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Prevalence of cardiac arrest during pregnancy: a systematic review and meta-analysis

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Abstract

Background: Cardiac arrest during pregnancy is a serious condition that can cause significant morbidity and mortality for both the mother and the unborn child

Objective: This systematic review and meta-analysis seek to estimate the worldwide prevalence of cardiac arrest during pregnancy.

Methods: Multiple databases, including "PubMed, Cochrane, and Embase", were searched until April 7, 2023, exclusively in English, to ensure a comprehensive selection of relevant studies. A stringent two-stage screening process was employed, evaluating titles, abstracts, and full-text reviews based on the research question, "What is the prevalence of cardiac arrest in women during pregnancy?" Two authors independently extracted relevant data from the selected studies, including author names, publication years, study design, cardiac arrest occurrences, and total number of pregnant participants. The third author resolved the conflict. The Random Effects Model (REM) computed the pooled cardiac arrest prevalence. Heterogeneity was assessed via the I2 statistic.

Results: The systematic search of the database resulted in the identification of 1246 articles. Out of these, 18 were deemed suitable for inclusion in the systematic review, and ultimately, 17 of them were included in the meta-analysis.The pooled cardiac arrest prevalence during pregnancy was estimated at 0.08% (95% CI 0.03-0.19). The PI was <0.001-5.03%. However, the heterogeneity remained high (I2=100%). Sub-group analysis disclosed varying prevalence across continents, with Asia displaying the highest rate [(2.76%) (95% CI 1.04-7.12].

Conclusions: The study reveals significant cardiac arrest prevalence in pregnancy, with increasing rates over time and variations by continent. Maternal mortality concerns persist, particularly in Asia.

Keywords: *Cardiac arrest, Maternal mortality, Meta-analysis, Pregnancy, Cardiovascular disease, Antenatal, Intrapartum, Myocardial infarction, Angina, Evidence synthesis*

Introduction

Cardiac health in pregnancy is a significant problem since it involves a complicated interplay between obstetric and cardiovascular care of the mother and foetus. Since the symptoms of the disease and typical physiological changes are similar, diagnosing and treating heart disease during pregnancy can be challenging. Cardiovascular

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Evidence in Context

Prior Evidence: Cardiovascular disease is the main contributor to indirect maternal mortality (~33% of deaths of pregnant women). Maternal cardiac arrest is an indication of severe maternal morbidity or unanticipated effects of labour and delivery that have a considerable negative impact on a woman's short- or long-term health. The evidence from studies regarding cardiac arrest during pregnancy is limited and contradictory.

Evidence added by this study:

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Disease is the main contributor to indirect maternal mortality, accounting for almost 33% of deaths of pregnant women.[1–6]. Furthermore, the risk varies depending on the underlying cardiac condition, with maternal heart disease occurring as a complication in approximately 4% to 16% of pregnancies in women who have previously diagnosed cardiac disorders [7–9]. According to estimates, managing cardiovascular diseases could prevent up to 68% of pregnancy-related deaths [1,10]. One of the most difficult clinical situations is cardiovascular arrest during pregnancy. There are significant and distinct differences between resuscitating an adult and a pregnant person, even though they share many traits. The most prominent difference is that there are two patients: the mother and the foetus [11]. First, resuscitation within the "golden hour" commonly goes unperformed due to subpar pre-hospital care, a lack of experienced professionals, and improper inter-hospital transfers. However, the results of polytrauma in pregnant women are frequently fatal [12]. Cardiac arrest during pregnancy is a serious condition that can cause significant morbidity and mortality for both the mother and the unborn child [13]. Cardiac arrest in the third trimester of pregnancy has implications for the neonatal injury and its survival if not immediately intervened [14]. Maternal cardiac arrest is an indication of severe maternal morbidity or unanticipated effects of labour and delivery that have a considerable negative impact on a woman's short- and long-term health. These conditions can result in pregnancy-related deaths if they are not promptly diagnosed and treated [15]. In order to facilitate the achievement of the Sustainable Development Goal (SDG) target of less than 30 maternal deaths per 100,000 live births by 2030, it is essential to estimate and focus on this mostly preventable cause of maternal mortality [16].

National-level population-based research from the United States of America (USA), Canada, the United Kingdom (UK), and the Netherlands reveals that between 1 in 12,000 and 1 in 36,000 pregnant women experience cardiac arrest [17–20]. In a recent cohort study in the United States, cardiac arrest occurred in one among every 9,000 hospital deliveries from 2017 to 2019, and nearly seven out of ten women survived the incident [21]. The cardiac arrest rate from 2017 to 2019 was 13.4 per 100,000 delivery hospitalisations. Among them, 68.6% of the patients who experienced cardiac arrest made it out of the hospital. In another study from Thailand, 23 women experienced cardiac arrest out of 89,368 deliveries from 2006 to 2015 (1:3885), with three of the arrests taking place prior to delivery (1:29,789), [22,23]. According to this study, pregnancy-related hypertension and cardiovascular conditions were the most frequent causes of cardiac arrests. Pregnancy-related cardiac arrests were more frequent than previously reported [19,24,25]. A number of factors, such as those related to anaesthesia, haemorrhage, cardiovascular illness, embolism, uterine atony, and hypertension/pre-eclampsia/eclampsia, are frequently responsible for maternal cardiac arrest and mortality [24,25]. Furthermore, in a study conducted between 2015 and 2019, no cardiac arrest event was reported in the Philippine General Hospital, with 30,053 women admitted for deliveries, of whom 293 had cardiovascular disease [26]. No cardiac arrests were noted in another cohort study from the Swedish population that included 6630 pregnant women [27].

In India, 60% of the heart diseases identified for the first time during pregnancy were later determined to be rheumatic heart disease in 42% of cases and pulmonary hypertension in 33% of cases, 15% of pregnancies experienced maternal cardiac problems, with heart failure being the most prevalent (66%) of these [28].

Overall, the collective evidence from studies regarding cardiac arrest during pregnancy is limited and contradictory. This emphasises the importance of doing a systematic inquiry to determine the frequency of incidents. The contradiction in the findings of the studies makes it more essential to investigate and quantify the issue of the threat of cardiac arrest during pregnancy. This will enable better resource allocation by policymakers towards the problem of cardiac arrest in pregnancy. However, previous systematic reviews and meta-analyses have been done on the management of cardiac arrest during pregnancy [24,29,30]. In a systematic search undertaken by the authors in the Cochrane Library and the "International Prospective Register of Systematic Reviews (PROSPERO)", no systematic reviews were in progress or planned on the frequency of cardiac arrest in pregnant women. Therefore, the objective of the current study was to systematically review and present the pooled prevalence of cardiac arrest among pregnant women globally.

Materials and Methods

The "Preferred Reporting Items for Systematic Review and Meta-analysis" (PRISMA) reporting requirements were followed during the conduct of this study [Table S1]. The study was registered in PROSPERO under registration number CRD42023410718. Informed consent and ethical approval do not apply to the index study because it did not collect data from human participants.

Data source

The research question for the present study was "What is the prevalence of cardiac arrest in pregnant women?", which was elaborated as per the criteria listed in Table S2. Three databases were utilised for the systematic search: Embase, Cochrane, and PubMed [Table S3]. "cardiac arrest," "cardiopulmonary arrest," and "pregnant women" were among the search terms. The search approach and the exact search strings used for each database are listed in Table S3. In order to handle citations, eliminate duplications, and coordinate the review process, we used Mendeley Desktop V1.19.5 software. After removing duplicates, the search results were exported into a Microsoft Excel spreadsheet.

Data Extraction

Two reviewers (SBS and GS) independently assessed the titles and abstracts of studies retrieved from the systematic search.

The reviewers discussed amongst themselves to come to an understanding when there was any disagreement over the study's inclusion criteria for the review of full-text articles. If there is still a difference of opinion regarding the publication's eligibility, the third author (PA) was asked to evaluate the title and abstract. PA decided whether to submit the article for full-text review. The same procedure was adopted for the full-text review of the studies, and the final list of studies eligible for data extraction was identified. In order to extract the data, the two reviewers (NK and DK) read the full texts of the eligible studies. The two reviewers extracted the data independently. A conference was held to discuss the disagreement among the reviewers at the end of the data extraction. The third reviewer (SBS) sorted the unresolvable disagreement. Using the PRISMA flowchart [Figure 1], the screening process and its results at various stages have been depicted.

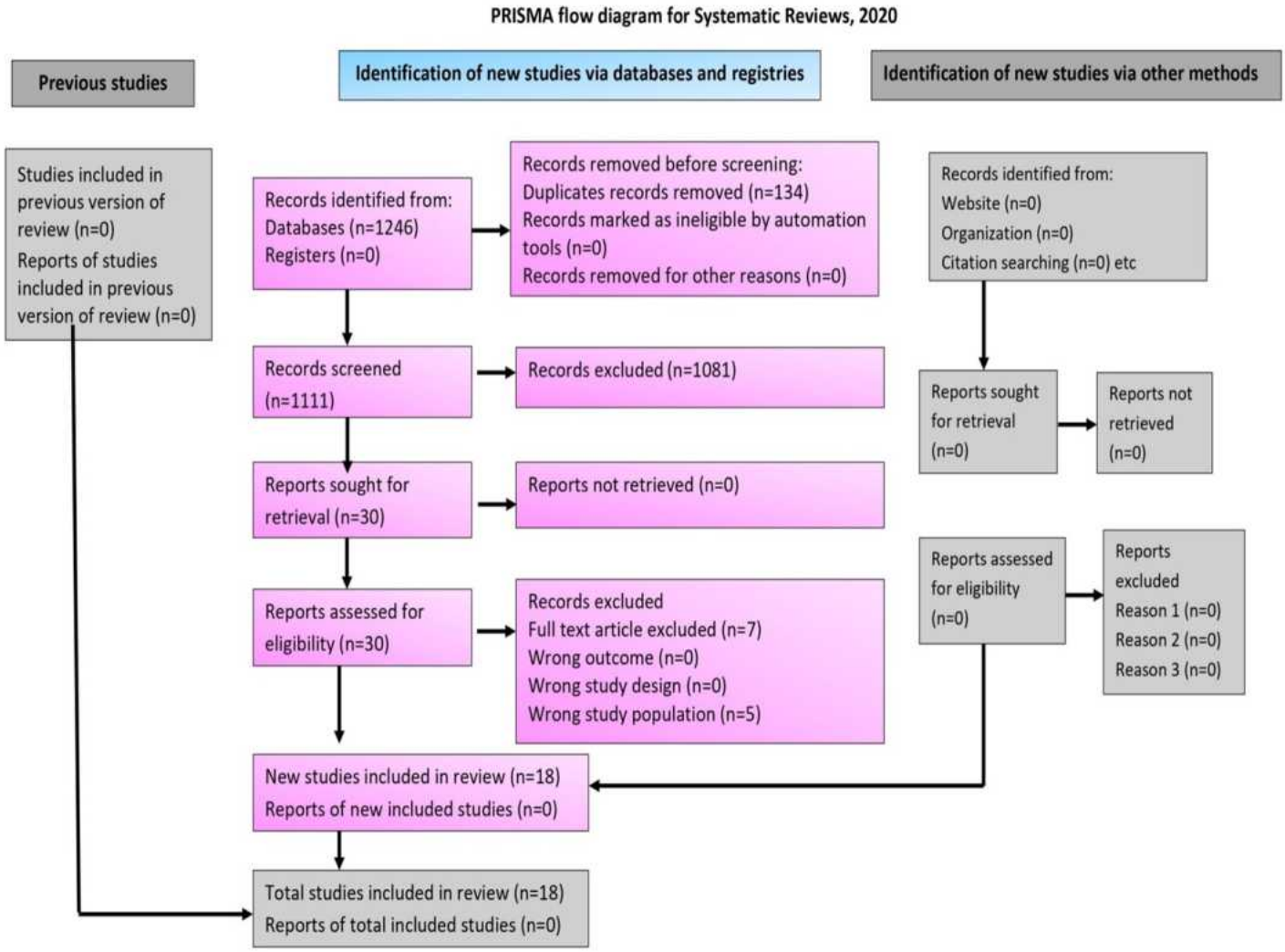

Figure 1.PRISMA diagram indicating the systematic inclusion of studies for evidence synthesis

Data Management

For analysis, a data extraction table was created using a Microsoft Excel spreadsheet. The following information was retrieved from each of the final eligible articles: the first author's name, publication year, study design, number of pregnant women reporting cardiac arrest (numerator), total number of pregnant women participating in the study (denominator) and country name. After excluding the unavailable studies, all the eligible studies were retrieved into the Excel spreadsheet.

Quality Assessment

Utilising the JBI quality evaluation tools [31], two authors evaluated the quality of each study separately. A sensitivity analysis was planned following the quality assessment by excluding the studies rated with poor quality.

Data Analysis

All the required analysis for the meta-analysis was undertaken in R Studio. In order to calculate the prevalence of cardiac arrest in pregnant women, the number of cardiac arrest episodes in pregnant women was divided by the total number of research participants. The Random Effects Model (REM) determined the pooled prevalence of cardiac arrest using the Dersimonian-Laird

(DL) method. The heterogeneity of studies was evaluated using the I^2 test. I^2 value of more than 50% was declared to have substantially high heterogeneity. A sub-group analysis was planned to explore the heterogeneity based on the continent of the study. The prediction interval (PI) was estimated to present high heterogeneity [32]. Meta-regression was planned to identify other potential reasons for heterogeneity. The Baujot plot, leave-one-out analysis, and Graphic Display of Heterogeneity (GOSH) plots were used to discover outliers. Sensitivity analyses were planned after leaving out poor-quality studies and outliers. Doi plot was employed to evaluate publication bias. Publication bias was quantified using the LFK index [32]. Other appropriate graphs, including forest plots and bubble plots, were made.

Results

Screening Process & Eligible Studies

The multiple database searches yielded a total of 1246 studies, among which 134 duplicates were identified and removed. Among the 1112 records screened for title-abstract, 30 were found eligible for full-text review. In the full-text review of the articles, seven articles were excluded due to the non-availability of full-text, and five were excluded due to the wrong population. Finally, 18 studies were included in the systematic review [18,22,33–48], and 17 studies were included in the meta-analysis [18,22,33–43,45–48]. The overall process and results of each stage of screening and eligibility are depicted in Figure 1.

Characteristics of the Eligible Studies

The studies included were undertaken between 2009 and 2022 in countries across the world. The majority of studies were from the USA (8, 44.4%), while three studies were from Canada and one study each from Namibia, Thailand, Poland, India, North African countries, Sweden, and China. The sample size included in the studies ranged from 64 to 58,784,013 [Table 1]. There was high heterogeneity between included studies, which is inferred from the I^2 (100%) [Figure 2a].

Table 1. Basic characteristics of the studies included for analysis (K=18)

S. no.	Author	Year of publication	Study design	Country	Events	Sample size
1	Lopez et.al	2022	Cohort	U.S.A	75	6120
2	Marschner et.al	2022	Cohort	U.S.A	82	74510
3	Nivatpumin et.al	2021	Cohort	Thailand	23	89368
4	Pfaller et.al	2020	Cohort	Canada	3	335
5	Köcher et.al	2020	Cohort	Sweden	0	6812
6	Dongarwar et.al	2020	Cross sectional	U.S.A	117568	58784013
7	Pierce-Williams et.al	2020	Cohort	U.S.A	1	64
8	Easter et.al	2020	Cohort	U.S.A	1	276
9	Balki et.al	2017	Cohort	Canada	286	3568597
10	Grotegut et.al	2014	Cohort	U.S.A	853	12628746
11	Li et.al	2009	Cohort	U.S.A	8	136422
12	Lipczynska et al.	2021	Cohort	Poland	1	140
13	Kumar et al.	2020	Cohort	India	1	205
14	Ballali et al.	2018	Cohort	North Africa	3	80
15	Lima et al.	2016	Cohort	U.S.A	501	7850381
16	Liu et al.	2012	Cohort	China	2	1741
17	Balint et al.	2010	Cohort	Canada	1	318
18	Heemelaar et al.	2022	Cohort	Namibia	1	65

Quality Assessment

The quality assessment of studies eligible for meta-analysis revealed that 14 studies were either good or fair quality, while three were poor [Table S4] [35,36,40].

Pooled Prevalence of the Cardiac Arrest Among Pregnant Women

There were 83,141,381 pregnant women included in the meta-analysis, among whom 119,410 events of cardiac arrest were reported. The prevalence of cardiac arrest varied from 0.005% to 1.56%. The pooled prevalence of cardiac arrest was estimated to be 0.12% (95% CI 0.05-0.30). The PI ranged from <0.001 to 8.83% [Figure 2a]. A sensitivity analysis undertaken by excluding the poor-quality studies revealed a slightly lower prevalence of cardiac arrest [0.08% (95% CI 0.03-0.19)] [Figure 2b]. The PI was <0.001-5.03%. However, the heterogeneity remained high (I^2=100%).

Outliers and Sensitivity Analysis

Baujat Plot and influence diagnostics revealed no outliers [Figures S1 and S2]. Leave-one-out analysis also revealed no significant changes in the pooled prevalence of cardiac arrest and the heterogeneity between the studies [Figure S3].

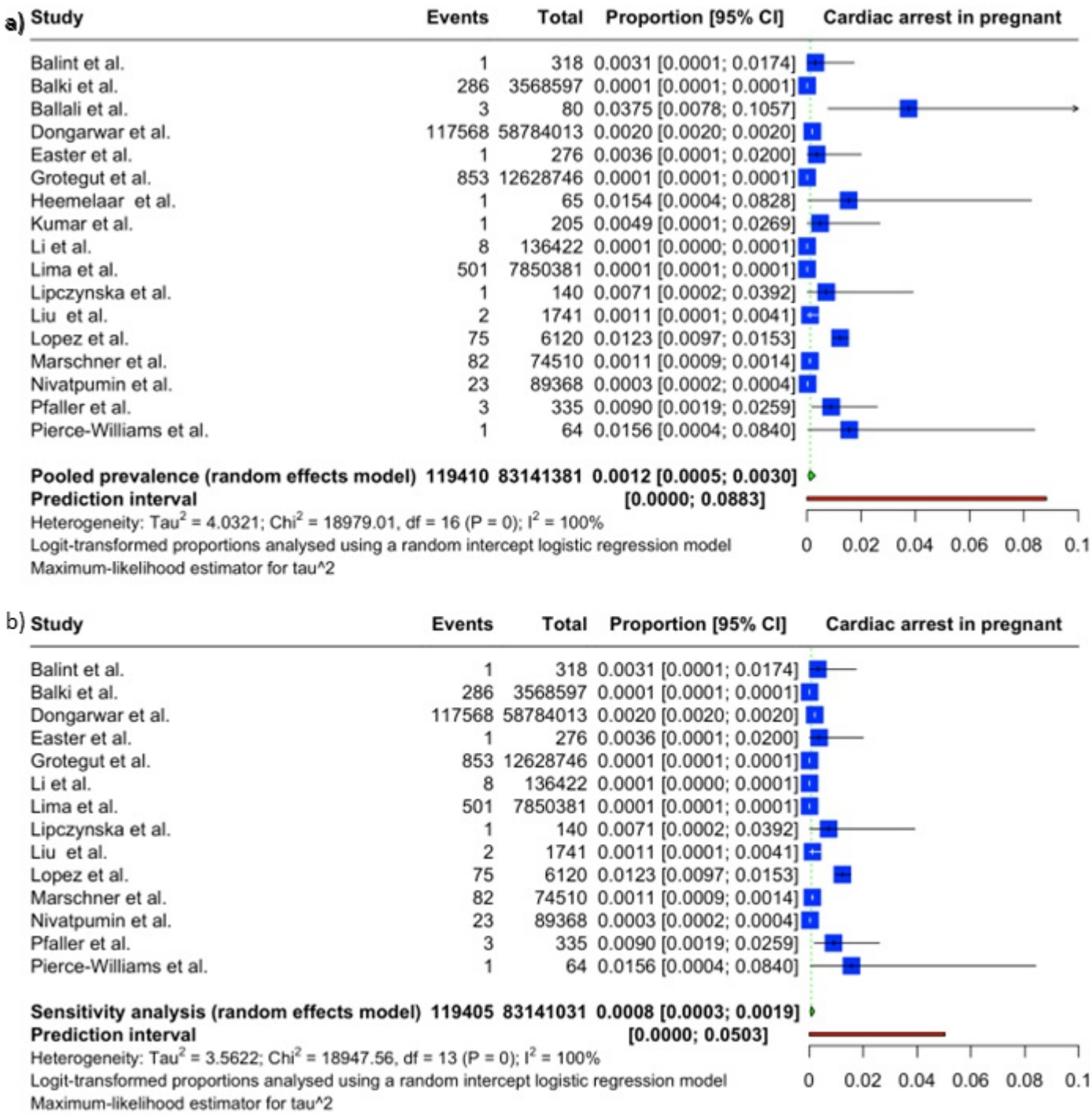

Figure 2. Forest Plots showing overall effect size of the a) proportion of cardiac arrest during pregnancy; b) proportion of cardiac arrest during pregnancy after excluding poor-quality studies

Exploring the Heterogeneity-Meta-regression and Sub-group Analysis

Meta-regression revealed that the sample size of the study did not have any significant impact on the outcome (cardiac arrest) (beta=0, p=0.631) [Figure 3a]. However, the bubble plot between the year of study and the prevalence of cardiac arrest showed a significant association (beta=0.273, p=0.014), indicating an increase in the prevalence of cardiac arrest over the period [Figure 3b]. Sub-group analysis according to geography did not reduce the heterogeneity. However, it revealed a significant difference in the prevalence of cardiac arrest across the continents. Studies from Asia reported the highest cardiac arrest prevalence among pregnant women [2.76% (95% CI 1.04-7.12], while studies from Africa reported the least [0.05% (95% CI 0.01-0.28]. Studies from North America reported a prevalence of 0.08 (95% CI 0.03-0.22) [Table 2].

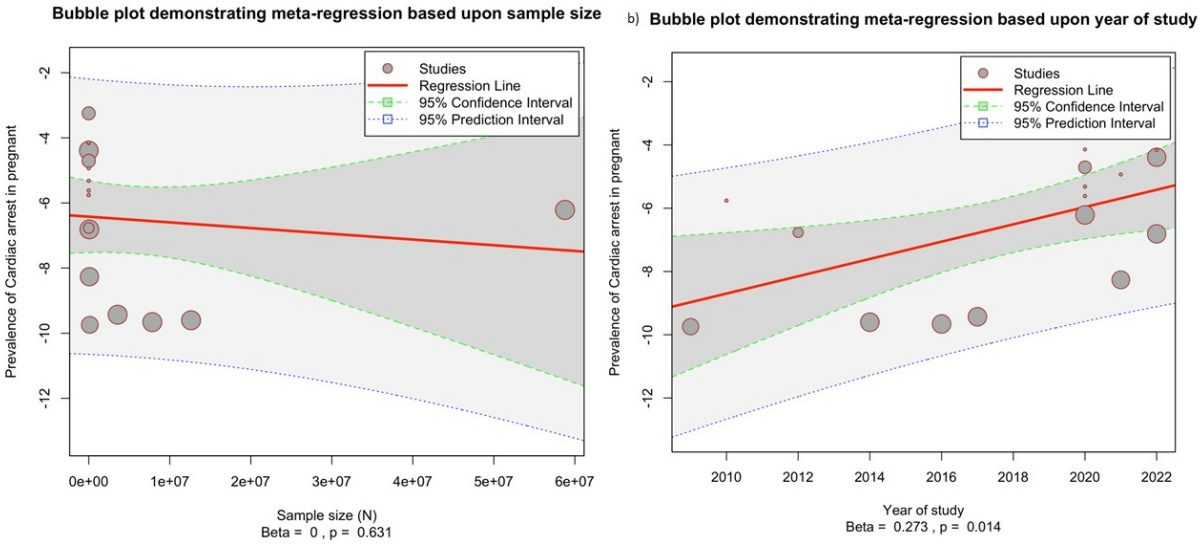

Figure 3. Bubble plot showing meta-regression analysis of effects of a) sample size on proportion of cardiac arrest during pregnancy b) year of study on prevalence of cardiac arrest during pregnancy

Table 2. Subgroup analysis for cardiac arrest among pregnant women based on geography (continents)

Subgrouping variable	Number of studies	Pooled estimate	Confidence interval	I2	p - value
Continent					
North America	11	0.08	0.03–0.22	99.9%	p < 0.01
Asia	3	2.76	1.04–7.12	83.0%	
Africa	2	0.05	0.01–0.28	0%	
Europe	1	0.71	0.10–4.89	-	

Publication bias

Assessment of publication bias revealed an asymmetrical Doi plot [Figure 4]. The LFK index was 1.41, indicating a publication bias towards studies reporting a higher prevalence of cardiac arrest.

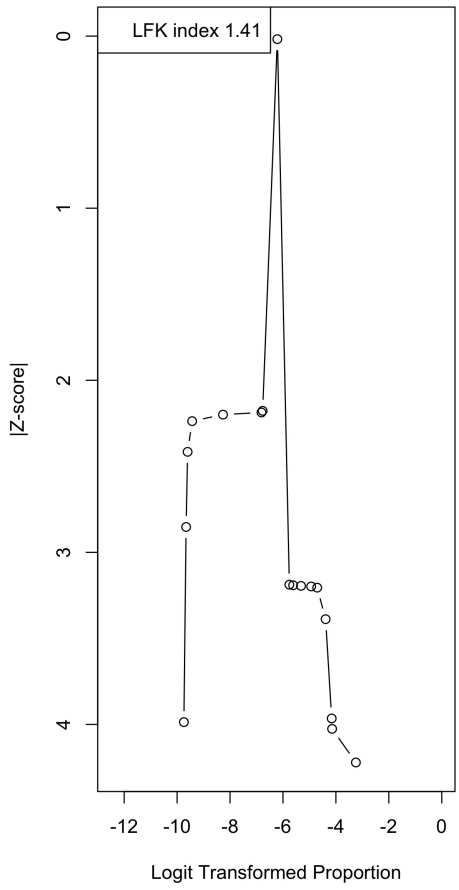

Figure 4. Doi plot for assessment of publication bias

Discussion

In the index meta-analysis, 17 studies were included, in which 119,410 events of cardiac arrest were reported among 83,141,381 pregnant women. Our result shows a high prevalence of cardiac arrest during pregnancy, with a pooled prevalence of 0.08% (95% CI 0.03-0.19). This reflects the fact that the risk of maternal morbidity due to cardiac arrest is high in pregnant women. The number of high-risk pregnancies and the frequency of serious pregnancy problems, including cardiac arrest, are both on the rise [49–51]. The current analysis shows that the prevalence of cardiac arrest has significantly increased over the period. This is similar to a previous study in which changes in characteristics of delivery and postpartum hospitalisations with chronic heart disease from 1995 to 2006 were described [50]. The odds ratios for cardiac arrest complications were 35.7 in 1995–1997, which increased to 82.3 in 2004–2005 for deliveries hospitalised with a chronic heart disease compared to deliveries hospitalised without a chronic heart disease [50]. In a recent study, approximately one in 9,000 women experienced a cardiac arrest during labour and delivery from 2017 to 2019, compared to one in 12,000 from 1998 to 2011 [21]. This suggests that cardiac arrest during labour and delivery has become increasingly frequent in recent years. On the other hand, the overall survival rate increased over time, going from 58.9% after a cardiac arrest during childbirth in a hospital between 1998 and 2011 to 68.6% in the period from 2017 to 2019 [21]. This improvement in the survival rate could be attributed to the advancements in the management of cardiac arrest in pregnancy over the period. In a different study, cardiac arrest accounted for 16.3% of all sudden maternal deaths, while the overall maternal mortality ratio was 1.7 per 100,000 live births [52]. Similar to this, 6.3 cardiac arrests during pregnancy or right after delivery per 100,000 births (1:16 000) and 2.8 cardiac arrests during pregnancy (1:36 000) per 100,000 natalities were recorded in a study, with nearly 60% of the women surviving [19].

The cardiovascular-related outcomes, including cardiac arrest during pregnancy, can occur as a result of a number of medical disorders that either existed prior to pregnancy or developed during pregnancy. The present meta-analysis examined studies involving both pregnant women with and without comorbid conditions. Obstetric causes of cardiac arrest include haemorrhage, pregnancy-induced hypertension, peripartum cardiomyopathy, anaesthesia complications, and amniotic fluid embolism, while non-obstetric causes include pulmonary embolism, sepsis, stroke, myocardial infarction and trauma [17,49,53,54]. A study from India revealed that serious maternal problems and mortality are substantially related to hypertensive disorders of pregnancy, particularly pre-eclampsia and eclampsia [35]. Another study discovered a high maternal mortality rate after cardiac arrests during hospitalisation for birth, and the most common reasons for arrests were hypertension during pregnancy and cardiovascular problems (30.4% and 21.7%, respectively). Maternal fatalities in peripartum cardiac arrests occurred in 20 of 23 cases, accounting for 86.9% of deliveries [22].

The subgroup analysis revealed a significant difference in the prevalence of cardiac arrest across the continents. Studies from Asia reported the highest cardiac arrest prevalence among pregnant women [2.76% (95% CI 1.04-7.12]. The high occurrence of cardiac arrest in Asian countries in this study could be explained by the high maternal mortality ratio in Southern Asia countries, which account for approximately 87% (along with Sub-Saharan Africa) of the expected global maternal fatalities in 2020 [55]. Maternal mortality is notably high in three countries outside of Sub-Saharan Africa: Afghanistan, Yemen, and Haiti. These high-maternal-mortality locations and countries are also known to have a high prevalence of peripartum cardiomyopathy [56], which can relate to the high prevalence of cardiac arrest cases in Asian countries. However, studies from North America reported a prevalence of 0.08 (95% CI 0.03-0.22). Maternal mortality is significantly higher in developing countries than in developed countries [57]. An earlier study discovered a significant relationship between the maternal mortality ratio and socioeconomic characteristics, healthcare system-related factors, morbidity burden, and their complex relationships [58].

Limitations

The findings of the index meta-analysis should be interpreted with caution due to the presence of publication bias towards research reporting a higher rate of cardiac arrest. The inherent limitations of both the original studies included in the review must also be taken into consideration. Only three databases (PubMed, Cochrane, and Embase) could be included in the SRMA index due to resource limitations (accessibility concerns).

Conclusion

The study concludes that the prevalence of cardiac arrest is high in pregnant women. The prevalence of cardiac arrest has increased over the period, and a spatial variation also exists between the continents. Maternal mortality is a cause of concern, especially in African and Asian countries. Thus, policies and initiatives to improve maternal health and lower maternal mortality, particularly in Asian nations, must focus on the determinants of cardiac arrest among pregnant women, such as population dynamics, socioeconomic influence, and healthcare system characteristics that pose a substantial risk to mothers.

Supporting information

None

Ethical Considerations

None

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Author contribution statement

Shashi B Singh: Conceptualization (Equal); Data Curation (Equal); Methodology; Writing- Original Draft Preparation (Equal). **P Aparnavi:** Conceptualization (Equal); Data Curation (Equal); Methodology; Writing- Original Draft Preparation (Equal). **Geetu Singh:** Data Curation (equal); Formal Analysis (supporting); Project Administration (lead); Writing- Review & Editing (lead). **Dewesh Kumar:** Data Curation (supporting); Formal Analysis (supporting); Writing- Review & Editing (supporting). **Asha Kiran:** Data Curation (supporting); Formal Analysis (supporting); Writing- Review & Editing (supporting). **Nisha Kumari:** Data Curation (supporting); Formal Analysis(supporting); Validation (lead); Writing- Review & Editing (supporting). **Pravin Yannawar:** Data Curation (supporting); Formal Analysis (supporting); Writing- Review & Editing (supporting). **Sandip Kumar:** Data Curation (supporting); Formal Analysis (supporting); Writing- Review & Editing (supporting). **Arvind Kumar:** Data Curation (supporting); Formal Analysis (supporting); Writing- Review & Editing (supporting). **Nitika Keshri:** Data Curation (supporting); Formal Analysis (supporting); Writing- Review & Editing (supporting).

Data availability statement
Data included in article/supp. material/referenced in article.

Additional information
No additional information is available for this paper.

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary Figures

Figure S1: Baujat Plot

Figure S2: Influence diagnostics

Figure S3: Leave-One-Out Meta-Analysis Results

Figure S4-S8: Graphic Display of Heterogeneity (GOSH) Plots Analysis

Supplementary Tables

Table S1. PRISMA (2020) checklist

Table S2. Inclusion and exclusion criteria

Table S3. Adjusted search terms as per searched electronic databases [as of 07.04.2023]

Table S4. Risk of bias assessment of included studies with the use of National Heart, Lung and Blood Institute quality assessment tool.

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