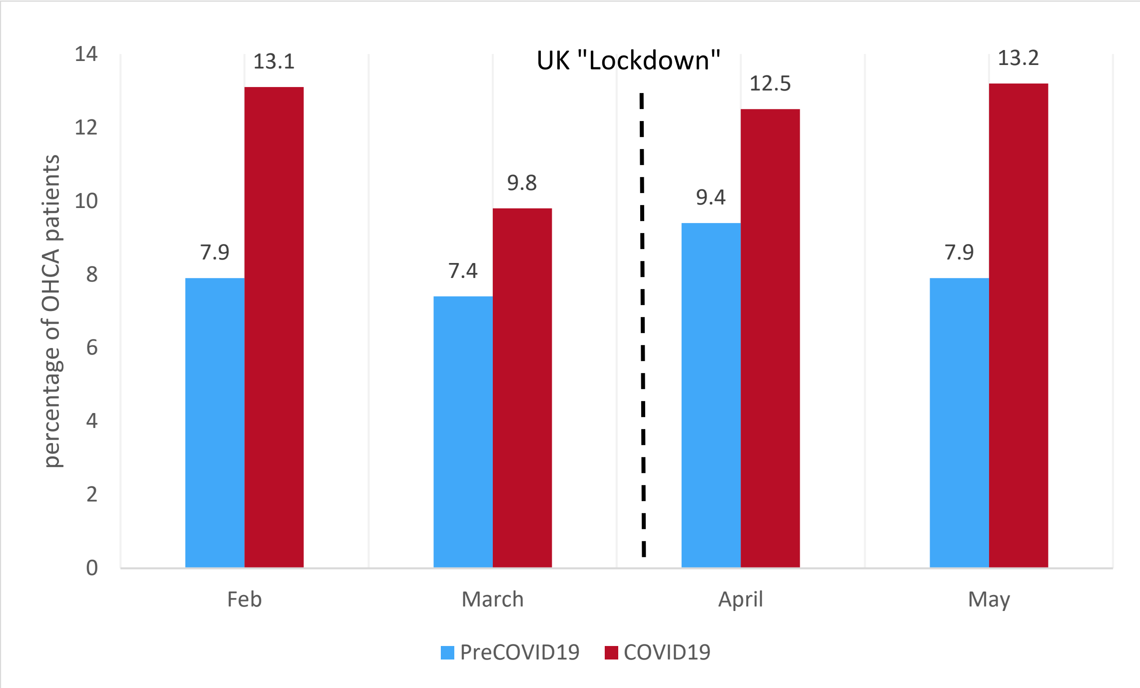
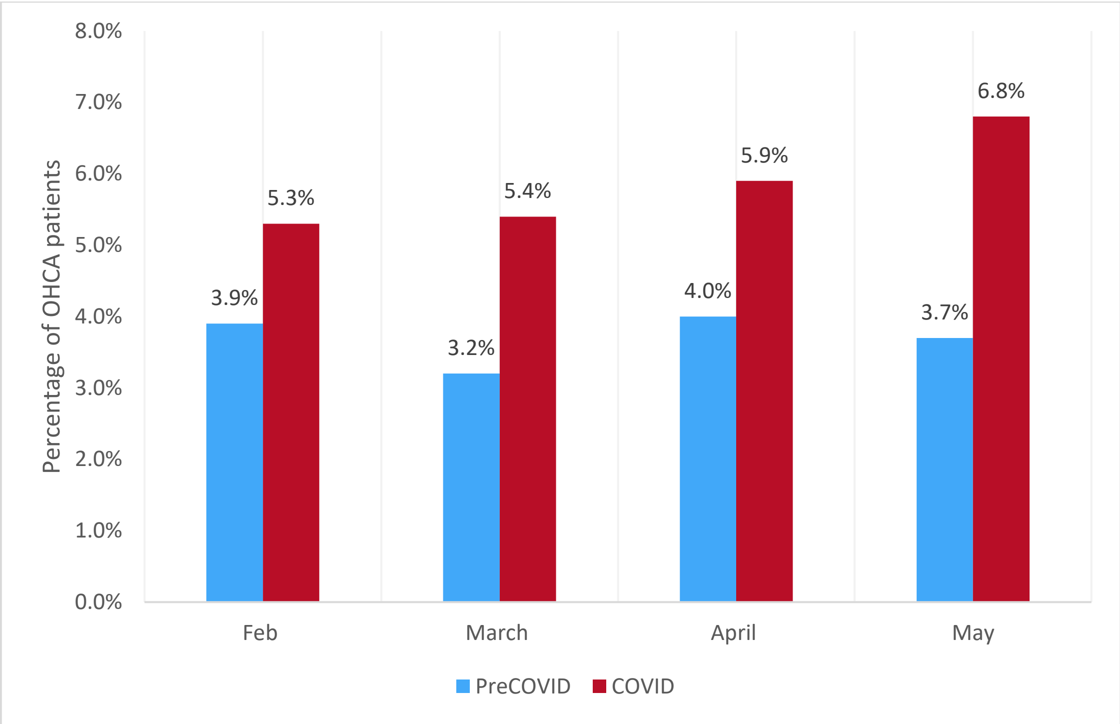


Figure S3. Temporal trends of monthly proportions of OHCA patients presenting with STEMI before and during COVID19 period.



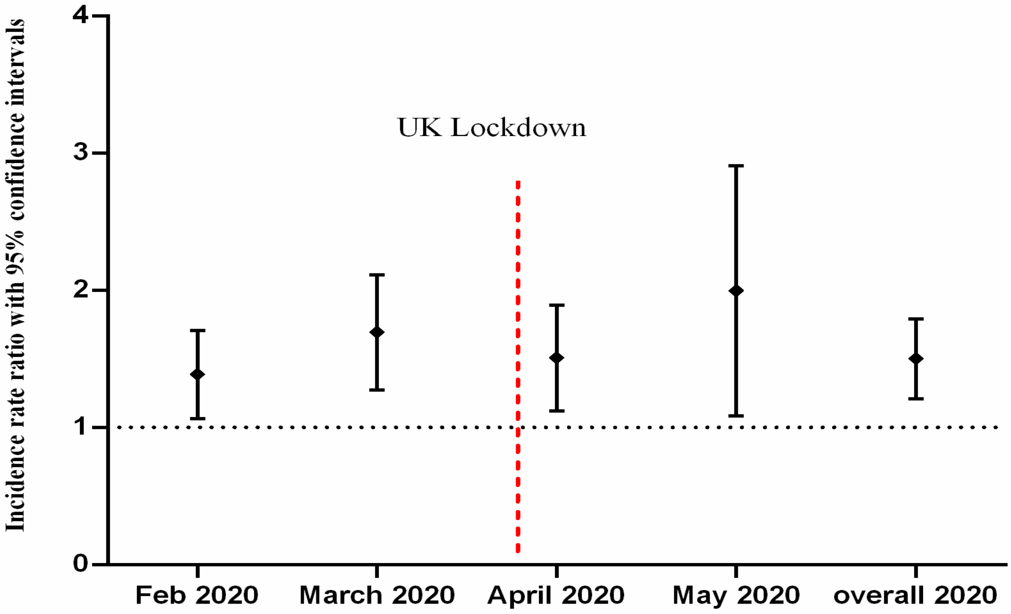
OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020, STEMI= st elevation acute myocardial infarction

Figure S4. Temporal trends of monthly proportion of patients presenting with OHCA before and during the COVID-19 pandemic amongst the rapid reporting hospitals.



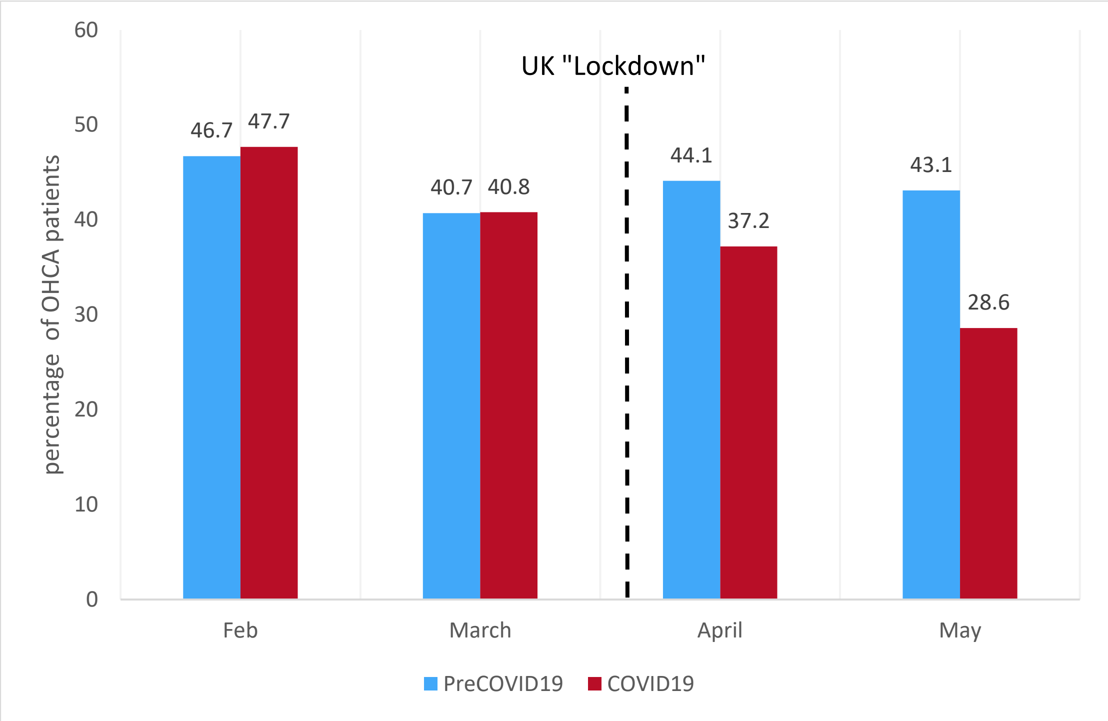
OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020

Figure S5. Incidence rate ratio of OHCA during COVID-19 pandemic amongst the rapid response hospitals.



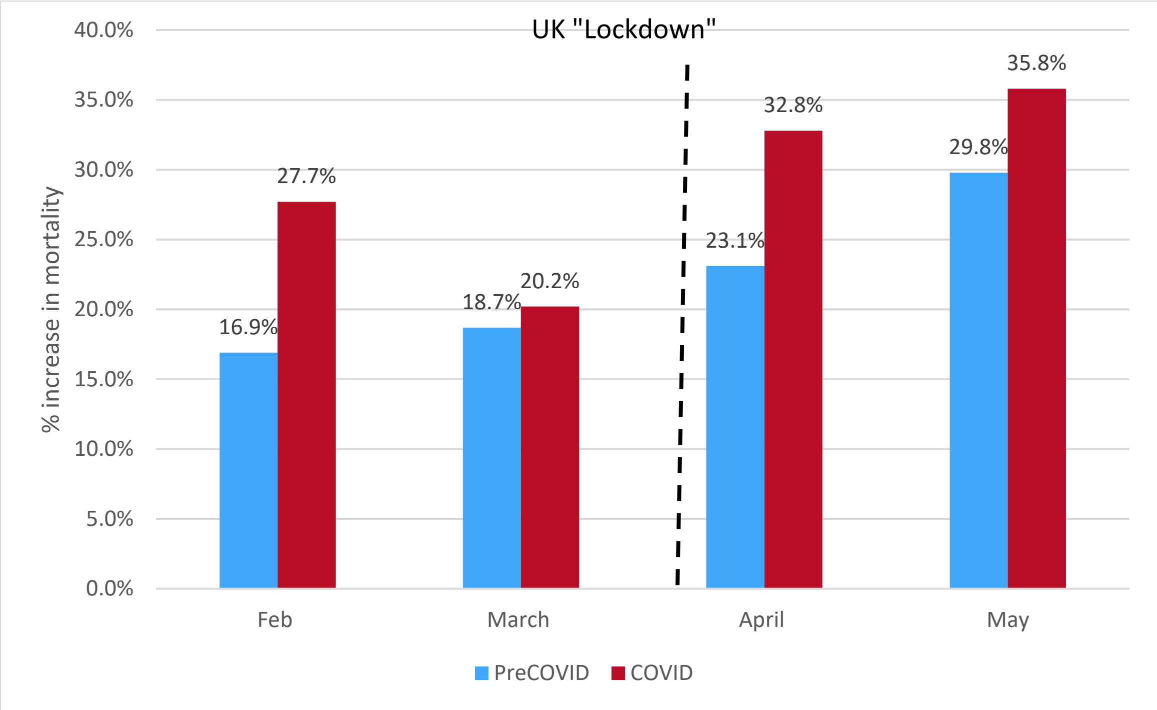
OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020

Figure S6. Temporal trends of use of percutaneous coronary intervention before and during COVID19 period in England.



OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020

Figure S7. Monthly adjusted probability of mortality between pre-COVID-19 and COVID-19 OHCA groups in England.



OHCA= out of hospital cardiac arrest, UK lockdown= 22nd March 2020, COVID19 = Corona virus infection. Pre-COVID19 period= 1st February 2019 to 14th May 2019, COVID19 period= 1st February 2020 to 14th May 2020