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Impact of the COVID-19 Pandemic on Percutaneous Coronary Intervention in England: Insights From the British Cardiovascular Intervention Society PCI Database Cohort. — Source link

Chun Shing Kwok, Chun Shing Kwok, Chris P Gale, Chris P Gale ...+14 more authors

Institutions: Royal Stoke University Hospital, Keele University, Leeds Teaching Hospitals NHS Trust, University of Leeds ...+7 more institutions

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Abstract: BACKGROUND The objective of the study was to evaluate changes in percutaneous coronary intervention (PCI) practice in England by analyzing procedural numbers, changes in the clinical presentation, and characteristics of patients and their clinical outcomes during the coronavirus disease 2019 (COVID-19) pandemic. METHODS We conducted a retrospective cohort study of all patients who underwent PCI in England between January 2017 and April 2020 in the British Cardiovascular Intervention Society database. RESULTS Forty-four hospitals reported PCI procedures for 126 491 patients. There were 700 procedures performed each week before the lockdown. After the March 23, 2020 lockdown (11th/12th week in 2020), there was a 49% fall in the number of PCI procedures after the 12th week in 2020. The decrease was greatest in PCI procedures performed for stable angina (66%), followed by non-ST-segment-elevation myocardial infarction (45%), and ST-segment-elevation myocardial infarction (33%). Patients after the lockdown were younger (64.5 versus 65.5 years, P<0.001) and less likely to have diabetes (20.4% versus 24.6%, P<0.001), hypertension (52.0% versus 56.8%, P=0.001), previous myocardial infarction (23.5% versus 26.7%, P=0.008), previous PCI (24.3% versus 28.3%, P=0.001), or previous coronary artery bypass graft (4.6% versus 7.2%, P<0.001) compared with before the lockdown. CONCLUSIONS The lockdown in England has resulted in a significant decline in PCI procedures. Fewer patients underwent PCI for stable angina. This enabled greater capacity for urgent and emergency cases, and a reduced length of stay was seen for such patients. Significant changes in the characteristics of patients towards a lower risk phenotype were observed, particularly for non-ST-segment-elevation myocardial infarction, reflecting a more conservative approach to this cohort.

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ORIGINAL ARTICLE

Impact of the COVID-19 Pandemic on Percutaneous Coronary Intervention in England

Insights From the British Cardiovascular Intervention Society PCI Database Cohort

Chun Shing Kwok, MBBS, PhD, MSc, BSc; Chris P. Gale, MBBS, PhD; Nick Curzen, MD; Mark A. de Belder, MD; Peter Ludman, MD; Thomas F. Lüscher, MD; Evangelos Kontopantelis, PhD; Chris Roebuck, MSc; Tom Denwood, MSc; Tony Burton; Julian Hains, MA; John E. Deanfield, BChir, MB; Mamas A. Mamas, BM BCh, PhD

BACKGROUND: The objective of the study was to evaluate changes in percutaneous coronary intervention (PCI) practice in England by analyzing procedural numbers, changes in the clinical presentation, and characteristics of patients and their clinical outcomes during the coronavirus disease 2019 (COVID-19) pandemic.

METHODS: We conducted a retrospective cohort study of all patients who underwent PCI in England between January 2017 and April 2020 in the British Cardiovascular Intervention Society database.

RESULTS: Forty-four hospitals reported PCI procedures for 126 491 patients. There were ≈700 procedures performed each week before the lockdown. After the March 23, 2020 lockdown (11th/12th week in 2020), there was a 49% fall in the number of PCI procedures after the 12th week in 2020. The decrease was greatest in PCI procedures performed for stable angina (66%), followed by non–ST-segment–elevation myocardial infarction (45%), and ST-segment–elevation myocardial infarction (33%). Patients after the lockdown were younger (64.5 versus 65.5 years, $P<0.001$) and less likely to have diabetes (20.4% versus 24.6%, $P<0.001$), hypertension (52.0% versus 56.8%, $P=0.001$), previous myocardial infarction (23.5% versus 26.7%, $P=0.008$), previous PCI (24.3% versus 28.3%, $P=0.001$), or previous coronary artery bypass graft (4.6% versus 7.2%, $P<0.001$) compared with before the lockdown.

CONCLUSIONS: The lockdown in England has resulted in a significant decline in PCI procedures. Fewer patients underwent PCI for stable angina. This enabled greater capacity for urgent and emergency cases, and a reduced length of stay was seen for such patients. Significant changes in the characteristics of patients towards a lower risk phenotype were observed, particularly for non–ST-segment–elevation myocardial infarction, reflecting a more conservative approach to this cohort.

GRAPHIC ABSTRACT: A graphic abstract is available for this article.

Key Words: acute myocardial infarction ■ COVID-19 ■ pandemics ■ percutaneous coronary intervention ■ stable angina

The coronavirus disease 2019 (COVID-19) has rapidly become a worldwide pandemic accounting for over 4 million confirmed cases and over a quarter of a million deaths.[1] Health care resources have been diverted away from routine hospital services, including cardiac catheterization facilities to focus on the care of patients infected with the severe acute respiratory syndrome coronavirus 2. As there currently are no curative therapies or vaccines against COVID-19, the current strategy is to contain the spread of infection through

Correspondence to: Mamas A. Mamas, BM BCh, PhD, Keele Cardiovascular Research Group, Keele University, Stoke-on-Trent, United Kingdom. Email mamasmamas1@yahoo.co.uk

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WHAT IS KNOWN

- While there are isolated reports on a local or regional level that the coronavirus disease 2019 (COVID-19) pandemic is associated with a reduction in both presentation with acute myocardial infarction and percutaneous coronary intervention (PCI) activity, little is known regarding its impact on national PCI practice.

WHAT THE STUDY ADDS

- After the March 23, 2020 COVID-19 pandemic lockdown in the United Kingdom, there was a 49% fall in the number of PCI procedures.
- The decrease was greatest in PCI procedures performed for stable angina (66%), followed by non–ST-segment–elevation myocardial infarction (45%), and ST-segment–elevation myocardial infarction (33%).
- Patients after the lockdown were younger and less likely to have diabetes, hypertension, and previous myocardial infarction compared with before the lockdown.
- The lockdown in England has resulted in a significant decline in PCI activity and a shift of patients towards a lower risk phenotype.

Nonstandard Abbreviations and Acronyms

ACS	acute coronary syndrome
BCIS	British Cardiovascular Intervention Society
COVID-19	coronavirus disease 2019
NICOR	National Institute of Cardiovascular Outcomes Research
NSTEMI	non–ST-segment–elevation myocardial infarction
PCI	percutaneous coronary interventions
STEMI	ST-segment–elevation myocardial infarction

minimizing the risk of exposure, with many countries having imposed social containment mandates (so called lockdown). Concerns have been raised that the public may delay seeking emergency care, because of fear of contracting COVID-19 at hospitals, have been raised which could have important consequences especially in conditions such as acute myocardial infarction in which timely treatment and coronary revascularization is proven to reduce mortality and complications.[2]

The most common form of coronary revascularization is percutaneous coronary intervention (PCI) with ≈100 000 PCI procedures undertaken in the United Kingdom annually.[3] While there are isolated reports on a local or regional level that the COVID-19 pandemic is associated with a reduction in both presentation with acute myocardial infarction and PCI procedures,[4,5] little is known regarding its impact on national PCI practice. Specifically, there has been no systematic data about comparative activity across the broad spectrum of indications for which PCI is undertaken, whether there have been changes in the clinical profile of patients undergoing these procedures, or how the PCI procedure is performed or its clinical outcomes.

The objective of this current analysis is to evaluate the changes in PCI practice during the COVID-19 pandemic through analysis of procedural numbers, changes in the clinical presentation, and characteristics of patients and their clinical outcomes.

METHODS

All data used in this analysis can be obtained from National Institute of Cardiovascular Outcomes Research (NICOR) through their application process (https://www.nicor.org.uk/) and the authors do not have permission to share the data. The reporting of this cohort is in accordance with the recommendations of the STROBE statement (Strengthening the Reporting of Observational Studies in Epidemiology).[6]

The British Cardiovascular Intervention Society (BCIS) registry is designed to collect data of all consecutive adults undergoing all PCI in the United Kingdom from time of admission to discharge in the National Health Service Hospitals in England. The data set contains around 120 variables covering demographic characteristics, clinical information, periprocedural, and outcome variables, as previously described.[7] This national audit is overseen by the NICOR.[8] As a consequence of the urgent need to get information about the impact of the COVID-19 pandemic on cardiology services, extraordinary government permission was obtained to evaluate anonymized records from this database through an agreement with National Health Service (NHS) Digital, therefore, institutional review board and ethical approval was not required.

Study Design, Population, and Outcomes

We conducted a retrospective cohort study of all patients who underwent PCI in England between January 1, 2017 and April 30, 2020 in the BCIS database. Participating hospitals may either enter data directly into a web-based interface provided by NICOR, although the majority of uploaded data has been collected using 19 different local databases. To enable rapid assessment of cardiovascular services and procedures during the COVID-19 pandemic in the United Kingdom, hospitals were encouraged to upload their data more frequently than normal, on a monthly basis, through a series of special communications from both the British Cardiovascular Society and BCIS to members, and also by direct contact from NICOR to each hospital's cardiovascular audit team about the particular importance of submitting data to NICOR. Data for this project are included from hospitals that successfully uploaded all the PCI procedures in each month of the current year until the end of April 2020. This was necessary to ensure only those centers in whom all procedures had been reported and uploaded until the end of April were included, to minimize the risk that we included data from some centers in which not

every PCI had yet been uploaded. Patients with missing sex were excluded as were those who did not have PCI (eg, only had a pressure wire assessment or intravascular imaging) or were admitted to private hospitals, which represent <5% of PCI activity in the United Kingdom.

The primary outcome of interest was number of PCI procedures undertaken before and after the COVID-19 pandemic and subsequent lockdown and the secondary outcomes were the in-hospital mortality and complication rates for these procedures over the same period. Only in-hospital events were considered for this analysis.

Covariates

Data were collected on patient demographics, comorbidities, and treatments received. Specifically, data were collected on age, sex, ethnicity, smoking status, comorbidities (diabetes, hypertension, hypercholesterolemia, renal failure, previous myocardial infarction, previous stroke, peripheral vascular disease, valvular heart disease), previous PCI, previous coronary artery bypass graft, indication for PCI, PCI access site, multivessel coronary disease, target vessel(s) for PCI, antiplatelet medications (clopidogrel, ticagrelor, prasugrel), use of glycoprotein IIb/IIIa inhibitors, imaging (optical coherence tomography/intravascular ultrasound), rotational atherectomy, intraaortic balloon pump, extracorporeal membrane oxygenation/Impella device, cardiogenic shock, use of inotropes, PCI with drug eluting stent, and number of stents. In-hospital outcomes were also collected including receipt of transfusion (blood or platelet), major bleeding, death, major adverse cardiovascular events (composite of death, reinfarction, and re-PCI), embolic stroke, coronary perforation, retroperitoneal bleed, renal failure/dialysis, and re-PCI.

Statistical Analysis

Statistical analyses were performed on Stata/MP version 16.0 (Stata Corp, College Station, TX). The cohort was divided into patients who underwent PCI in 2017 to 2019 and those who had a PCI procedure performed from January 1 to April 30, 2020. For the analysis of trend, the weekly average PCI procedures for the years 2017, 2018, and 2019 were determined, and these mean rates were compared against the number of procedures in each week in 2020. This was determined for the entire PCI cohort and according to subgroups based on indication for PCI (stable angina, unstable angina/non–ST-segment–elevation myocardial infarction [NSTEMI], and ST-segment–elevation myocardial infarction [STEMI]), age group (18–49, 50–59, 60–69, 70–79, and ≥80 years), sex (male/female) and ethnicity as defined in the data set (White/Black/South Asian/East Asian). The date of the lockdown was March 23, 2020 and is depicted in the figures between week 11 and week 12. Descriptive statistics are presented in tables by year of PCI before 2020, and by month in 2020. Using the 2017 to 2019 group as a reference group, the *t* test for continuous variables and χ^2 test for categorical variables were used to determine if there was any statistical difference in patient characteristics, procedural variables, and in-hospital outcomes for each month of 2020 and the group before 2020. A multiple logistic regression model was used to evaluate the independent odds of in-hospital mortality for procedures undertaken in each month of 2020 compared with before 2020. This model was adjusted for all covariates previously mentioned, except for left ventricular function, smoking status and ethnicity because of the extent of missing data for these variables. A significance level of $P<0.05$ was used for significance testing. Finally, the descriptive statistics were also presented in tables stratified by indication for PCI. A sensitivity analysis was performed restricting the control group to the same months of January to April in the calendar years 2017, 2018, and 2019 to avoid any potential issues related to seasonal differences in numbers of procedures.

Ethical Approval

This work was endorsed by the Scientific Advisory Group for Emergencies, (a body responsible for ensuring timely and coordinated scientific advice is made available to decision makers to support UK cross-government decisions in the Cabinet Office Briefing Room) and NHS England, a public body of the Department of Health and Social Care, and NHS Improvement—responsible for overseeing NHS trusts. NICOR, which houses the BCIS registry, has support under section 251 of the NHS Act 2006 to use patient information for medical research without informed consent. For this rapid NHS evaluation, health data analysis was enabled under section 254 of the Health and Social Care Act 2012.

RESULTS

A total of 44 hospitals out of 85 hospitals in England successfully uploaded data to NICOR for PCI procedures recorded in the BCIS database for every month up to and including April in 2020 (Figure 1). After applying exclusions to the 291 325 records available, 126 491 records formed the sample that was analyzed. The extent of missing data is shown in Table I in the Data Supplement. The characteristics of patients in the hospitals included versus all hospitals were analyzed to investigate any potential biases related to exclusion of hospitals because of failure to report procedures up to and including April 2020. The clinical and procedural characteristics of patients were largely similar, despite statistical differences due to the large sample (Table II in the Data Supplement).

The overall trend in PCI procedures is shown in Figure 2. The weekly average number of PCI procedures in these hospitals in 2017 to 2019 was 744 which was greater than the average over the first 10 weeks of 2020 (n=694). After the lockdown on March 23, 2020, the average number of procedures beyond 12 weeks was 354 procedures, a reduction of 49% compared with the first 10 weeks of 2020. For patients with stable angina, the weekly average of procedures in 2017 to 2019 was 239 procedures while in the first 10 weeks of 2020 it was 232 procedures (Figure 3). After 12 weeks in 2020, the average number of procedures for elective patients dropped to 79, a reduction of 66% compared with weeks 1 to 10 in 2020, respectively. For unstable angina/NSTEMI, the weekly average was 301, 281, and 154 for 2017 to 2019, the first 1 to 10 weeks of 2020 and beyond 12 weeks, respectively. There was a 45%

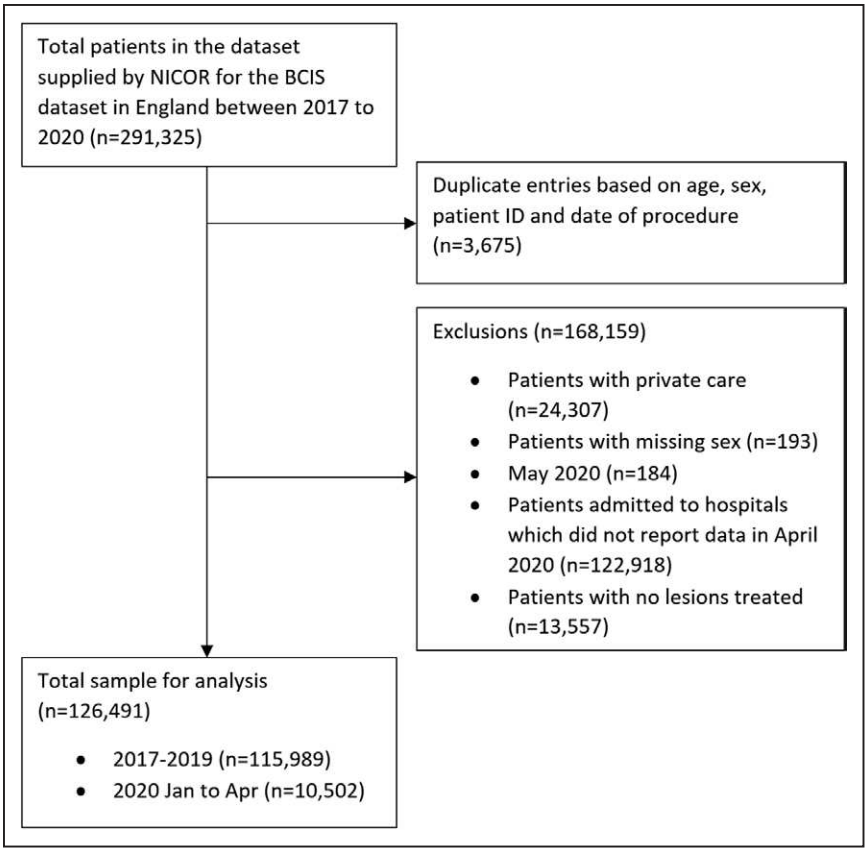

Figure 1. Flow diagram of patient inclusion.
BCIS indicates British Cardiovascular Intervention Society; and NICOR, National Institute of Cardiovascular Outcomes Research.

decrease in procedures beyond 12 weeks compared with the first 1 to 10 weeks of 2020. For patients with STEMI, there were on average 201 procedures weekly in 2017 to 2019 and 180 procedures weekly for the first 10 weeks of 2020. Beyond 12 weeks, there were 120 procedures weekly (33% reduction) compared with the first 10 weeks of 2020.

The decline was also observed for different age groups, sex and ethnicity (Figure 4). The reduction was 42%, 49%, 43%, 51%, and 62% for age groups 18 to 49, 50

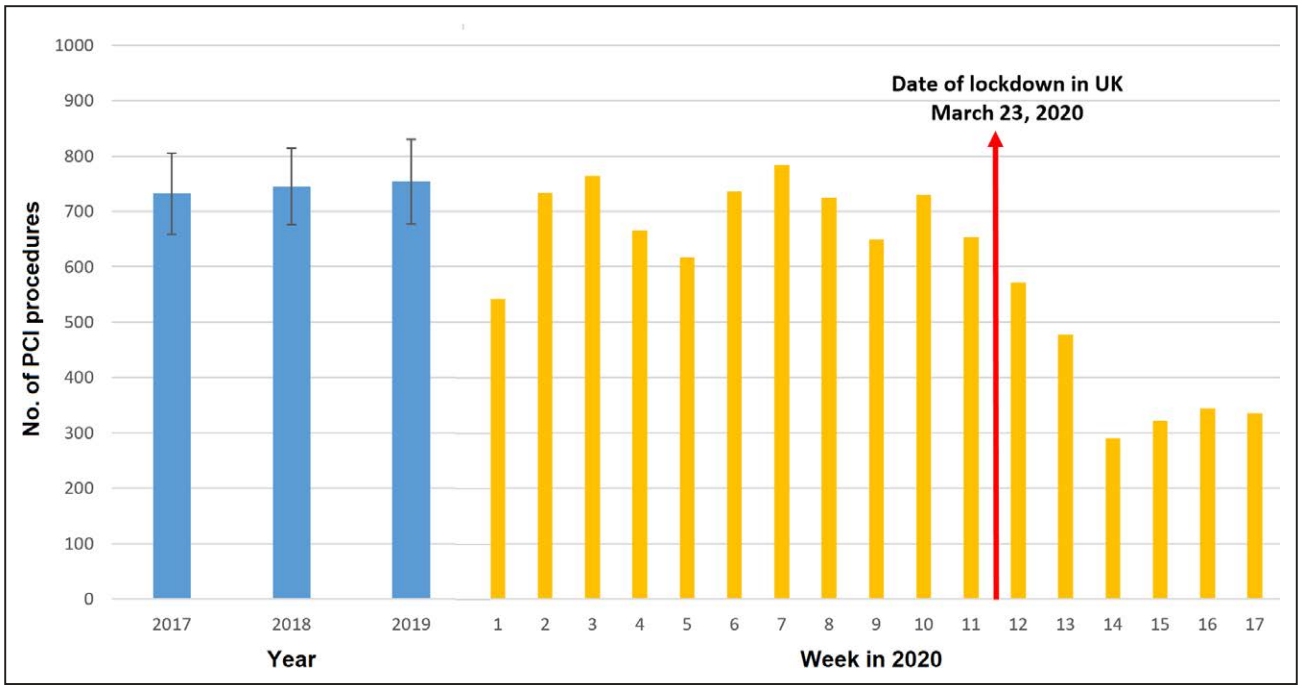

Figure 2. Trends in percutaneous coronary intervention (PCI) procedures.

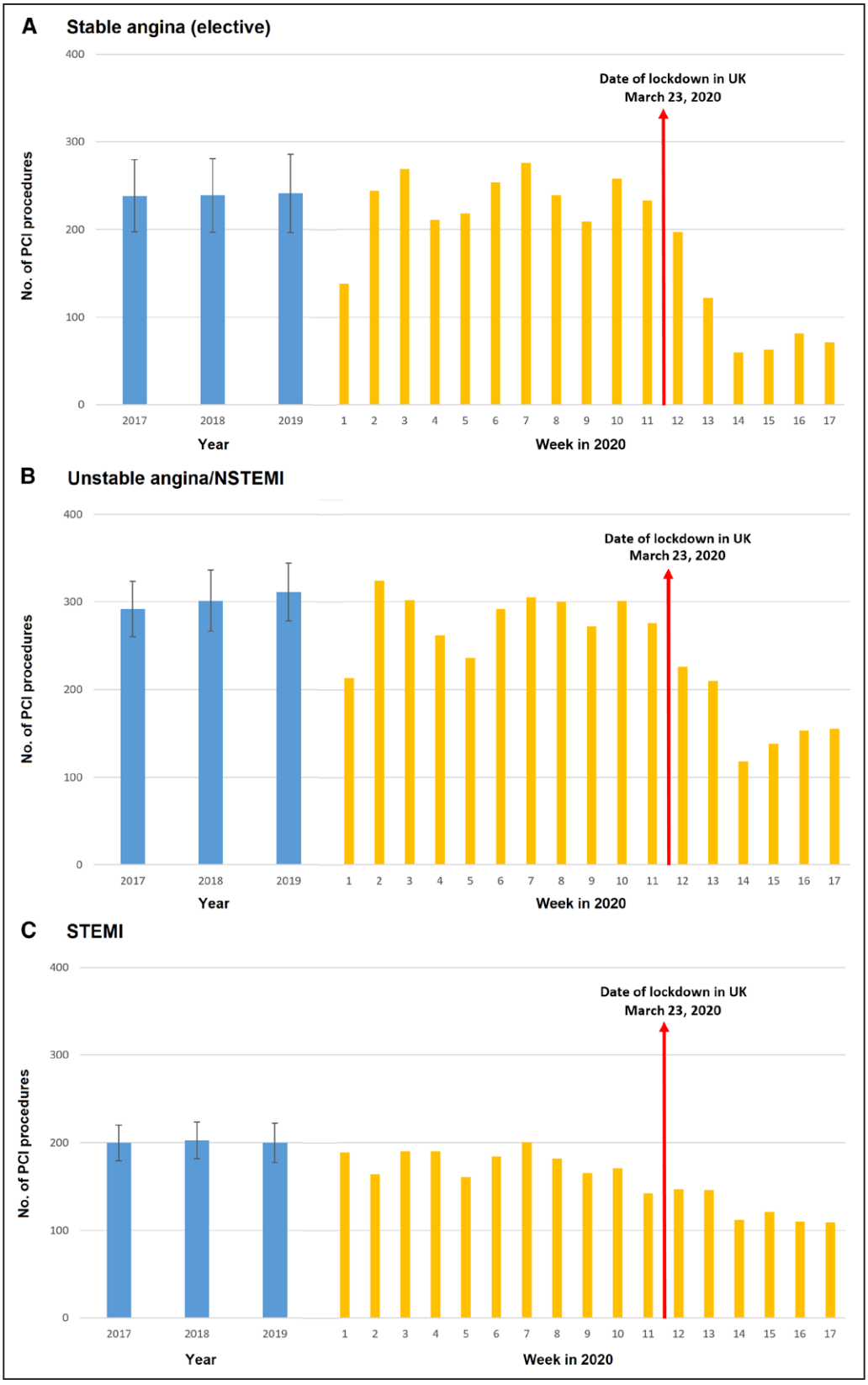

Figure 3. Trends in percutaneous coronary intervention (PCI) procedures according to indication.
NSTEMI indicates non–ST-segment–elevation myocardial infarction; and STEMI, ST-segment–elevation myocardial infarction.

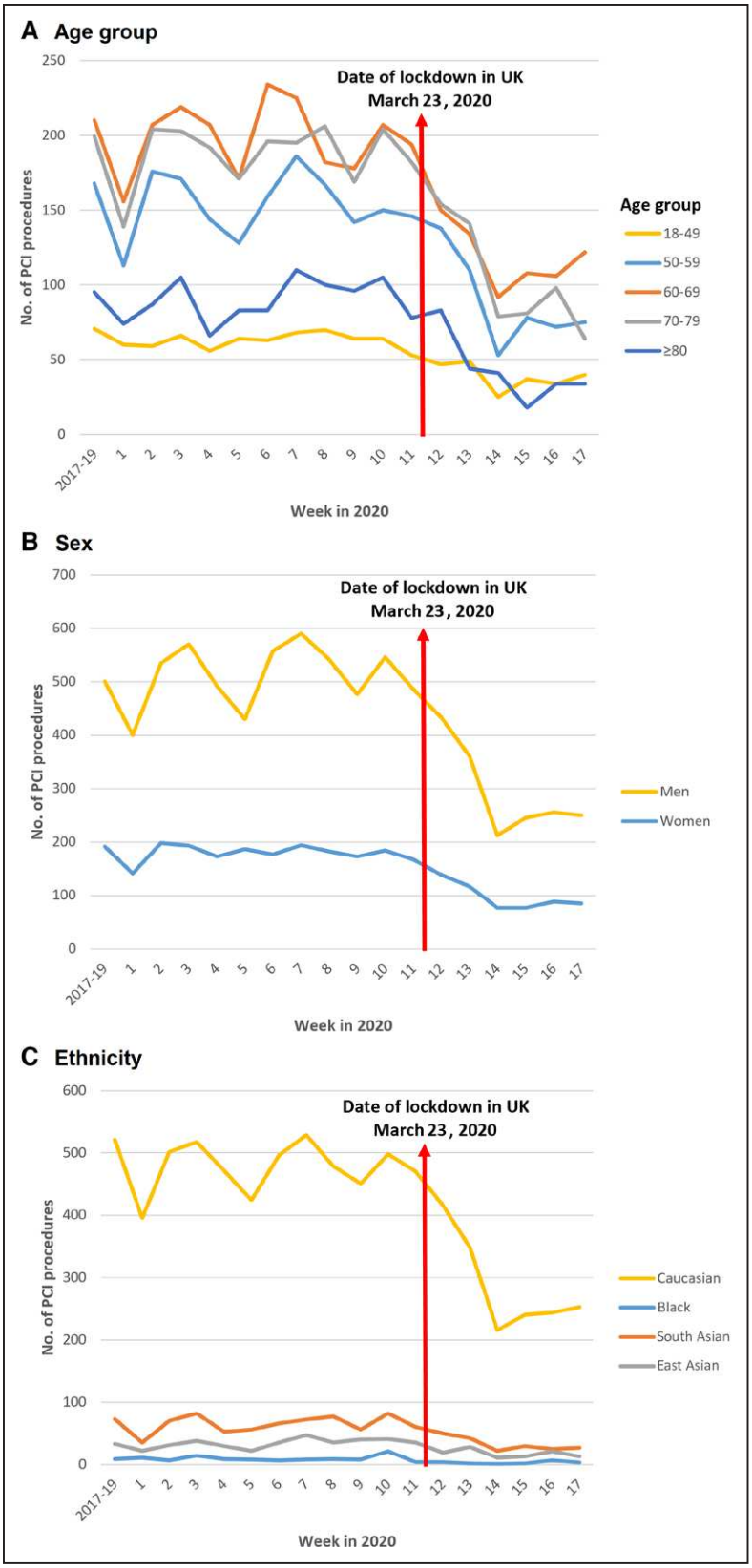

Figure 4. Trends in percutaneous coronary intervention (PCI) procedures by age group, sex, and ethnicity.

to 59, 60 to 69, 70 to 79, and ≥80 years compared with the first 1 to 10 weeks of 2020. Compared with the first 1 to 10 weeks in 2020, there was a reduction of 48% in procedures for men and 51% in procedures for women. There was an observed decrease in PCI procedures of 45%, 71%, 55%, and 50% for patients who were White, Black, South Asian, and East Asian comparing weeks beyond 12 weeks in 2020.

The patient characteristics are shown in Table 1. There were significant differences in patient characteristics between patients in the month after the lockdown (April 2020) compared with the patients with procedures between 2017 and 2019, while the characteristics remained largely unchanged from January 2020 to March 2020. Patients who underwent PCI in April 2020 were younger (64.5 versus 65.5 years, $P<0.001$), less likely to have diabetes (20.4% versus 24.6%, $P<0.001$), hypertension (52.0% versus 56.8%, $P=0.001$), hypercholesterolemia (44.0% versus 50.6%, $P<0.001$), previous myocardial infarction (23.5% versus 26.7%, $P=0.008$), previous PCI (23.7% versus 27.3%, $P=0.001$) or previous coronary artery bypass graft (4.6% versus 7.2%, $P<0.001$), and were more likely to have a PCI procedure for STEMI (34.3% versus 27.1%).

The procedural variables are shown in Table 2. After the lockdown, there were significantly more multivessel interventions (25.1% versus 21.8%, $P=0.003$), intervention to the left anterior descending artery (52.7% versus 49.8%, $P=0.023$), greater proportionate use of ticagrelor (35.7% versus 32.4%, $P=0.008$), prasugrel (6.2% versus 2.3%, $P<0.001$), and intravascular imaging (15.4% versus 12.5%, $P=0.001$). There was also a shorter average length of stay in April 2020 (1.2 days) compared with 2017 to 2019 (3.4 days).

The in-hospital outcomes are shown in Table 3. Adverse events were largely similar before and after the lockdown. Compared with procedures undertaken in 2017 to 2019 the independent odds of in-hospital death were odds ratio (OR), 0.86 (95% CI, 0.58–1.27) for January 2020; OR, 0.46 (95% CI, 0.27–0.77) for February 2020; OR, 1.34 (95% CI, 0.92–1.95) for March 2020; and OR, 0.83 (95% CI, 0.46–1.49) for April 2020 (Figure 5). The independent odds of in-hospital major adverse cardiovascular event were OR, 0.88 (95% CI, 0.63–1.23) for January 2020; OR, 0.53 (95% CI, 0.35–0.83) for February 2020; OR, 1.17 (95% CI, 0.84–1.64) for March 2020; and OR, 0.70 (95% CI, 0.41–1.20) for April 2020.

The characteristics of patients, procedural variables, and outcomes stratified by each indication are shown in Tables III through V in the Data Supplement. Changes in clinical characteristics, procedural variables, and clinical outcomes were observed for patients in whom PCI was undertaken for stable angina. Patients were more likely to be White (86.6% versus 79.3%; $P=0.015$), less likely to have radial access (76.3% versus 81.8%; $P=0.011$), and were more likely to have intravascular imaging (21.8% versus 16.6%; $P=0.014$). Similarly, in PCI procedures undertaken for STEMI, patients were more likely to have multi-vessel PCI (17.1% versus 12.9%; $P=0.005$) and were more likely to be prescribed prasugrel (12.8% versus 6.3%; $P<0.001$). Significant differences were also observed in clinical characteristics in PCI procedures undertaken for unstable angina/NSTEMI after the lockdown. In patients in whom PCI was undertaken for unstable angina/NSTEMI indications after the lockdown, patients were younger (64.8 versus 65.9 years, $P=0.020$), had lower prevalence of diabetes (23.3% versus 27.2%, $P=0.024$), previous coronary artery bypass graft (6.0% versus 8.4%, $P=0.036$) and peripheral vascular disease (2.9% versus 4.7%, $P=0.033$), and were more likely to be White (83.6% versus 81.8%; $P=0.017$).

The sensitivity analysis restricting the control group to the months of January to April to account for seasonality in the years 2017, 2018, and 2019 yielded very similar results to the analysis including all months (Table VI in the Data Supplement).

DISCUSSION

Our evaluation of how national PCI activity has changed during the COVID-19 pandemic has several key findings. First, following the lockdown imposed on March 23, 2020 there was a 49% decrease in PCI procedures performed in England, with the majority of the decline seen in PCI undertaken for elective (66%) and NSTEMI/unstable angina (45%) indications. While we also observe a decline in PCI undertaken for STEMI indications, this has been more modest (33%). Second, the decline in PCI procedures has been particularly evident in older age groups and Black, Asian, and minority ethnic patients. Third, while the clinical characteristics of the patients undergoing PCI during the COVID pandemic have remained relatively unchanged for procedures undertaken for stable angina and STEMI indications, by contrast, patients undergoing PCI for unstable angina/NSTEMI are younger and have fewer comorbidities. This may suggest there may be selection bias for undertaking PCI procedures in this group of patients, to a younger and lower risk cohort. This may represent the differences in which patients have presented to hospital as well as any modifications to clinical pathways once in hospital. Finally, we observe that in-hospital outcomes including mortality and peri-procedural complication rates are largely similar before and during the COVID pandemic.

A few studies have already reported on changes in PCI activity during the COVID pandemic,[4,5] although they have not evaluated changes in the profile of the patients undergoing these procedures or their outcomes. An evaluation of 9 high-volume cardiac catheterization laboratories in the United States between January and March 2020 reported a 38% decrease in STEMI activations.[4] The data from the current study are consistent with this finding, having shown a 33% decline in PCI for STEMI. Our study provides the additional information that neither the risk profile of patients with STEMI has significantly changed during the COVID-19 pandemic and nor have the clinical outcomes. A reduction in interventional cardiology activity as a result of the COVID-19 pandemic

Table 1. Patient Characteristics

Variable	2017–2019 (n=115 989)	January 2020 (n=3237)	*P* value*	February 2020 (n=3061)	*P* value*	March 2020 (n=2740)	*P* value*	April 2020 (n=1464)	*P* value*
Mean age (±SD)	65.5±11.9	65.6±11.9	0.64	65.6±11.8	0.61	65.8±11.6	0.22	64.5±11.6	<0.001
Male	86 121 (74.3%)	2387 (73.7%)	0.51	2285 (74.7%)	0.62	2035 (74.9%)	0.42	1100 (75.1%)	0.44
Ethnicity			0.19		0.062		0.51		0.097
White	81 329 (81.0%)	2263 (82.6%)		2068 (81.0%)		1942 (81.7%)		1078 (84.1%)	
Black	1320 (1.3%)	46 (1.7%)		35 (1.4%)		32 (1.4%)		15 (1.2%)	
Asian	11 357 (11.5%)	287 (10.5%)		287 (11.2%)		263 (11.1%)		119 (9.3%)	
Other	5139 (5.2%)	143 (5.2%)		163 (6.4%)		139 (5.9%)		70 (5.5%)	
Diabetes	27 944 (24.6%)	793 (25.4%)	0.27	749 (25.7%)	0.15	654 (24.9%)	0.68	286 (20.4%)	<0.001
Smoker	38 197 (47.0%)	1067 (47.7%)	0.47	899 (45.2%)	0.11	842 (45.1%)	0.11	404 (42.5%)	0.006
Hypertension	64 147 (56.8%)	1713 (56.7%)	0.97	1593 (58.4%)	0.095	1458 (57.5%)	0.46	691 (52.0%)	0.001
Hypercholesterolemia	57 219 (50.6%)	1482 (49.1%)	0.092	1376 (50.4%)	0.82	1233 (48.6%)	0.046	584 (44.0%)	<0.001
Left ventricular function			0.10		0.009		0.10		0.30
Good	38 286 (68.5%)	1080 (69.2%)		1028 (71.9%)		920 (71.3%)		397 (65.7%)	
Fair/moderate	13 910 (24.9%)	361 (23.1%)		331 (23.2%)		292 (22.6%)		161 (26.7%)	
Poor	3672 (6.6%)	119 (7.6%)		71 (5.0%)		78 (6.1%)		46 (7.6%)	
Renal failure			0.34		0.060		0.26		0.89
None	108 371 (97.1%)	2971 (97.3%)		2746 (96.7%)		2481 (97.6%)		1303 (97.2%)	
Acute renal failure	2155 (1.9%)	49 (1.6%)		71 (2.5%)		42 (1.7%)		24 (1.8%)	
Chronic renal failure	1067 (1.0%)	33 (1.1%)		22 (0.8%)		18 (0.7%)		14 (1.0%)	
Previous MI	30 550 (26.7%)	828 (26.2%)	0.52	767 (26.4%)	0.76	712 (27.0%)	0.74	328 (23.5%)	0.008
Previous stroke	5145 (4.6%)	128 (4.2%)	0.41	129 (4.7%)	0.67	100 (3.9%)	0.15	62 (4.7%)	0.84
Previous PCI	31 314 (27.3%)	915 (29.2%)	0.022	840 (28.9%)	0.056	816 (31.1%)	<0.001	331 (23.7%)	0.003
Previous CABG	8337 (7.2%)	192 (6.0%)	0.009	188 (6.4%)	0.090	185 (7.0%)	0.61	64 (4.6%)	<0.001
Peripheral vascular disease	4598 (4.1%)	103 (3.4%)	0.071	94 (3.4%)	0.10	101 (4.0%)	0.83	33 (2.5%)	0.004
Valvular heart disease	2787 (2.5%)	57 (1.9%)	0.042	55 (2.0%)	0.13	56 (2.2%)	0.41	29 (2.2%)	0.51
Indication			0.38		0.090		0.056		<0.001
Stable angina	37 357 (32.3%)	1073 (33.2%)		1032 (33.9%)		910 (33.3%)		316 (21.6%)	
Unstable angina/NSTEMI	47 030 (40.7%)	1312 (40.6%)		1232 (40.5%)		1141 (41.7%)		646 (44.1%)	
STEMI	31 319 (27.1%)	843 (26.1%)		779 (25.6%)		684 (25.0%)		502 (34.3%)	

CABG indicates coronary artery bypass graft; MI, myocardial infarction; NSTEMI, non–ST-segment–elevation myocardial infarction; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

**P* value vs 2017–2019.

has also been reported in Spain.[5] Specifically, data from 73 Spanish centers suggest an overall decrease of 48% in PCI and a 40% decrease in PCI in STEMI. However, these findings were derived from a remote survey, without the ability to describe individual patient characteristics or clinical outcomes. In contrast, our current study is a retrospective analysis of a national audit, with the advantage that data is prospectively collected and data checks and validations take place.

There are several potential reasons for our observed decline in PCI procedures. First, the UK government response to the COVID-19 pandemic was to recommend cancellation of elective procedures,[9] allowing hospital services to be restructured to divert more hospital staff and infrastructure to increase capacity for the treatment of COVID-19, reduce the exposure of individual patients and their relatives to the hospital environment and reduce the exposure of health care workers to patients with asymptomatic COVID-19. This is in line with recent recommendations from the European Association of Percutaneous Coronary Intervention Position Statement on Invasive Management of Acute Coronary Syndromes during the COVID-19 pandemic and recommendations that were endorsed by British Cardiovascular Society and BCIS.[10,11]

A second important reason for the reduction of PCI activity for urgent and emergency cases could be that patients may be reluctant to present to hospital because of the fear of contracting COVID-19. This has the most serious impact on patients with STEMI, where primary PCI has been shown to reduce mortality, mechanical complications and longer-term cardiovascular morbidity and mortality. Data from Hong Kong have suggested significant increases in times from symptom onset to first

Table 2. Procedural Variables

Variable	2017–2019 (n=115 989)	January 2020 (n=3237)	*P* value*	February 2020 (n=3061)	*P* value*	March 2020 (n=2740)	*P* value*	April 2020 (n=1464)	*P* value*
Radial access	96 547 (83.2%)	2734 (84.5%)	0.066	2577 (84.2%)	0.17	2315 (84.5%)	0.083	1242 (84.8%)	0.10
Multivessel intervention	25 308 (21.8%)	727 (22.5%)	0.39	644 (21.0%)	0.30	634 (23.1%)	0.099	367 (25.1%)	0.003
Vessel of intervention									
Left main	5556 (4.8%)	152 (4.7%)	0.80	137 (4.5%)	0.42	165 (6.0%)	0.003	82 (5.6%)	0.15
RCA	40 584 (35.0%)	1099 (34.0%)	0.22	1079 (35.3%)	0.77	987 (36.0%)	0.26	499 (34.1%)	0.47
LAD	57 702 (49.8%)	1598 (49.4%)	0.67	1508 (49.3%)	0.60	1388 (50.7%)	0.35	772 (52.7%)	0.023
LCx	28 483 (24.6%)	801 (24.8%)	0.81	725 (23.7%)	0.27	679 (24.8%)	0.79	405 (27.7%)	0.006
Graft	3339 (2.9%)	71 (2.2%)	0.021	56 (1.8%)	0.001	76 (2.8%)	0.75	33 (2.3%)	0.16
Medications									
Clopidogrel	55 246 (47.6%)	1254 (38.7%)	<0.001	1172 (38.3%)	<0.001	1126 (41.1%)	<0.001	454 (31.0%)	<0.001
Ticagrelor	37 546 (32.4%)	960 (29.7%)	0.001	785 (25.7%)	<0.001	805 (29.4%)	0.001	522 (35.7%)	0.008
Prasugrel	2661 (2.3%)	92 (2.8%)	0.041	105 (3.4%)	<0.001	101 (3.7%)	<0.001	90 (6.2%)	<0.001
Glycoprotein IIb/IIIa inhibitor	12 294 (10.6%)	321 (9.9%)	0.21	277 (9.1%)	0.006	248 (9.1%)	0.009	173 (11.8%)	0.13
Imaging (OCT/IVUS)	14 535 (12.5%)	587 (18.1%)	<0.001	591 (19.3%)	<0.001	509 (18.6%)	<0.001	225 (15.4%)	0.001
Rotational atherectomy	2611 (2.3%)	49 (1.5%)	0.005	50 (1.6%)	0.023	42 (1.5%)	0.012	27 (1.8%)	0.30
IABP	909 (0.8%)	16 (0.5%)	0.064	16 (0.5%)	0.11	8 (0.3%)	0.004	1 (0.1%)	0.002
ECMO/Impella	59 (0.05%)	1 (0.03%)	0.62	0 (0%)	0.21	1 (0.04%)	0.74	1 (0.07%)	0.77
Cardiogenic shock	3054 (2.6%)	70 (2.2%)	0.098	50 (1.6%)	0.001	56 (2.0%)	0.056	34 (2.3%)	0.46
Inotropes	1907 (1.6%)	49 (1.5%)	0.57	31 (1.0%)	0.006	36 (1.3%)	0.18	19 (1.3%)	0.30
Number of stents			0.004		<0.001		<0.001		0.52
0	13 042 (11.2%)	430 (13.3%)		455 (14.9%)		361 (13.2%)		169 (11.5%)	
1	59 083 (50.9%)	1619 (50.0%)		1531 (50.0%)		1,393 (50.8%)		737 (50.3%)	
2	27 451 (23.7%)	743 (23.0%)		653 (21.3%)		572 (20.9%)		333 (22.8%)	
3+	16 413 (14.2%)	445 (13.8%)		422 (13.8%)		414 (15.1%)		225 (15.4%)	
Length of stay, d	3.4±6.1	2.6±4.4	<0.001	2.5±4.5	<0.001	2.4±4.2	<0.001	1.2±3.4	<0.001

ECMO indicates extracorporeal membrane oxygenation; IABP, intraaortic balloon pump; IVUS, intravascular ultrasound; LAD, left anterior descending artery; LCx, left circumflex artery; OCT, optical coherence tomography; and RCA, right coronary artery.

*P value vs 2017–2019.

medical contact, door to device time and catheter laboratory arrival to device times in patients with STEMI during the COVID pandemic,[2] with worse reported clinical outcomes.[12] The guidance issued by NHS England, with BCIS and the British Cardiovascular Society in March[11] specifically encouraged interventionalists in the United Kingdom to continue to employ primary PCI as the default treatment for STEMI, despite recommendations advising

Table 3. In-Hospital Outcomes

Variable	2017–2019 (n=115 989)	January 2020 (n=3237)	*P* value*	February 2020 (n=3061)	*P* value*	March 2020 (n=2740)	*P* value*	April 2020 (n=1464)	*P* value*
Transfusion	162 (0.14%)	2 (0.06%)	0.24	1 (0.03%)	0.11	0 (0%)	0.050	3 (0.20%)	0.51
Major bleeding	206 (0.18%)	1 (0.03%)	0.048	2 (0.07%)	0.14	2 (0.07%)	0.20	5 (0.3%)	0.14
Death	2059 (1.8%)	39 (1.2%)	0.019	23 (0.8%)	<0.001	45 (1.7%)	0.67	17 (1.2%)	0.11
MACE (death, reinfarction, PCI)	2498 (2.2%)	50 (1.5%)	0.018	31 (1.0%)	<0.001	51 (1.9%)	0.30	19 (1.3%)	0.025
Embolic stroke	96 (0.08%)	1 (0.03%)	0.31	2 (0.07%)	0.74	3 (0.11%)	0.63	0 (0%)	0.27
Coronary perforation	402 (0.4%)	14 (0.4)	0.41	10 (0.3%)	0.85	12 (0.4%)	0.42	6 (0.4%)	0.68
Retroperitoneal bleed	35 (0.03%)	0 (0%)	0.32	1 (0.03%)	0.94	0 (0%)	0.36	2 (0.14%)	0.023
Renal failure/dialysis	128 (0.1%)	4 (0.1%)	0.82	1 (0.03%)	0.20	2 (0.07%)	0.56	1 (0.07%)	0.63
Re-PCI	378 (0.3%)	10 (0.3%)	0.87	8 (0.3%)	0.54	4 (0.2%)	0.10	2 (0.1%)	0.21

MACE indicates major adverse cardiovascular event; and PCI, percutaneous coronary intervention.

*P value vs 2017–2019.

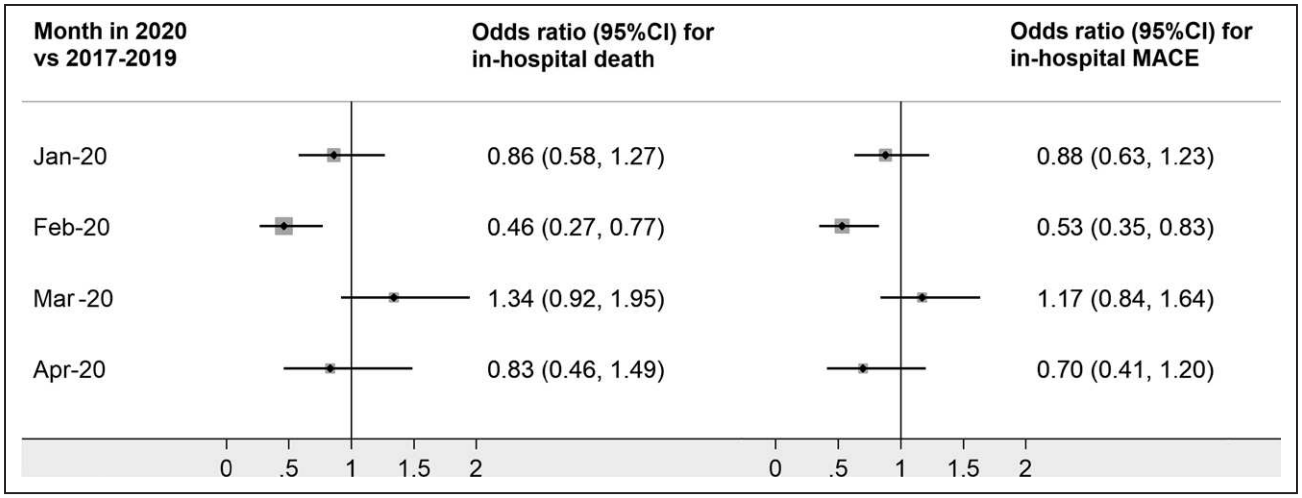

Figure 5. Forrest plot for in-hospital death and major adverse cardiovascular event (MACE).

the use of thrombolysis released by other organizations and countries.[11] Further data from the Myocardial Infarction National Audit Project will allow us to cross reference with the current analysis to confirm that this guidance was generally followed.

In some hospital cases, the reduction in activity in catheter laboratories may additionally relate to differences in referral for invasive management, particularly in patients with NSTEMI. The recent Chinese Society of Cardiology consensus statement around the clinical management of patients with severe emergent cardiovascular diseases during the COVID-19 epidemic has recommended the medical management of the majority of NSTEMI cases.[13] Interestingly, we observed that the characteristics of patients with unstable angina/NSTEMI who undergo PCI differed before and after the lockdown have changed. Mainly, patients who had revascularization were younger and less comorbid after the lockdown. This suggests that there may be a selection bias of patients with unstable angina/NSTEMI who are receiving PCI which would contribute to the reduction on PCI procedures in this patient group, or it may also reflect that elderly comorbid patients are more likely to avoid hospitalization from fear of COVID-19 infection. We also report shorter length of stay, particularly for acute coronary syndrome (ACS) cases. Cancellation of elective activity in many units may have paradoxically allowed NSTEMI PCI cases to be undertaken earlier to the catheter lab due to increased catheter lab capacity, but also shorter length of stays would decrease the potential for nosocomial COVID exposure.

Importantly, we observe that there was no increase in mortality rates or complications in PCI procedures that were undertaken during the COVID-19 period. This is particularly important given that coagulopathies have been reported in patients with COVID-19,[14] with a substantial proportion of patients with severe COVID-19 developing venous and arterial thromboembolic complications.[15] This is particularly relevant in patients undergoing PCI where stent thrombosis and major bleeding complications remain an important cause of mortality. Interestingly, the rates of intravascular imaging during the COVID period have also increased in ACS cases, which may reflect operator's awareness of the increased risk of thrombotic complications and, therefore, the need to adequately expand stents and achieve good stent apposition.[16]

The decline in PCI procedures appears to have occurred mainly in elderly and Black, Asian, and minority ethnic patients. There are several possible explanations for this observation. First, the United Kingdom government defined several groups of patients as being at increased risk of severe illness from COVID-19 and recommended that they be particularly stringent in following social distancing measures. This high-risk group included those over the age of 70 regardless of underlying medical conditions.[17] This may have decreased the likelihood of these patients seeking medical assistance particularly in NSTEMI. Interventional cardiologists may also have preferred to manage elderly patients with multiple comorbidities without intervention, to facilitate rapid discharge and, therefore, reduce the risk of nosocomial acquired COVID-19. Similarly, there is recognition of the greater risk of mortality from COVID in Black, Asian, and minority ethnic populations, with Black men and women reported to have a 4× greater risk of mortality in the latest Office of National Statistics report in the United Kingdom.[18,19] The reduction in PCI for ACS cases, and STEMI in particular may have significant implications for patients, especially if the reduction relates to not seeking medical assistance. A recent multicenter study from Italy reported that acute myocardial infarction related hospitalizations were reduced by almost 50% during the COVID-19 period and accompanied by a 3-fold rise in mortality and complications[20] while from the Lombardia Cardiac Arrest Registry reported a 58% increase in OHCA during the first 40 days of COVID-19 outbreak.[21]

Our study has several limitations. First, not all hospitals in England were included in the analysis because they did not report their PCI activity in either March or April 2020. It was important to exclude these hospitals that had so far not submitted, because the decline in PCI activity could be incorrectly attributed to failure of timely data submission rather than fewer cases. Furthermore including different hospitals in the analysis at different time points would introduce bias, by virtue of the fact that there is significant variability around the type of PCI services that hospitals offer in England (some do not offer primary PCI, others primary PCI during working hours while others offer 24/7 primary PCI), as well as the populations that they serve, which may confound analyses particularly when changes in indications for PCI, as well as changes in characteristics of patients are being examined. While statistically significant differences were detected because of the large sample size, there were no major differences in characteristics for patients that were from excluded and included hospitals. Second, the data and in-hospital outcomes are self-reported, which may bias findings or result in under-reporting. There is no post discharge follow-up data, and there was missing data particularly regarding left ventricular ejection fraction and smoking status which may confound multivariate adjustment. Nevertheless, the data are subject to logical checks and assessments of internal validity at upload to NICOR. Furthermore, because operator outcomes are publicly reported as part of the UK transparency agenda and are key components of revalidation and license to practice for interventional cardiologists, the data are sent to operators and centers for 2 cycles of validation before being locked in the central NICOR servers. Additionally, the decline in PCI activity that we have observed, is in line with that reported in Spain and United States.[5,6] Finally, there is no understanding of how local policies at each hospital may have changed as a result of the COVID-19 crisis which may be driving the decline in procedures.

In conclusion, our national evaluation demonstrates a 49% decrease in PCI activity as a consequence of the COVID-19 response lockdown. The decline in PCI activity was greatest among patients with stable angina (66% decrease) and NSTEMI ACS cases (45% decrease) and least among patients with STEMI (33% decrease). The patients receiving PCI with a diagnosis of unstable angina/NSTEMI were younger with fewer comorbidities compared with the population with this diagnosis before the lockdown. These findings suggest that the impact of COVID-19 restrictions and changes in catheter laboratory activity are significant, and more studies are needed to understand if patient's outcomes are compromised because of the reduction in numbers of procedures, especially in the context of an ACS.

ARTICLE INFORMATION

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To follow current publication standards, the authors and editors have revised terminology from the National UK Dataset to use East Asian in place of Oriental and South Asian in place of Asian.

Affiliations

Keele Cardiovascular Research Group, Centre for Prognosis Research, Institute for Primary Care and Health Sciences, Keele University, Stoke-on-Trent, United Kingdom (C.S.K., M.A.M.). Department of Cardiology, Royal Stoke University Hospital, Stoke-on-Trent, United Kingdom (C.S.K., M.A.M.). Leeds Institute of Cardiovascular and Metabolic Medicine (C.P.G.) and Leeds Institute for Data Analytics (C.P.G.), University of Leeds, United Kingdom. Department of Cardiology, Leeds Teaching Hospitals NHS Trust, United Kingdom (C.P.G.). Wessex Cardiothoracic Unit, Southampton University Hospital Southampton & Faculty of Medicine University of Southampton, United Kingdom (N.C.). National Institute for Cardiovascular Outcomes Research, Barts Health NHS Trust, London, United Kingdom (M.A.d.B., J.H., J.E.D.). Institute of Cardiovascular Sciences, University of Birmingham, United Kingdom (P.L.). Royal Brompton and Harefield Hospital Trust, Imperial College London, United Kingdom (T.F.L.). Centre for Molecular Cardiology, University of Zurich, Switzerland (T.F.L.). Division of Population Health, Health Services Research and Primary Care, School of Health Sciences, Faculty of Biology, Medicine and Health, Manchester Academic Health Science Centre (MAHSC), The University of Manchester, United Kingdom (E.K.). NHS Digital, Leeds, United Kingdom (C.R., T.D., T.B.). Department of Cardiology, Great Ormond Street Hospital, University College London, United Kingdom (J.E.D.).

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Supplemental Maaterials

Tables I–V

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