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Review Article

Investigating the implications of COVID-19 outbreak on systems of care and outcomes of STEMI patients: A systematic review and meta-analysis

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A R T I C L E I N F O

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A B S T R A C T

Introduction: There has been a concern whether the decrease in ST-segment elevation myocardial infarction (STEMI) cases during the COVID-19 pandemic era is related to unsatisfactory performance of STEMI systems of care as well as worsening of the clinical outcomes in STEMI patients. Thus, our meta-analysis was conducted to evaluate this matter.
Methods: We compared the predetermined variables in this meta-analysis during the early and late pandemic. Using a combination of adapted search terms to fit the requirements of several search engines (PubMed, EuropePMC, SCOPUS, ProQuest, and EBSCOhost), we reviewed all observational studies citing our outcomes of interest before and during the outbreak.
Results: Thirty-five records comprising a total of 62,247 participants were identified. Overall, our meta-analysis showed that there was a huge reduction of nearly 80% for STEMI admission during the outbreak ($n = 10{,}263$) in contrast to before the outbreak period ($n = 51{,}984$). STEMI patients who were admitted during the outbreak received less primary PCI and had longer symptom-to-FMC (first medical contact) time along with prolonged door-to-balloon (DTB) time. A decrease in the achievement of final TIMI (thrombolysis in myocardial infarction) 3 flow after primary PCI was also observed in this study. However, the number of in-hospital mortality was similar between two groups.
Conclusion: There was a decrease in the STEMI care performance and worsening of clinical outcomes in STEMI patients, especially in the early pandemic period. Overall, concise health services must be implemented following a responsibility to obey health protocols to deliver high-quality services related to STEMI systems of care amidst the global pandemic.

1. Introduction

The year 2021 marks the anniversary of the World Health Organization (WHO) official announcement of novel coronavirus disease 2019 (COVID-19) pandemic. The outbreak has caused a massive global burden, leading to a major interference in medical services and a death toll up to 3.22 million people worldwide.[1] The impact given, especially on time-sensitive health services such as primary percutaneous coronary intervention (PCI) in ST-segment elevation myocardial infarction (STEMI) setup, appears to be greater. Several studies reported that hospital admissions related to coronary heart disease, especially in STEMI cases, tend to decrease dramatically contrasted to the period before the pandemic.[2–4] The shift in management that originally recommended the use of fibrinolytic therapy in STEMI cases during early pandemic, has changed into reperfusion therapy in the form of primary PCI considering a more superior end result.[5] However, the decline in STEMI cases and its relationship to the performance of STEMI systems of care remains questionable. Inconsistent results across the studies make it impossible to determine the effect of the COVID-19 pandemic on mentioned issues, especially the aftermath given to

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several clinical outcomes. For instance, mortality and predictors of satisfactory prognosis which of course affect STEMI patients' quality of life.[6,7] Hence, this meta-analysis was designed to evaluate the effect of the COVID-19 pandemic on the delivery of care systems and clinical outcomes in STEMI patients.

2. Methods

2.1. Protocol and registration

This systematic review and meta-analysis was written based upon the Cochrane handbook for systematic reviews of interventions and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).[8] The research protocol has been registered at the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD42021250716.

2.2. Search strategy

Since we performed systematic review and meta-analysis of observational studies, we systematically search relevant articles through several search engines including PubMed, EuropePMC, SCOPUS, ProQuest, and EBSCOhost investigating comparisons between systems of care and clinical outcomes in STEMI patients before and during the COVID-19 pandemic from the time in which severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified (January 2020) up until April 2021. We utilize minimum keywords (STEMI AND COVID-19) to maximize the initial scope of research in order to ensure the largest amount of articles recorded. Moreover, hand search from the references of included studies were screened to broaden our search results. The complete search and screening processes were contained in PRISMA flow chart presented in Fig. 1.

2.3. Eligibility criteria

In the present study, we included either prospective or retrospective observational studies containing our data of interest. Our study population was STEMI patients described as the presence of ischemic heart symptoms for more than 20 minutes accompanied by elevation of the ST-segment at least two contiguous electrocardiogram (ECG) leads or characterized by a new onset left bundle branch block.[9] The studies should report specifically on the primary outcomes of the STEMI systems of care performance consisting number of primary PCI performed, door-to-balloon (DTB) time, and final TIMI (thrombolysis in myocardial infarction) 3 flow accomplishment after PCI. Secondary outcomes included symptom-to-FMC (first medical contact) time and in-hospital mortality. Supplied data must be described in a comparative manner amid the COVID-19 pandemic period with pre-pandemic group. The comparator group was a group that existed prior to the pandemic for a same given period of time. Animal studies, expert opinions, literature review studies, news articles, letters, editorials, guidelines, and any studies that did not mention the outcomes of interest were excluded from this study.

2.4. Data extraction and risk of bias assessment

Extraction of relevant data and risk of bias assessment were carried out by two independent authors. We extracted several pertinent variables from the selected studies using predesigned table that comprised of name of the first author, year of publication, country from which the study was conducted, pre-pandemic and pandemic period, outcomes of interest (symptom-to-FMC time, door-to-balloon time, the amount of primary PCI carried out, final TIMI 3 flow after PCI, and in-hospital mortality). DTB time was calculated as the period of time between patient's admission at PCI center and first device introduction in order to reopen the occluded coronary vessel(s).[9] Symptom-to-FMC time was defined from in which the first symptom onset to emergency department admission at PCI center.[9]

Several confounding factors that could potentially affect the effect size of study outcomes e.g. age, sex, hypertension, diabetes mellitus, dyslipidemia, family history of coronary artery disease (CAD), smoking status, Killip class >1, anterior myocardial infarction (MI), and multiple coronary artery involvement were also involved in the data extraction process for regression purpose. Dichotomous data were reported in terms of frequencies and/or percentages, while mean and standard deviation were used assuming the data were continuous. If the study did not report mean and standard deviation, estimation was utilized using a method proposed by Wan et al[10] . Disagreements regarding study selection and data extraction were resolved through consensus or by a third reviewer.

Quality assessment was performed using the Newcastle–Ottawa Scale (NOS).[11] Each article received a score to indicate their degree of bias (low [included] and high [excluded]). If studies receive a total score of seven or above, the study was considered having a low risk for bias. Otherwise, if studies receive a total score of six or below, that means the study was ascertained to have a high risk of bias and excluded from this meta-analysis. Discrepancies in quality ratings were resolved by discussion with a third reviewer.

2.5. Statistical analysis

We used STATA: Software for Statistics and Data Science 16.0 version to measure the overall effect size in this meta-analysis. Acquired data for each study's endpoint which was converted into dichotomous data were analyzed using the Mantel-Haenzel method and pooled as risk ratio (RR) to measure the effect size. For continuous data, the generic inverse variance method was used and standardized mean difference was employed as an effect measure. The pooled outcomes were calculated through computative random-effects model regardless of their heterogeneity. To make an optimized, more robust summary across the included articles, we performed subgroup meta-analysis and divided it based on COVID-19 pandemic period into early and late pandemic stage. As the World Health Organization (WHO) declared COVID-19 as a pandemic in March 2020,[12] mid April 2020 was chosen as the cut-off point for the mentioned subset evaluation. To investigate potential sources of heterogeneity among included studies, we performed restricted-maximum likelihood meta-regression using potential covariates mentioned in previous sub-heading. Additionally, any statistically significant confounding variables will be added into subgroup analysis using median-split method. Finally, Begg's funnel plot was used to detect any publication bias. All statistical tests were two-sided, and $P < 0.05$ indicated statistical significance.

3. Results

3.1. Study selection and characteristics

According to the predetermined search strategy, there were a total of 1258 studies obtained from five different search databases of which two of them were obtained throughout hand searching process. After excluding 25 duplicate records, a screening process for titles and abstracts was carried out and a total of 91 eligible

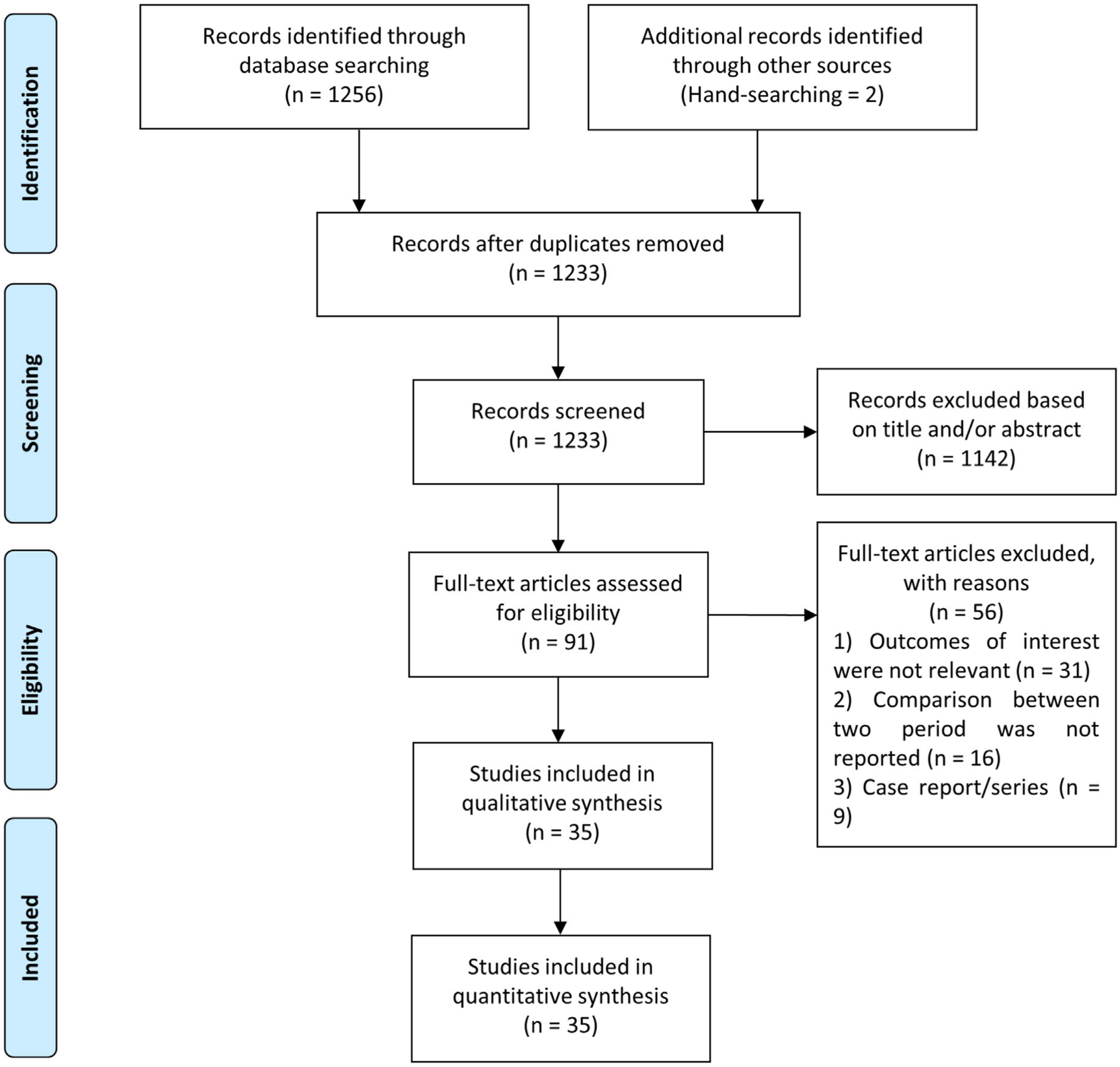

Fig. 1. Flow chart of study selection.

studies were remained. Additionally, 56 records were excluded based on several reasons: 1) outcomes of interest were not relevant ($n = 31$); 2) a comparison between two period was not reported ($n = 16$); 3) articles were case report/series ($n = 9$). Eventually, a total of 35 studies with 62,247 participants[13–47] were evaluated in our meta-analysis. STEMI patients who presented in the pandemic period were older, predominately from male population, had a higher prevalence of comorbid conditions, and had worse cardiac function during hospital admission. The mean NOS of the included studies was 8.23 ± 0.69, indicating a low risk of bias. Complete data on baseline characteristics between three pandemic stages were provided in Table 1.

3.2. Comparison of performance on STEMI systems of care and clinical outcomes

The outline characteristics of STEMI care performance and clinical outcomes regarding STEMI patients were reported in Table 2. Our meta-analysis showed that fewer people were visiting the emergency department for angina symptoms and the number of hospital admission regarding STEMI was dropped by almost 80 percent during COVID-19 pandemic in compare with pre-pandemic period (10,263 versus 51,984 patients respectively). In addition, our analysis revealed a statistically significant longer symptom-to-FMC time during pandemic as opposed to pre-pandemic time, especially in early pandemic subgroup (SMD = 1.18, 95% CI = 0.94–1.43, $I^2 = 98.1\%$, $P < 0.001$) (Fig. 2a). Meanwhile, lesser rate of performed primary PCI was affirmed in the time of pandemic period and was 72% (53%–97%) of that during the overall pre-pandemic period but not in the late pandemic (Fig. 3a). We also observed significant longer door-to-balloon time as the key of excellency in implementing STEMI care during the whole COVID-19 catastrophe (SMD = 1.02, 95% CI = 0.67–1.38, $I^2 = 99.1\%$, $P < 0.001$) (Fig. 4a) along with a 40% (12%–59%) decrease in the achievement of final TIMI 3 flow after primary PCI (Fig. 5a). On the contrary, our pooled analysis showed no notable difference in mortality between two groups (RR = 1.34, 95% CI = 0.96–1.86, $I^2 = 83.5\%$, $P = 0.086$) although significant distinction was noted during early pandemic time (RR = 1.90, 95% CI = 1.10–3.27, $I^2 = 33.2\%$, $P = 0.021$) (Fig. 6a).

Table 1
Baseline characteristics of the included studies.

	Pre-pandemic period	During pandemic period (overall)	Early pandemic period (before mid April 2020)	Late pandemic period (after mid April 2020)
Total subjects (*n*)	51,984	10,263	939	9324
Age (years) (mean ± SD)	62.01 ± 9.42	62.43 ± 9.41	61.65 ± 7.56	62.74 ± 10.16
Male (%)	75.31	75.13	72.05	76.37
Hypertension (%)	53.54	54.45	55.47	54.01
Diabetes mellitus (%)	27.71	28.45	24.66	25.29
Dyslipidemia (%)	43.5	45.59	44.08	46.27
Family history of CAD (%)	20.97	20.59	24.57	16.28
Smoking (%)	42.86	41.69	42.5	41.29
Killip class II-IV (%)	24.13	31.61	38.25	27.26
Anterior MI (%)	48.2	46.01	50.25	40.12
Multivessel disease (%)	43.17	46.45	49.43	45.35

CAD: coronary artery disease; MI: myocardial infarction; SD: standard deviation.

3.3. Meta-regression analysis

A further meta-regression analysis was performed to discover whether there was a correlation between potential covariates and outcomes of interest in this study. The results showed that the number of performed primary PCI, symptom-to-FMC time, and door-to-balloon time differences between two periods were not affected by the country developmental status. Apart from that, the variance in clinical outcomes observed in this meta-analysis (final TIMI 3 flow and in-hospital mortality) were also not influenced by age, gender, hypertension, diabetes mellitus, dyslipidemia, family history of CAD, smoking, Killip class >1, anterior MI, and multiple coronary artery involvement ($P > 0.05$).

3.4. Publication bias

Begg's funnel plot analysis showed qualitatively symmetrical funnel plots over all of the corresponding outcomes (Figs. 2b–6b) and showed no indication of publication bias.

4. Discussion

In our meta-analysis, we found that hospital admission for STEMI patients has significantly decreased during the COVID-19 outbreak. More importantly, the symptom-to-FMC and DTB time were longer along with a decline in the number of final TIMI 3 flow achievement during pandemic. However, the in-hospital mortality did not vary between two groups which deserve further discussion.

Avoiding hospital visits and the fear of SARS-CoV-2 exposure are alleged to be the main causes of the decline in STEMI cases during pandemic. Stay at home regulation and prohibition to visit public places, that occurred mostly during the early days of pandemic, are also thought to be the major factors in terms of longer symptom-to-FMC time as it was shown consistently across all studies within the early pandemic subgroup.[48,49] Soon after the implementation of health campaign to keep seeking medical attention when experiencing symptoms of a heart attack,[50] there has been an improvement in the symptom-to-FMC time trend which was later confirmed through the late pandemic subgroup analysis throughout our study. Although tendency of improvement was observed, this emphasizes again the importance of not underestimating coronary heart disease and pursuing health care in conjunction with STEMI cases is an absolute necessity.

Conferring about the STEMI chain of survival could not be separated from the topic of primary PCI utilization. An interim guideline issued in China recently recommended the use of fibrinolytic therapy for STEMI patients attending healthcare facilities within 12 hours of symptom onset during this outbreak.[51] However, it should be noted that the success rate of fibrinolytic therapy in restoring occluded blood vessel flow has a much lower success rate when compared to PCI.[52] A quotation goes “time is muscle”, which means that handling cases of myocardial infarction in the minimum possible time can save viable myocytes as maximum as possible. Nevertheless, prolonged door-to-balloon time was observed during the outbreak, particularly in the early pandemic subgroup.[9] This may have been caused by time-wasting COVID-19 screening which consists of epidemiological screening, swab specimen collection for polymerase chain reaction (PCR) testing, chest X-rays, and several other laboratory tests to prevent intrahospital transmission of COVID-19. Besides, the term “myocarditis associated with COVID-19”, acknowledged as the most preeminent cause of myocardial infarction with non-obstructive coronary arteries (MINOCA) during this pandemic era could be one of the foremost differential diagnosis that should be considered by healthcare personnel to be demarcated from an acute STEMI diagnosis.[53] The COVID-19 screening at the emergency room must be implemented effectively and efficiently, and this can be achieved through good cooperation between staffs in interdepartmental level.

Other important criteria used as measures of successful performance in handling STEMI cases are the achievement of final TIMI 3 flow after primary PCI and the number of reported mortality cases. Inconsistent results among included studies with respect to the above two parameters were found in our analysis. The reason is that the final TIMI 3 flow rate after primary PCI and mortality rates were differ significantly in early COVID-19 outbreak, but not in the late pandemic period. It appears to suggest that the majority of studies included in the early pandemic subgroup were studies conducted at the pandemic focal point, namely United Kingdom[13] and Italy.[23,34,38] In addition, the majority of recorded studies presented in the late pandemic period conducted in countries of which the national or regional STEMI network has already been well developed.[54] Worse clinical outcome found in the early pandemic era, exhibit an unpreparedness and delay in times of system that influence performance of STEMI care. And yet, on the other hand, the performance of STEMI care during the pandemic period has gradually improved, which is indicated by no statistically significant difference between the two periods in the late pandemic subgroup analysis.

4.1. Limitations

Admittedly, this study is also subject to several limitations. Firstly, the majority of studies did not include articles that took

Table 2
Changes in STEMI system of care and clinical outcomes (pre-pandemic vs pandemic period).

No.	Author (year)	Country	Pre-pandemic vs pandemic period	Symptom-to-FMC onset (Mean ± SD) (minutes)	Primary PCI	DTB (Mean ± SD) (minutes)	Final TIMI 3 flow	Mortality	NOS
1	Abdelaziz et al (2020)	United Kingdom	March 1 to 31, 2019 vs March 1 to 31, 2020	117 ± 37.22 vs 327.25 ± 163.94	N/A	51.25 ± 6.12 vs 48.75 ± 4.94	N/A	1/69 vs 0/46	8
2	Balghith et al (2020)	Saudi Arabia	August 1, 2019 to December 31, 2019 vs January 1, 2020 to May 31, 2020	N/A	81/81 vs 89/92	87 vs 94	N/A	N/A	7
3	Chew et al (2021)	Singapore	October 1, 2019 to February 6, 2020 vs February 7, 2020 to May 31, 2020	146 ± 35.18 vs 135.25 ± 34.11	208/208 vs 95/95	54.25 ± 6.62 vs 55.75 ± 7.51	202/208 vs 91/95	12/152 vs 4/63	9
4	Çinier et al (2020)	Turkey	March 5, 2019 to April, 6, 2019 vs March 5, 2020 to April 6, 2020	232.5 ± 39 vs 360 ± 97.8	174/174 vs 90/90	25.95 ± 5.39 vs 43.3 ± 9.35	168/174 vs 82/90	6/174 vs 6/90	9
5	Claeys et al (2020)	Belgium	March 13 to May 4 in 2017, 2018, 2019 vs March 13, 2020 to May 4, 2020	129.5 ± 31.56 vs 168.5 ± 51.75	455/479 vs 111/116	42.25 ± 7.81 vs 50.75 ± 10.39	N/A	51/761 vs 11/188	8
6	Clifford et al (2020)	Canada	November 15, 2019 to March 16, 2020 vs March 17, 2020 to July 16, 2020	154.75 ± 34.27 vs 253.25 ± 90.46	196/238 vs 154/193	78.5 ± 12.54 vs 83.25 ± 15.97	N/A	15/238 vs 11/193	8
7	Daoulah et al (2021)	Saudi Arabia	January 1, 2019 to April 30, 2019 vs January 1, 2020 to April 30, 2020	N/A	553/635 vs 420/500	N/A	48/635 vs 53/500	31/635 vs 17/500	8
8	De Luca et al (2020)	Italy	March 1, 2019 to April 30, 2019 vs March 1, 2020 to April 30, 2020	195.75 ± 25.36 vs 221 ± 32.74	3484/3484 vs 2811/2811	31.25 ± 2.1 vs 39 ± 5.13	3212/3484 vs 2567/2811	169/3484 vs 192/2811	8
9	Dharma et al (2021)	Indonesia	March 1, 2019 to May 31, 2019 vs March 1, 2020 to May 31, 2020	367.5 ± 38.21 vs 375 ± 58.81	141/208 vs 70/116	109.19 ± 12.69 vs 85 ± 8.63	123/141 vs 61/70	11/141 vs 4/70	9
10	Fabris et al (2020)	Italy	March 1, 2019 to April 30, 2019 vs March 1, 2020 to April 30, 2020	99.5 ± 31.12 vs 105.5 ± 39.16	43/43 vs 21/21	106 ± 10.07 vs 108.75 ± 14.55	29/43 vs 18/21	2/43 vs 1/21	9
11	Gramegna et al (2020)	Italy	March 25 to April 1 in 2018, 2019 vs March 25, 2020 to April 1, 2020	120 ± 31.75 vs 1200 ± 696.71	21/21 vs 21/26	42.5 ± 7.94 vs 65 ± 25.24	21/21 vs 24/26	2/21 vs 4/26	9
12	Kobo et al (2020)	Israel	March 20, 2019 to April 30, 2019 vs March 20, 2020 to April 30, 2020	206.25 ± 43.18 vs 292.5 ± 65.41	133/136 vs 103/107	51 ± 8.44 vs 57.75 ± 11.69	128/136 vs 98/107	7/136 vs 9/107	9
13	Kwok et al (2020)	United Kingdom	January 1, 2017 to December 31, 2019 vs January 1, 2020 to April 30, 2020	N/A	33,255/33,255 vs 683/683	46 ± 9.46 vs 57.25 ± 14.59	N/A	1164/33,255 vs 33/6843	8
14	Leng et al (2020)	China	January 23 to April 30 in 2018, 2019 vs January 23, 2020 to April 30, 2020	N/A	144/240 vs 14/164	118.25 ± 13.78 vs 171 ± 17.24	N/A	15/240 vs 6/164	8
15	Rodrıguez-Leor et al (2020)	Spain	April 1, 2019 to April 30, 2019 vs March 16, 2020 to April 30, 2020	88 ± 22.94 vs 119.25 ± 27.68	1113/1305 vs 881/1009	113 ± 10.7 vs 113.75 ± 11.73	1152/1305 vs 925/1009	67/1305 vs 75/1009	9
16	Salarifar et al (2020)	Iran	March 1, 2019 to April 30, 2019 vs February 29, 2020 to April 30, 2020	447.94 ± 151.02 vs 451.13 ± 145.39	146/146 vs 178/178	78.44 ± 17.06 vs 64.56 ± 9.69	N/A	4/146 vs 8/178	7
17	Scholz et al (2020)	Germany	March 1 to May 31 in 2017, 2018, 2019 vs March 1, 2020 to May 31, 2020	159.1 ± 2.3 vs 163.1 ± 7.9	1205/1329 vs 352/387	51.3 ± 1.1 vs 53.2 ± 2.0	1127/1329 vs 332/387	118/1329 vs 37/387	9
18	Song et al (2021)	China	January 24, 2019 to May 31, 2019 vs January 24, 2020 to May 31, 2020	N/A	88/95 vs 11/73	107.5 ± 11.69 vs 127.75 ± 22.85	88/95 vs 11/73	2/95 vs 2/73	9
19	Soylu et al (2021)	Turkey	Before January 13, 2020 vs After March 10, 2020	52.75 ± 10.07 vs 220.75 ± 97.42	80/83 vs 73/82	151 ± 91.28 vs 170.5 ± 94.74	79/83 vs 77/82	3/83 vs 6/82	8
20	Nan et al (2021)	China	August 1, 2019 to January 22, 2020 vs January 23, 2020 to May 31, 2020	55.22 ± 4.64 vs 61.25 ± 4.86	183/183 vs 60/60	48.08 ± 5.78 vs 71.2 ± 6.53	171/183 vs 45/60	5/183 vs 9/60	9
21	Mesnier et al (2020)	France	February 17, 2020 to March 16, 2020 vs March 16, 2020 to April 30, 2020	214.5 ± 45.22 vs 209.5 ± 41.17	288/331 vs 223/252	N/A	N/A	3/331 vs 5/252	8
22	Cammalleri et al (2020)	Italy	March 1 to 31, 2019 vs March 1 to 31, 2020	106.75 ± 34.95 vs 973.13 ± 1060.26	34/35 vs 13/13	101.75 ± 21.16 vs 135.75 ± 39.15	34/35 vs 9/13	0/35 vs 0/13	9
23	Natarajan et al (2020)	Canada	January 1, 2020 to March 15, 2020 vs March 16, 2020 to May 10, 2020	N/A	990/1397 vs 622/824	N/A	N/A	N/A	7
24	Popovic et al (2021)	France	Unspecified (February 26, 2020 to May 10, 2020)	228 ± 180 vs 444 ± 462	1459/1552 vs 80/83	72 ± 138 vs 78 ± 138	1220/1552 vs 71/83	66/1552 vs 7/83	8
25	Reinstadler et al (2020)	Austria	Unspecified (February 24, 2020 to April 5, 2020)	179 ± 36.79 vs 327.5 ± 96.12	69/69 vs 43/43	46.5 ± 13.53 vs 49 ± 16.02	67/69 vs 35/43	4/69 vs 1/43	8
26	Tomasoni et al (2020)	Italy	January 3, 2020 to February 20, 2020 vs February 21, 2020 to April 10, 2020	118.75 ± 34.43 vs 289 ± 167.83	51/51 vs 34/34	47.5 ± 8.89 vs 89.25 ± 21.28	45/51 vs 26/34	3/51 vs 4/34	9
27	Freitas et al (2020)	Portugal	March and April, 2019 vs March and April, 2020	N/A	55/55 vs 46/49	59.56 ± 17.6 vs 137.5 ± 20.13	N/A	4/55 vs 7/49	8
28	Calvãoet al (2021)	Portugal	March and April, 2019 vs March and April, 2020	132 ± 43.34 vs 225 ± 83.86	27/31 vs 32/39	187 ± 94.46 vs 211.5 ± 99.24	N/A	1/31 vs 4/39	8
29	Arai et al (2021)	Japan	January 30 to September 30 in 2017, 2018, 2019 vs January 30, 2020 to September 30, 2020	46.8 ± 63.4 vs 37 ± 83.6	145/156 vs 51/53	103.1 ± 62.5 vs 127.6 ± 145.2	N/A	13/156 vs 5/53	8
30	Aldujeli et al (2021)	Lithuania	March 11, 2019 to April 15, 2019 vs March 11, 2020 to April 15, 2020	292.25 ± 82.83 vs 639 ± 219.23	82/86 vs 64/67	76 ± 15.54 vs 77.5 ± 11.26	77/86 vs 60/67	5/86 vs 3/67	7
31	Medranda et al (2021)	United States	March 1, 2019 to August 31, 2019 vs March 1, 2020 to August 31, 2020	N/A	90/90 vs 93/93	74.4 ± 46.1 vs 95.9 ± 66.9	N/A	10/90 vs 18/93	9
32	Hannan et al (2020)	United States	January 1, 2019 to March 14, 2020 vs	103.25 ± 17.26 vs 135.75 ± 33.73	3411/3411 vs 187/187	66.5 ± 5.05 vs 69.5 ± 8.11	N/A	170/3411 vs 10/187	8

Table 2 (*continued*)

No.	Author (year)	Country	Pre-pandemic vs pandemic period	Symptom-to-FMC onset (Mean ± SD) (minutes)	Primary PCI	DTB (Mean ± SD) (minutes)	Final TIMI 3 flow	Mortality	NOS
			March 15, 2020 to April 30, 2020						
33	Erol et al (2020)	Turkey	March 25 to April 1 in 2018, 2019 vs March 25, 2020 to April 1, 2020	50 ± 16.78 vs 96.25 ± 27.37	674/711 vs 442/485	41 ± 6.39 vs 43.25 ± 7.13	*N*/A	38/711 vs 23/485	8
34	Mengal et al (2020)	Pakistan	March to April, 2019 vs March to April, 2020	346.75 ± 207.31 vs 429.25 ± 272.16	1537/1537 vs 1139/1139	*N*/A	*N*/A	49/1537 vs 60/1139	7
35	Haddad et al (2020)	Canada	Mid-March to mid-April, 2019 vs Mid-March to mid-May, 2020	127.88 ± 47.67 vs 322 ± 169.93	60/60 vs 53/53	73.25 ± 14.27 vs 66.25 ± 15.23	56/60 vs 46/53	1/60 vs 5/53	8

DTB: door-to-balloon; FMC: first medical contact; *N*/A: not available; NOS: Newcastle–Ottawa Scale; PCI: percutaneous coronary intervention; SD: standard deviation; STEMI: ST-segment elevation myocardial infarction; TIMI: thrombolysis in myocardial infarction.

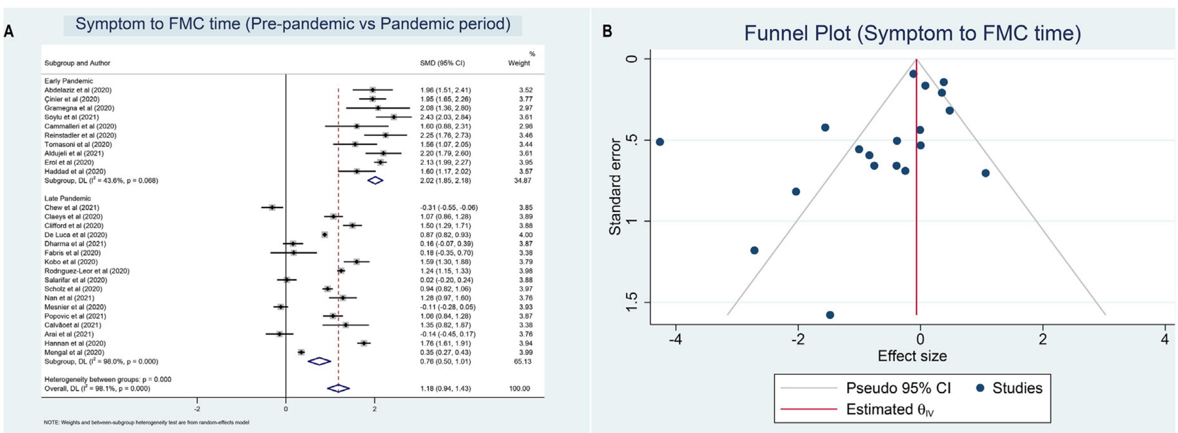

Fig. 2. (A) Forest plot and (B) funnel plot regarding symptom-to-FMC time between pre-pandemic and pandemic period.

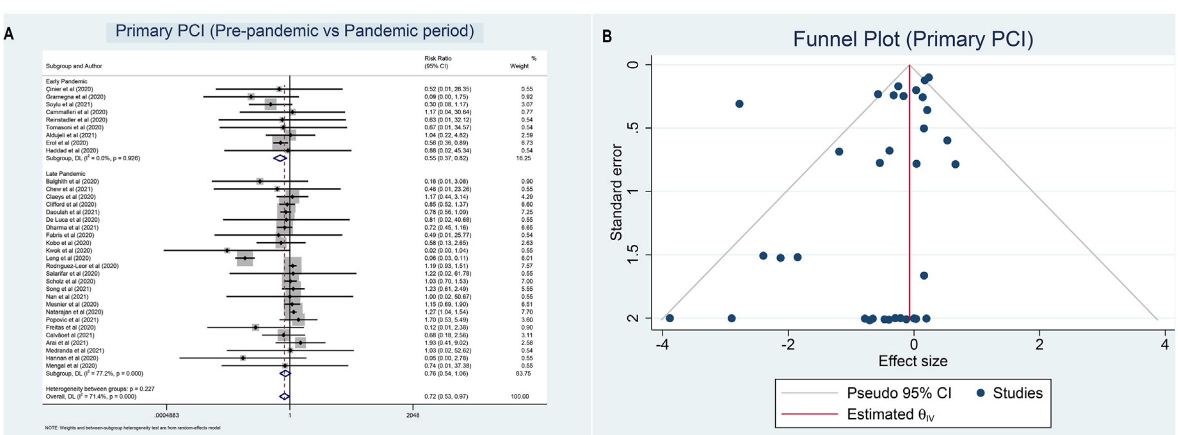

Fig. 3. (A) Forest plot and (B) funnel plot regarding the amount of performed primary PCI between pre-pandemic and pandemic period.

place in late 2020 and early 2021. Secondly, some studies did not report data in terms of mean and standard deviation in absolute terms. Thus, the prediction of value using the method proposed by Wan et al[10] may lead to inaccurate calculations. Other than that, disparity in the number of samples across the studies may affect the pooled effect size during meta-analysis process. Eventually, there was a considerable heterogeneity among the included studies. Fortunately, after we conducted subgroup analysis, the heterogeneity was significantly dropped which possibly due to more distinct conditions related to STEMI systems of care in the late outbreak period.

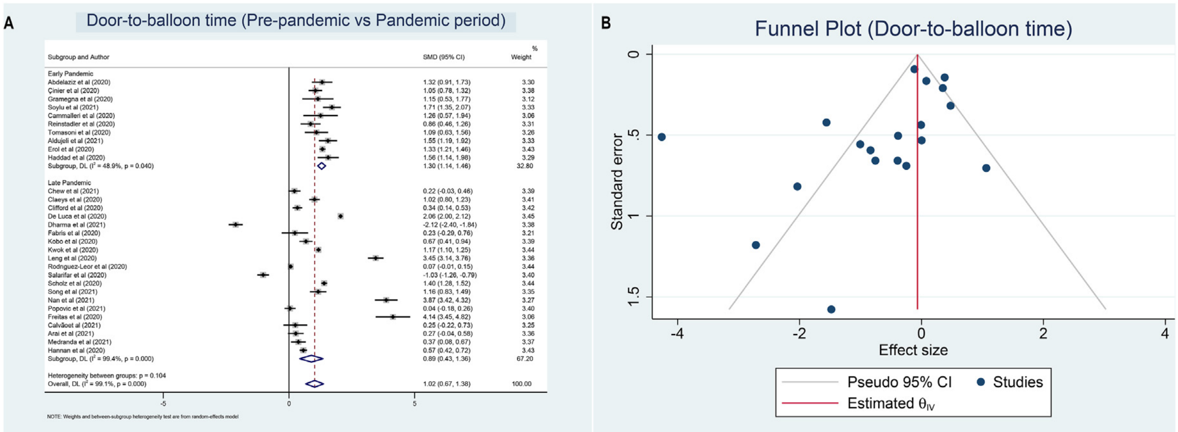

Fig. 4. (A) Forest plot and (B) funnel plot regarding door-to-balloon time between pre-pandemic and pandemic period.

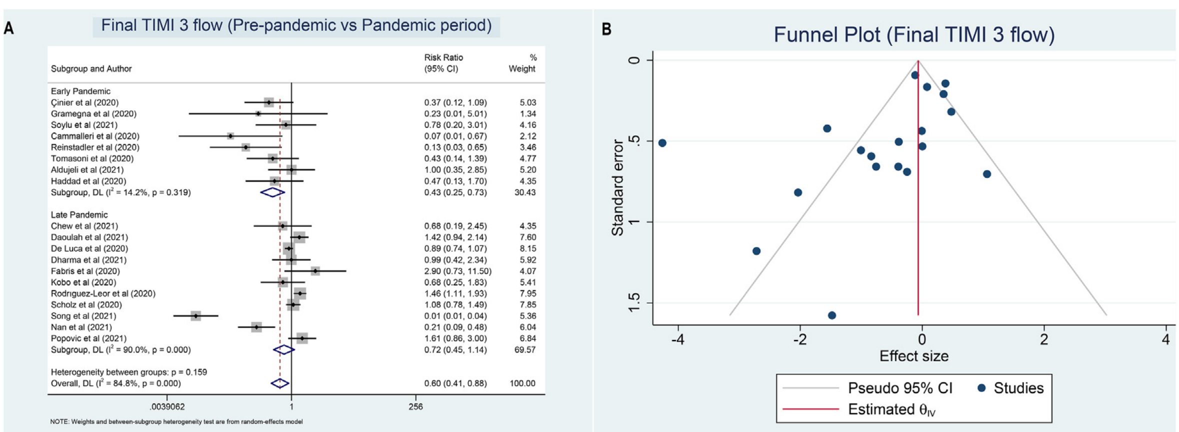

Fig. 5. (A) Forest plot and (B) funnel plot regarding final TIMI 3 flow between pre-pandemic and pandemic period.

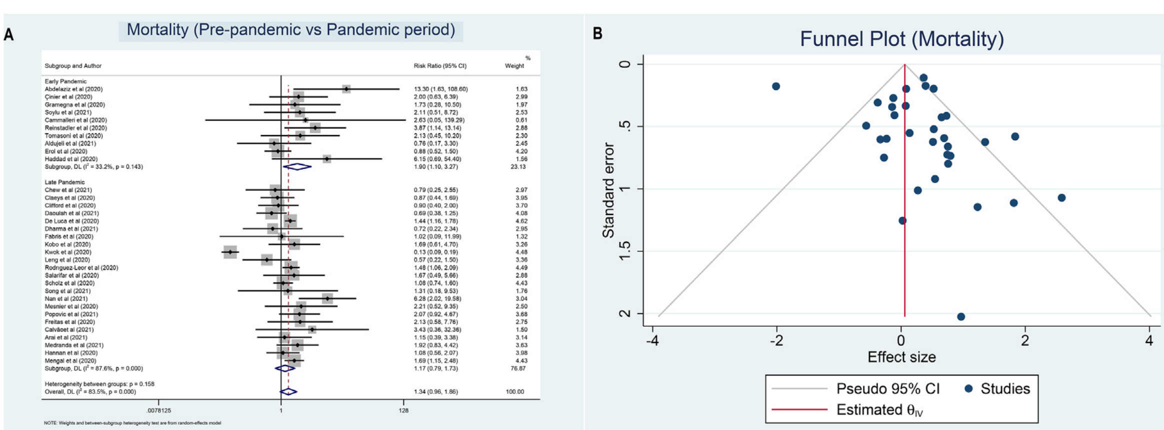

Fig. 6. (A) Forest plot and (B) funnel plot regarding mortality between pre-pandemic and pandemic period.

5. Conclusion

This meta-analysis shows that there has been a decline in the performance of STEMI systems of care and a deterioration of clinical outcomes in STEMI patients during the COVID-19 pandemic, particularly in the early pandemic period. The yield trend in the late pandemic era shows superior results and is expected to continue becoming better from now onwards.

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Authors' contribution

WK helped in the conception and design of the study, as well as performed the statistical analysis. WK, APS, MAR, and DRG were actively involved in literature search, study selection, data extraction, extensive review, and writing the manuscript. All authors read and approved the final version submitted for publication.

Declaration of competing interest

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ihj.2021.06.009.

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