Review Article

Door-to-Balloon Time in Patients with ST-Segment Elevation Myocardial Infarction (STEMI) in Iran: A Systematic Review and Meta-Analysis

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Highlights

- Myocardial infarction known as a heart attack, is life-threatening cardiovascular condition.
- Timely reperfusion therapy, particularly primary percutaneous coronary intervention (PPCI), can prevent further myocardial damage and reduce irreversible complications.
- The Door-to-Balloon time is crucial in the management of STEMI.
- The average Door-to-Balloon time in Iran was 85.05 minutes, which is within the global benchmark.

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ABSTRACT

Background: Myocardial infarction is a severe cardiovascular condition that necessitates prompt reperfusion therapies, particularly primary percutaneous coronary intervention (PCI), to prevent irreversible myocardial damage and associated complications. This study aimed to determine the average door-to-balloon (D2B) time in Iranian hospital emergency departments through a systematic review and meta-analysis.

Methods: Following the PRISMA guideline, the protocol for this study was registered in PROSPERO (CRD420251171966). A comprehensive search with no time restrictions was conducted through the end of September 2025 in data resources such as PubMed, Scopus, Web of Science, Google Scholar, SID, and Magiran. A random-effects model was used for the meta-analysis, and heterogeneity among studies was assessed using the I^2 index. Publication bias was evaluated with Begg test.

Results: Of 154 initial articles retrieved, 13 studies met the eligibility criteria and were included in the final analysis. The pooled mean D2B time was 85.05 minutes (95% CI, 75.32 to 94.78). A significant level of heterogeneity was observed among the included studies. Meta-regression analysis indicated a decreasing trend in D2B time over the years.

Conclusion: The results of this study indicate that the average D2B time in Iran aligns with global standards. However, significant variability among hospitals highlights systemic gaps in STEMI care. Addressing these gaps requires coordinated emergency-PCI teams, nationwide 24/7 services, ongoing training, and uniform quality standards.

Keywords: Door-to-Balloon Time; ST-Segment Elevation Myocardial Infarction (STEMI); Primary Percutaneous Coronary Intervention; Systematic Review; Meta-Analysis; Iran

Introduction

Myocardial infarction, commonly known as a heart attack, is a prevalent and life-threatening cardiovascular condition caused by partial or complete blockage of blood flow in 1 of the coronary arteries.[1] This blockage leads to ischemia and necrosis of the heart muscle tissue, potentially resulting in severe heart failure or sudden death if not promptly treated. In the United States, a heart attack occurs approximately every 40 seconds, affecting nearly 805000 individuals annually.[2] In Iran, national registry data estimate the incidence of myocardial infarction at 73.3 cases per 100000 population, with an in-hospital mortality rate of approximately 12.1% among affected patients.[3]

During acute myocardial infarction, changes in the electrocardiogram (ECG) often manifest as ST-segment elevation, indicating complete blockage of a coronary artery. This characteristic alteration serves as the primary diagnostic feature of ST-segment elevation myocardial infarction (STEMI). Prompt recognition of these ECG changes is crucial, because timely initiation of reperfusion therapy, particularly primary percutaneous coronary intervention (PCI), can prevent further myocardial damage and reduce irreversible complications.[4]

Studies have shown that any delay in performing angioplasty results in the loss of additional myocardial tissue and increases the risk of heart failure and mortality.[5,6] Therefore, the door-to-balloon (D2B) time, defined as the time from patient arrival at the hospital to reopening of the occluded coronary artery, is crucial in the management of STEMI.[7] The American Heart Association[8] and the European Society of Cardiology[9] recommend that this time should not exceed 90 minutes. Achieving this target has been linked to reduced mortality, reduced infarct size, and improved left ventricular function. Zeng et al[7] found that each 30-minute delay in D2B time was associated with a 7.5% increase in 1-year mortality risk. In Iran, efforts have been made to improve STEMI care and reduce D2B time, but national studies still show varying averages, with many centers exceeding the recommended 90-minute threshold.[10] Based on a systematic review, D2B time in patients with STEMI is influenced by patient characteristics, hospital infrastructure, efficiency of care processes, and time of patient arrival at the hospital.[11]

Despite numerous cross-sectional studies conducted in different regions of the country, no comprehensive systematic review and meta-analysis has been performed to date. Such a study is needed to assess data quality, determine the overall mean D2B time, and systematically analyze the factors influencing it.

Conducting this research could provide a clear overview of the current situation in Iran. It may also serve as a valuable tool for improving health care system efficiency and reducing mortality among patients with STEMI. The aim of the present study is to determine the average D2B time in patients with STEMI in Iran through a systematic review and meta-analysis.

Methods

This systematic review and meta-analysis followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[12] Furthermore, the study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with the registration number CRD420251171966.

Search Strategy

A thorough literature search was conducted across various data resources, including PubMed, Scopus, Web of Science, Google Scholar, SID, and Magiran. The search terms were identified through Medical Subject Headings (MeSH), keywords from relevant articles, and expert input. Search strategies in each database were developed using a combination of keywords, search fields, and Boolean operators (AND, OR, NOT). The searches were conducted without any time restrictions up to the end of September 2025. The detailed search strategies for each database can be found in Appendix 1. The search was conducted using English and equivalent Persian keywords, such as “myocardial infarction,” “ST-segment elevation,” “primary PCI,” “door-to-balloon time,” and “acute coronary syndrome.”

Inclusion Criteria

The inclusion criteria for this systematic review were defined based on the PICOS framework.

Population: Adult patients (≥18 y) diagnosed with STEMI who underwent primary PCI.

Intervention: Patients receiving primary PCI.

Outcome: Studies reporting D2B time in minutes along with the standard deviation (SD).

Study design: Observational studies (cross-sectional, cohort, prospective, or retrospective) and interventional studies.

Study setting: Research conducted in health care centers across Iran, with no restrictions on hospital type (teaching or nonteaching) or geographical region.

Language and publication type: Articles published in Persian or English in peer-reviewed journals, providing full-text access and sufficient data for statistical analysis, were included.

Exclusion Criteria

Studies were excluded if they were review articles, case reports, letters to the editor, or prevalence reports. Additionally, studies that reported only mean D2B time without SD or that used the interquartile range (IQR) instead of SD to describe dispersion were excluded.

Study Selection

All articles found were imported into EndNote X7 software, and any duplicate records were eliminated to streamline the search results. The titles and abstracts of the remaining studies were reviewed according to the predetermined eligibility criteria. Subsequently, potentially relevant articles were chosen for a thorough full-text review. Two reviewers (AS and HE) independently examined the full texts of these articles. Any disagreements were resolved through discussion. Ultimately, studies that met the inclusion criteria were included in the systematic review and meta-analysis.

Quality Assessment

The quality of the included studies was assessed by 2 independent reviewers. Cross-sectional studies were evaluated using the AXIS (Appraisal Tool for Cross-Sectional Studies) instrument, which assigns a total score from 0 to 20. Studies with a score of 12 or higher were deemed suitable for inclusion in the meta-analysis.[13] For cohort or case-control studies, the Newcastle-Ottawa Scale (NOS) was used to assess quality. This scale evaluates studies based on selection, comparability, and outcome or exposure domains. Studies scoring below 5 were considered low quality, scores of 5 to 6 indicated moderate quality, and scores of 7 to 9 reflected high quality.[14] Clinical trial studies were evaluated using the CONSORT (Consolidated Standards of Reporting Trials) checklist to ensure methodological rigor and comprehensive reporting.[15] Quality assessment was carried out by 2 reviewers independently to guarantee reliability. In instances of disagreement, a third expert reviewer was consulted to achieve consensus.

Data Extraction

Data extraction was carried out by 2 reviewers independently. The extracted data included details about each study, such as the author name, publication year, location, study design, sample size, and the mean and SD of D2B time.

Statistical Analysis

The mean and SD of D2B time and sample size were extracted for each study. The standard error (SE) for D2B time was calculated using the SD and the sample size (Comments: gen se=SD/sqrt(N)). A random-effects model was used for the meta-analysis (command: Metan D2B time se, label (namevar=Author, yearvar=Year) sortby(Year) random). Heterogeneity among studies was assessed using the I^2 statistic, with values indicating the level of heterogeneity. The Begg test was drawn upon to evaluate potential publication bias (command: metabias6 D2B time se, graph(begg)). Meta-regression was conducted to assess the association between mean D2B time and study year (command: metareg Year D2B time, wsse(se) bsest(reml)graph). Sensitivity analysis was performed to examine the impact of individual studies on pooled mean D2B estimate (command: metaninf D2B time se, label (namevar=Author, yearvar=Year) random).

STATA software was used for all statistical analyses.

Results

Systematic Review Findings

Initially, 154 records were retrieved through database searches. After duplicate removal, 142 articles were screened based on title and abstract, with 19 studies selected for full-text review. Following detailed evaluation, 13 studies met the eligibility criteria and underwent quality assessment. All included studies demonstrated acceptable methodological quality. Subsequently, all 13 studies were included in the meta-analysis (Figure 1).

In terms of study design, 7 were cross-sectional, 3 were prospective cohort studies, 1 was a retrospective cohort study, and 2 were clinical trials. These studies collectively represented data from 2718 patients with STEMI who underwent primary PCI in Iran. Additional characteristics of the included studies are summarized in (Table 1).

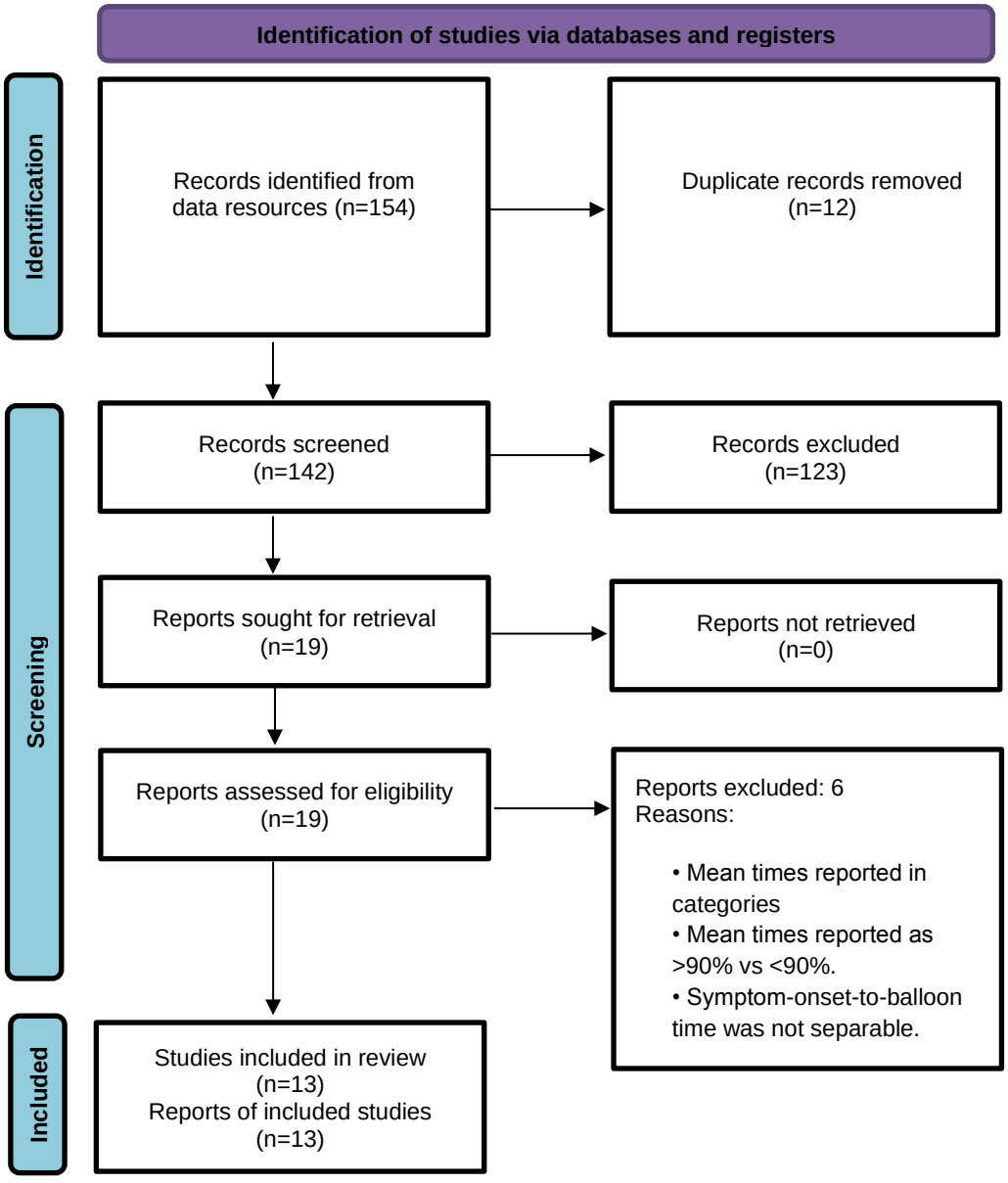

Figure 1. Flowchart of the selection of studies based on PRISMA

Table 1. Specifications of studies included in the meta-analysis

First Author	Year of Publication	Design	Location	Number of Patient	D2B Time Mean (SD)
Falsoleiman[16]	2012	Randomized clinical trial	Mashhad	41	70 (25)
Khosravi[17]	2013	Cross-Sectional	Isfahan	93	148.9 (168.5)
Kassaian[18]	2015	Prospective observational Cohort	Tehran, Mashhad,Isfahan, Shiraz , Tabriz	463	82.8 (112.5)
Hosseini[19]	2018	Cross-Sectional	Tabriz	191	76.15 (48.48)
Rezaee[20]	2018	Cross-Sectional	Zanjan	141	89.43 (213.06)
Yekefallah[21]	2019	Cross-Sectional	Tehran	121	104.60 (62.30)
Haybar[22]	2019	Cross-Sectional	Ahvaz	148	89.5 (13.7)
Soleimani[23]	2020	Prospective observational cohort	Isfahan	121	182.4 (233.7)
Alizadeh[24]	2020	Retrospective observational cohort	Tehran	293	57.78 (127.74)
				79	141.70 (237.64)
Namdar[25]	2021	Controlled clinical trial	Qazvin	29	113.5 (43.6)
				29	79.3 (27.4)
Shahbazi[26]	2022	Cross-Sectional	Sabzevar	161	52.68 (27.46)
				118	73.23 (91.87)
Gharanjik[27]	2023	Prospective observational cohort	Zanjan	90	63.95 (23.92)
Hadizadeh[28]	2024	Cross-Sectional	Tehran	300	54.83 (59.78)
			Sanandaj	300	88.31 (60.66)

Meta-Analysis Findings

The meta-analysis findings revealed that average D2B time in Iran was 85.05 minutes (95% CI, 75.32 to 94.78). The studies exhibited a high level of heterogeneity (I^2=96.2%), indicating significant variation among them (Figure 2).

Shahbazi et al[26] (2022) reported the shortest mean D2B time in Sabzevar (52.68 [SD, 27.46] minutes), while Soleimani et al[23] (2020) documented the longest mean D2B time in Isfahan (182.40 [SD, 233.70] min).

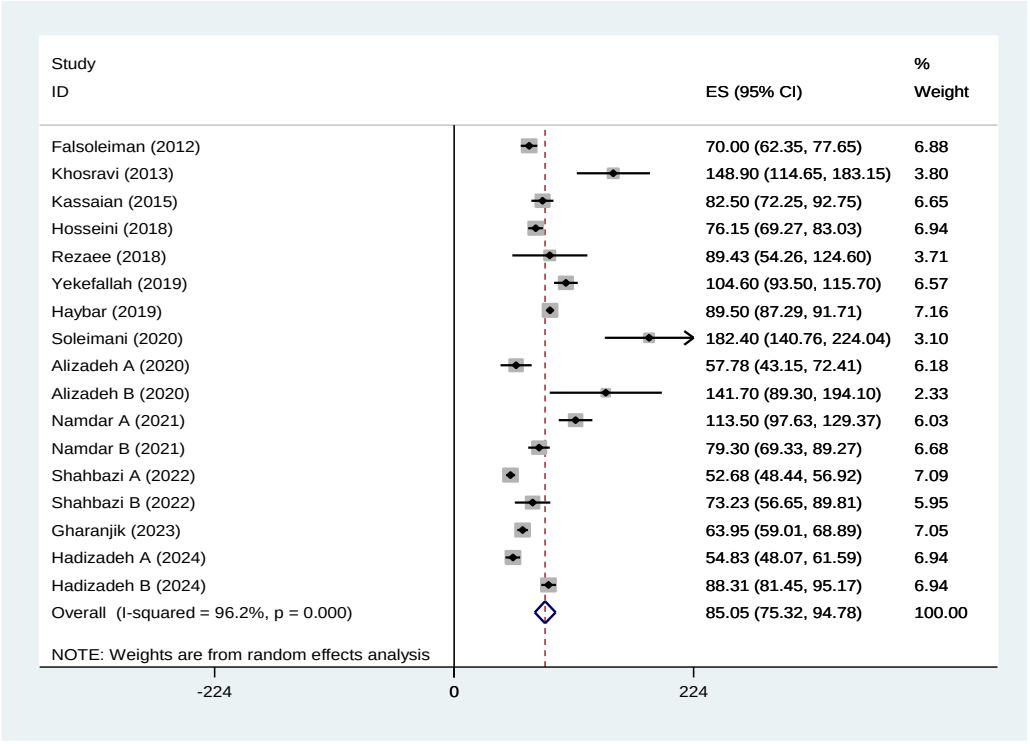

Figure 2. The forest plot of the mean and standard deviation of door-to-balloon (D2B) time in the studies with 95% confidence intervals

Publication Bias

The results of the Begg test did not indicate statistically significant evidence of publication bias for the combined mean D2B time (Begg test, P=.07) (Figure 3).

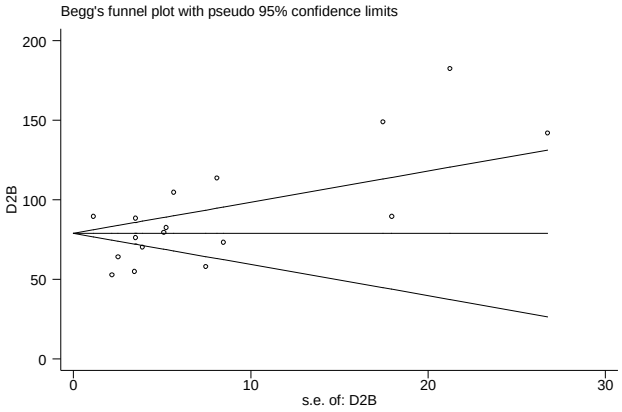

Figure 3. Funnel plot of the Begg test results

Meta-Regression

The meta-regression analysis results showed a declining trend in the average D2B time over time (Figure 4).

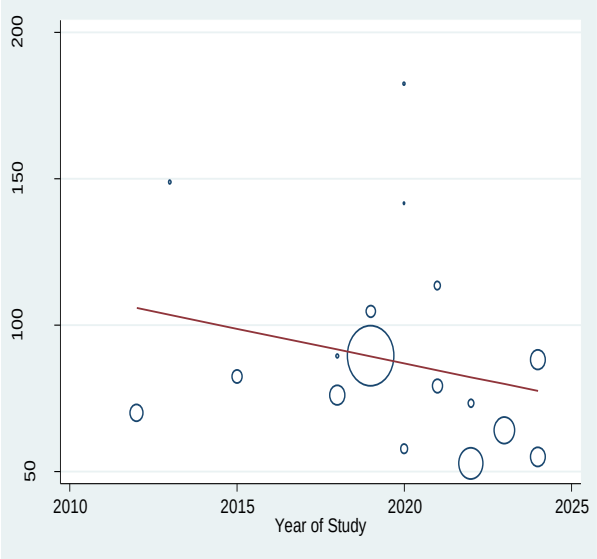

Figure 4. Meta-regression of mean door-to-balloon (D2B) time by study year

Sensitivity Analysis

The sensitivity analysis results indicated that the overall mean D2B time remained stable even when individual studies were excluded (Figure 5).

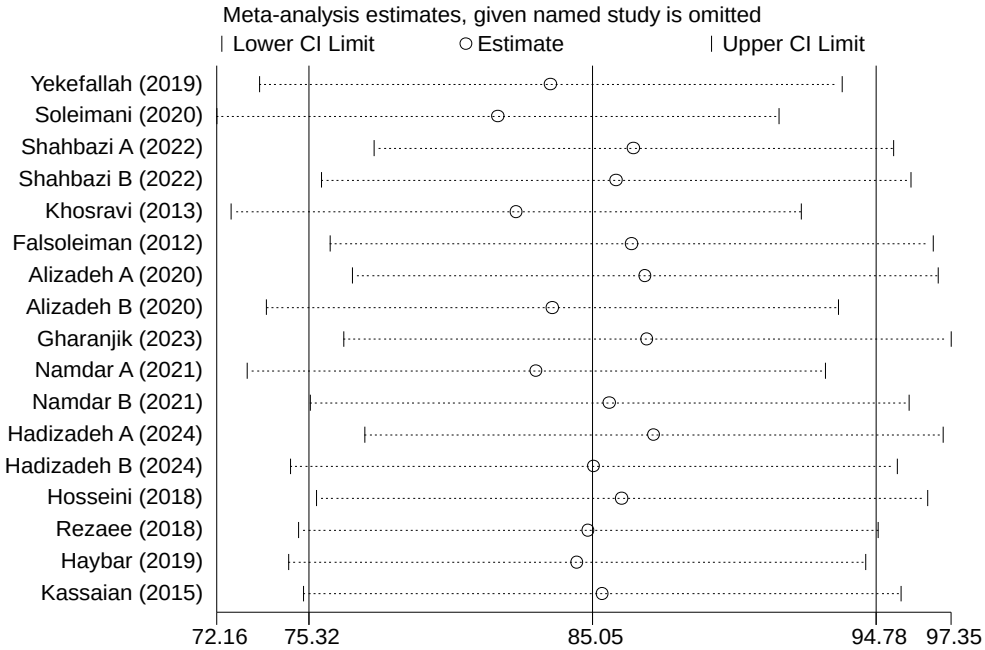

Figure 5. Sensitivity analysis for the mean door-to-balloon (D2B) time

Discussion

The results of this systematic review and meta-analysis revealed that the average D2B time in Iran was 85.05 minutes, which is within the global benchmark of less than 90 minutes. Nonetheless, the high heterogeneity (I^2=96.2%) indicates significant variability in the performance of health care facilities throughout the country. The wide range of reported D2B times further supports this

variability. By way of example, Shahbazi et al[29] in Sabzevar reported the shortest mean D2B time (52.68 min), while Soleimani et al[30] in Isfahan reported the longest (182.4 min). This substantial difference suggests that despite the existence of standardized national guidelines, their implementation and adherence vary among institutions, reflecting disparities in organizational efficiency, resource availability, and the level of coordination between prehospital and hospital emergency systems.

One of the key factors that influences D2B time is the implementation of a prehospital triage and STEMI diagnosis system. Research by Yekefallah et al[21] and Alizadeh et al[24] indicated that conducting an ECG in the prehospital setting and activating the catheterization laboratory (cath-lab) before patient arrival could substantially reduce D2B time. This chimes with global findings indicating that prehospital cath-lab activation can cut D2B time by approximately 30 to 45 minutes.[31,32] Conversely, Rezaee et al[33] identified the lack of such a system as a major contributor to delays. Hence, it can be inferred that a key challenge is not in the equipment itself but in the coordination and communication between prehospital emergency services and hospital systems.

Having access to an active 24/7 primary angioplasty team is essential for improving patient outcomes. Research conducted by Khosravi et al[34] and Rezaee et al[33] found that delays in contacting staff outside of regular working hours resulted in significant increases in D2B times. Conversely, facilities with on-site angioplasty teams available around the clock, as demonstrated in studies by Shahbazi et al[29] and Hadizadeh et al[35], experienced a notable reduction in D2B times. Accordingly, the organizational structure and preparedness of the medical team are critical factors influencing performance variations among treatment centers. This contrast shows that enhancing human resource systems and implementing ongoing on-call shifts are substantially more impactful than simply increasing medical equipment.

When patients are transferred from hospitals that cannot perform PCI procedures, studies by Kassaian et al[36] and Hadizadeh et al[35] showed that interhospital transfer led to longer D2B times and an increased risk of myocardial injury. This is consistent with findings from global STEMI networks, which recommend direct transfer to PCI-capable centers as the best approach to reduce delays in treatment and enhance patient outcomes.[37] As a result, it is essential to prioritize the establishment of regional STEMI treatment networks and the development of clear referral pathways as a critical health care policy initiative.

The efficiency of care is substantially influenced by the workload and experience level of the treatment center. Research by Gharanjik et al[38] and Kassaian et al[36] showed that centers with a higher volume of PCI procedures tended to have shorter D2B times, attributed to their extensive clinical experience, effective team coordination, and operational preparedness. On the other hand, low-volume centers typically experience longer procedural delays. These results underscore the significance of consolidating interventional cardiac services in experienced, well-equipped centers and ensuring optimal allocation of health care resources within the national health care system.

Namdar et al[39] concluded that improving training and coordination among emergency services and the interventional team could lead to a substantial reduction in D2B time, even without additional technological resources. This is concordant with the overall findings of the current meta-analysis, highlighting the importance of enhancing organizational and procedural efficiency in reducing treatment delays. Simply acquiring more medical equipment is not enough; restructuring managerial systems and enhancing interdepartmental communication are essential for achieving optimal clinical outcomes.

The meta-regression analysis results showed a decrease in mean D2B time in recent years, indicating an improvement in STEMI care in Iran. This improvement is attributed to the establishment of 24/7 primary PCI networks, enhanced prehospital emergency systems, increased clinical awareness among health care teams, and systematic hospital performance monitoring.

Similar results have been found in international studies, which also linked structured system-level interventions and quality improvement programs to decreasing D2B times.[6,7] Nevertheless, sustaining this positive trend requires national

health policies to ensure consistent implementation of clinical standards in all health care facilities.

While the Begg test did not show significant publication bias, the limited number of studies, high heterogeneity, and reliance on single-center reports call for cautious interpretation. Future research should involve multicenter studies and nationwide registries to validate and build upon these findings.

Limitations

This study, like other systematic reviews and meta-analyses, has several limitations that should be considered when interpreting the findings. First, the relatively small number of included studies, many of which were single-center investigations, may limit the generalizability of the results to the national health care system. Second, the high heterogeneity among the included studies—potentially due to differences in sample size, geographic distribution, study design, number of included studies, and hospital infrastructure—may affect D2B time.

Conclusions

This systematic review and meta-analysis highlight the need for system-level reforms in STEMI care in Iran. Although overall D2B times are within acceptable ranges, significant heterogeneity reflects structural and organizational disparities. Improving care requires upgrading infrastructure, implementing regional STEMI networks, training health care teams, enhancing coordination between emergency services and PCI centers, and establishing on-call interventional teams. The recent decline in D2B time shows positive national efforts, which should be sustained through ongoing monitoring, standardized guidelines, and a national registry. This study provides a foundation for national quality improvement initiatives to reduce disparities and improve patient outcomes.

Declarations:

Ethical Approval

Ethical approval was not required for conducting this research.

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Conflict of Interest

The authors report no conflict of interest.

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