Article published online: 2026-05-29

Original Article

Preventability of Severe Maternal Morbidity: A Scoping Review of the Literature in High-Income Countries

Yira N. Alfonso[1], Qingfeng Li[1], Porcia Manandhar[1], Andreea A. Creanga[1,2]

Affiliation addresses are listed at the end of the article.

ABSTRACT

Objective Severe maternal morbidity (SMM) affects 0.5 to 4% of pregnancies in the United States and other high-income countries (HIC). Research examining SMM preventability is limited but has emerged following recommendations from professional organizations to identify and review SMM events, determine preventability, and derive recommendations for care improvement. This study examined existing evidence on SMM preventability in HICs, synthesizing definitions, assessment approaches, and preventability rates.

Study Design A scoping literature review was conducted using the Joanna Briggs Institute methodology and Preferred Reporting Items for Systematic Reviews Extension for Scoping Reviews guidelines. Four databases (PubMed, Embase, Scopus, and Cochrane) were searched from January 2011 to June 2024 using terms related to SMM and preventability. Eligible studies reported SMM preventability estimates in HICs. Two reviewers independently screened articles and extracted data. Content analysis assessed methodological patterns, and narrative synthesis identified conceptual frameworks.

Results Of the 1,835 studies identified, 53 underwent full-text review, and 19 studies met inclusion criteria, primarily from the United States (52.6%) and New Zealand (26.3%). Studies showed diverse assessment approaches, with 47.4% using Geller-based frameworks, and three distinct classification methods. SMM preventability ranged from 21 to 76% (weighted average: 47.9%) for events deemed preventable, potentially preventable, or where care improvements were identified. Preventability rates varied by primary cause, being highest for sepsis (25–68%, average: 57.1%), followed by hemorrhage (22–72%, average: 45.2%), hypertensive disorders (22–73%, average: 43.6%), and cardiovascular events (13–49%, average: 38.9%). Across four studies, external reviews consistently identified higher SMM preventability rates than internal facility reviews.

Conclusion This review revealed substantial methodological heterogeneity in SMM preventability assessment across HICs, with up to three-quarters of events having improvement opportunities. Despite variation, most studies identified substantial preventability, demonstrating the feasibility and value of conducting SMM preventability reviews. Standardized definitions and review processes are needed to enhance cross-study comparisons and establish evidence-based improvement targets.

Keywords severe maternal morbidity, maternal near miss, preventability assessments, high-income countries

received September 04, 2025 | **accepted after revision** May 11, 2026 | **article published online** May 29, 2026

Bibliography Am J Perinatol 2026; 43: 2127–2140 **DOI** 10.1055/a-2874-8557 **Art ID** AJP-25-Sep-0536

© 2026. The Author(s). Thieme Medical Publishers, Inc., 333 Seventh Avenue, 18th Floor, New York, NY 10001, USA

Correspondence Yira N. Alfonso, PhD, Department of International Health, Johns Hopkins Bloomberg School of Public Health, 615 North Wolfe Street, Baltimore, Maryland 21205-2103, United States, Email: ynalfonso@jhu.edu

Introduction

Severe Maternal Morbidity: Definition and Global Approaches for Assessment

Women who experience but survive life-threatening conditions during pregnancy, childbirth, and the postpartum period are considered to have severe maternal morbidity (SMM, per Centers for Disease Control and Prevention) or maternal near miss (MNM, per World Health Organization, WHO) events.[1–3] Although these two terms are often used interchangeably in literature, this review uses SMM throughout for consistency. These conditions are important yet understudied in high-income countries (HIC). WHO defines SMM as "a woman who nearly died but survived a complication that occurred during pregnancy, childbirth, or within 42 days of termination of pregnancy."[1,4] While the WHO framework established organ dysfunction-based criteria for SMM identification,[5] HICs have developed diverse approaches that reflect different healthcare systems and data availability.[6] These approaches range from deriving composite indicators using administrative data to clinical consensus definitions, incorporating organ dysfunction (e.g., cardiovascular, renal, neurological, etc.), diagnostic (eclampsia, severe

Key Points

- SMM preventability assessments lack standardization.
- A wide range (21–76%) of SMM events are preventable.
- Higher SMM preventability with external versus internal facility reviews.

preeclampsia, stroke, etc.), or interventional (i.e., admission to intensive care unit [ICU]) criteria.[6]

The United States employs 21 International Classification of Diseases (ICD)-based indicators for population-based surveillance and a simplified two-factor screening (ICU admission or ≥4 units of blood transfusion) for facility-based surveillance.[7–11] In Europe, approaches include EURO-PERISTAT's 5-indicator[12] and France's EPIMOMS 17-indicator[13] definitions. Australia developed a composite 18-indicator, while the United Kingdom Confidential Enquiries into Maternal Morbidities employs condition-specific surveillance systems that focus on a different near-miss condition annually based on open topic proposals,[14,15] and New Zealand uses ICU/high dependency unit (HDU) admission-based screening with the world's first national SMM preventability review system. The International Network of Obstetric Surveillance Systems developed clinical consensus definitions for eight specific severe morbidity conditions.[16] These approaches share common elements like ICU admission and organ dysfunction criteria but vary in the number of indicators (1–25) and data sources (administrative data and ICD codes vs. medical records and clinical criteria).

Severe Maternal Morbidity Burden and Trends

SMM rates vary across HICs, with systematic reviews documenting ranges between 0.0 to 1.8%[6] and 0.5 to 4%[17] of pregnancies, and substantial variation depending on the definitions and inclusion criteria employed.[18] Reported SMM rates are higher in countries like Canada (1.7% in 2019)[17,19] and the United States (4% in 2013–2017 when including blood transfusion indicators)[17,20] than in Australia (0.5% in 2015)[17] or France (1.4% in 2012–2013).[21]

Despite advances in medical technologies and healthcare delivery, SMM rates are rising in some HICs.[22] In the United States, SMM increased from 69.9 to 79.7 per 10,000 delivery hospitalizations between 2012 and 2019 (a 14.7% increase),[23] with substantial variation by state (52.5–111.3 per 10,000 in 2019).[23] Analyses that include blood transfusion indicators show a continued upward trend, with rates increasing from 160.1 to 206.1 per 10,000 delivery hospitalizations between 2014 and 2021 (a 28.7% increase).[22] Risk factors include advanced maternal age, minority race or ethnicity, healthcare insurance status and type, socioeconomic status, violence, trauma, psychological stress, rural or urban location, environment, as well as cesarean delivery, presence of comorbidities, healthcare access and use.[22,24]

Common primary causes of SMM in HICs include obstetric hemorrhage and hypertensive disorders such as preeclampsia/eclampsia.[25] In the United States, the most frequent primary causes are hemorrhage (47.6%), followed by hypertensive complications (20.5%), and acute cardiopulmonary complications (19%).[3] In Europe, primary causes with data available include eclampsia among 16 countries (0.02–0.16% of births), hysterectomy for postpartum hemorrhage among 15 countries (0.01–0.10% of births), and blood transfusion among 10 countries (0.01–1.15% of births).[26]

Preventability and Evidence for Quality Improvement

The increasing rates of SMM can be addressed. SMM appears to be associated with high preventability, with evidence from international syntheses and national and subnational review programs identifying preventable events across high-income settings,[6,27–29] similar to maternal mortality[30] given shared risk factors.[31] As such, SMM can serve as a quality improvement indicator for maternal health systems, providing opportunities to identify gaps in care and implement targeted interventions. A recent review of evidence from Maternal Mortality Review Committees (MMRC) across multiple U.S. states and cities found that most pregnancy-related and pregnancy-associated deaths were preventable.[30] Recognizing this preventability, professional organizations, including the CDC, American College of Obstetricians and Gynecologists (ACOG), and Society for Maternal-Fetal Medicine (SMFM), recommend that birthing facilities routinely identify and review SMM events, determine preventability, and implement targeted practice changes to prevent recurrence.[11,32,33]

Current Evidence and Knowledge Gaps

Multiple HICs have initiated SMM preventability reviews.[6] CDC, ACOG, and SMFM developed recommendations for facility-level multidisciplinary reviews[32–34] using a validated two-factor scoring system,[10] implemented in California (United States) facilities[35] and in a statewide review in Illinois (United States).[36] New Zealand adapted the Illinois (United States) model, finding 34% of ICU cases potentially preventable.[37] The UK expanded its Confidential Enquiry into Maternal Deaths to include SMM reviews by shifting its focus to different conditions over time, such as uterine rupture and eclampsia.[14] Scotland's Scottish Confidential Audit of Severe Maternal Morbidity conducted national surveillance from 2003 to 2012, demonstrating specific areas of quality of care improvements following reviews of SMM events.[6] The Netherlands' review of 67 cases between 2005 and 2008 identified substandard care in 74.6% of cases.[38] SMM reviews in all these countries consistently found provider-related factors, particularly diagnostic and treatment delays, as the most common preventable contributors.[6]

Despite growing recognition of SMM preventability, significant knowledge gaps persist. Reported preventability rates vary dramatically, and no study has comprehensively synthesized the emerging evidence on SMM preventability. This scoping literature review addresses these knowledge gaps by examining SMM preventability evidence in HICs. The specific aims of this study are to: (1) synthesize definitions, identification approaches, and assessment methodologies used to evaluate SMM preventability across HICs; and (2) determine variability in SMM preventability rates overall and by the main primary causes (i.e., hemorrhage, hypertensive disorders, cardiovascular events, sepsis). By examining these aspects across different settings and SMM review types, this study provides a comprehensive and contemporary review of

© 2026. The Author(s).

knowledge regarding SMM preventability in HICs and highlights gaps for future research and recommendations for quality improvement initiatives.

Materials and Methods

Scoping Review Overview

This scoping review was conducted in accordance with the Joanna Briggs Institute methodological frameworks for scoping reviews and the Preferred Reporting Items for Systematic Reviews Extension for Scoping Reviews (PRISMA-ScR) reporting standards.[39–42] A scoping review approach was chosen to provide an overview of the extent and type of data sources and research available in HIC, including methodological aspects and key findings on SMM preventability. A nonregistered study protocol was developed a priori, revised, and agreed upon by all study authors.

Eligibility Criteria

Studies were included if they: (1) were published between January 2011 (i.e., a full year after the publication of maternal near-miss criteria by WHO) and June 2024; (2) represented original research in peer-reviewed journals or dissertation publications; (3) examined SMM as primary or secondary outcome; (4) employed clearly described methodology for assessing preventability; (5) reported quantitative preventability estimates (percentage, fraction, or rate) of SMM cases or provided sufficient raw data to calculate these; (6) conducted in HICs, defined according to the World Bank 2024 to 2025 income classification as countries with a gross national income per capita of U.S.$14,005 or higher[43]; and (7) published in English or Spanish.

Search Strategy

Searches were conducted in four electronic databases: PubMed, EMBASE, Scopus, and Cochrane. The final search was conducted on June 25, 2024. The search strategy was developed in consultation with a medical librarian and combined three concept areas: SMM and preventability. Medical Subject Headings and keywords were used, including "Near Miss, Healthcare," "Morbidity," "Maternal Health Services," "Prevented," and "preventab." The complete search strategy for PubMed is provided in **Supplementary Appendix Table 1** (available in the online version). This strategy was adapted for three other databases while maintaining conceptual consistency.

Evidence Screening and Study Selection

One reviewer (YNA) screened titles and abstracts, with a second reviewer (AAC) resolving any eligibility questions. At this stage, studies were retained if they met criteria one to three and potentially met criteria four to seven. Two reviewers (YNA and PM) independently assessed full texts, resolving differences through discussion. When agreement could not be reached, AAC made the final decision. A web-based screening tool (Covidence) was used to manage the review process and document decisions.

Data Extraction

A standardized data extraction form was developed as required for scoping review methodology. Given the heterogeneous nature of study reporting formats, this form was used in a data abstraction process to capture key study elements. Two reviewers (YNA and PM) piloted the form with three studies, refining it through discussion. Coauthors (AAC and QL) reviewed and approved the final version of the form. The reviewers divided and independently extracted data, with all extractions cross-checked by a second reviewer. Regular meetings resolved any data abstraction differences. The Covidence platform was used to manage the abstraction process and documentation.[44]

The form collected information on study characteristics (geographic location, publication year, timeframe), SMM definitions and data sources, SMM identification approaches, and review processes. Data were extracted on review settings (single facility vs. regional/multi-hospital reviews), review type (internal vs. external facility committees), and committee composition. Key variables included preventability definitions and assessment methodologies, preventability classification approaches, and quantitative preventability estimates (overall and by primary causes). The extraction form used is included in **Supplementary Appendix Table 2** (available in the online version).

Data Analysis

Content analysis served as the primary analytical approach for assessing methodological patterns and categorizing data elements,[45] with narrative synthesis employed to identify conceptual patterns in SMM review frameworks, definitions, and processes.[39] Frequency analysis quantified methodological approaches for SMM reviews and preventability assessments across different stratifications. A standardized four-category SMM preventability classification framework was derived based on the combination of unique classifications reported by studies: (1) "Preventability" (preventability classifications stating either strong, definitive, or studies reporting "yes" in a single yes/no binary classification type); (2) "Potential/possible preventability" (preventability classifications stating either potentially or possibly preventable); (3) "Not preventable, but opportunity to improve care" (preventability classifications stating that SMM was not preventable, but opportunities to improve care were identified); and (4) "Not preventable, no opportunity to improve care" (preventability classifications stating that SMM was not preventable and no opportunities to improve care were identified). Weighted averages by number of SMM events were calculated using the standard formula: $\sum(rate \times N) / \sum N$ to estimate central tendencies in preventability rates. All analyses adhered to PRISMA-ScR guidelines[40] with consistent stratification by geographic location, review setting, and type to enable comparative assessment. All analyses and figures were done using Microsoft Excel 365.

Results

Characteristics of Included Studies

The search strategy identified 1,837 studies. After removing duplicates and screening titles and abstracts, 53 studies underwent full-text review. Nineteen studies met all inclusion criteria and were included in the review (**Fig. 1**). Primary reasons for

© 2026. The Author(s).

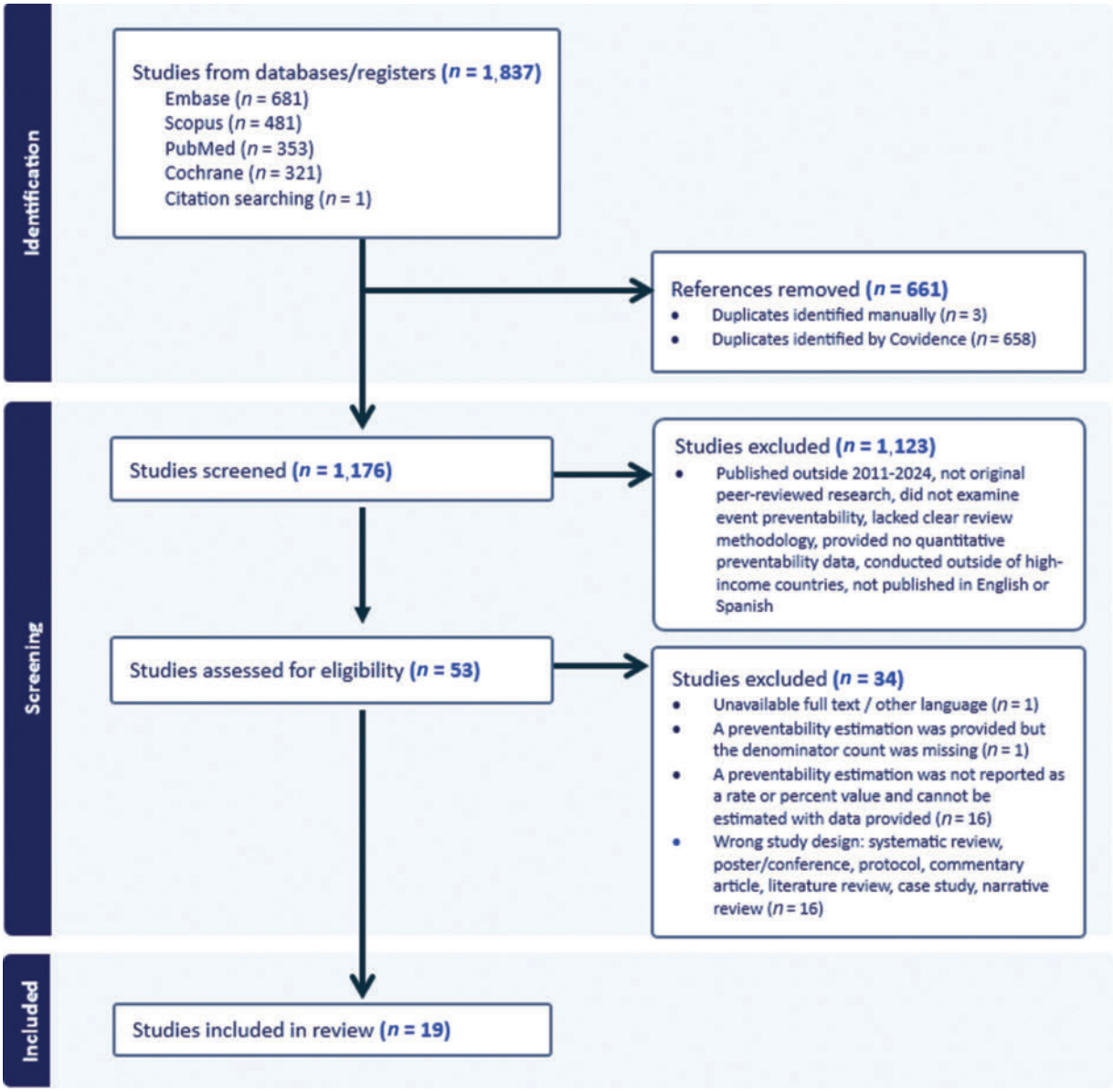


Fig. 1 PRISMA flow diagram.

exclusion after full-text review included inability to calculate preventability rates ($n = 16$) and wrong study type (i.e., conference poster, case study, literature or narrative reviews, and case studies; $n = 16$).

Table 1 presents characteristics of the 19 studies examining SMM preventability.[28,29,35–37,46–59] Most originated from the United States (52.6%, $n = 10$) and New Zealand (26.3%, $n = 5$), with single studies from Canada, Australia, Romania, and Oman. Studies were about equally distributed between single-hospital review (36.8%, $n = 7$), nationwide or statewide reviews (36.8%, $n = 7$), and multi-hospital/regional reviews (26.3%, $n = 5$) such as networks of facilities that did not expand to all birthing centers in a jurisdiction, including studies in Illinois (United States),[46,48] New Zealand,[37] Toronto/Vancouver regions,[55] and Maryland (United States).[57] All national reviews were in New Zealand and Oman, and both statewide reviews were from Illinois (United States).[29,36] Six studies (31.6%) conducted multiple review exercises within the same study (totaling 27 review exercises), enabling direct comparison, such as internal versus external reviews of the same cases, pre- and postintervention assessments, reviews across different hospital levels, and comparison with and without SMM events contributed by COVID-19 infection only. Internal review processes predominated (63.2%, $n = 12$), with fewer external reviews (26.3%, $n = 5$) or combined approaches (10.5%, $n = 2$). Out of the 19 studies, 57.9% ($n = 11$) assessed preventability for all SMM events, and 78.9% ($n = 15$) reported preventability by primary cause of SMM. Among the 11 studies assessing all SMM events, 63.6% ($n = 7$) also provided breakdowns by primary cause.

Severe Maternal Morbidity Definitions and Primary Causes

Only five studies provided explicit SMM definitions using varied terminology ("severe maternal morbidity," "severe acute

© 2026. The Author(s).

Table 1 Characteristics of studies included in the scoping review

Publication	Study population					SMM review characteristics		Preventability of SMM assessment				
Citation	Country	Region/ city	Scope of review	Hospital count and type	Reporting period	Internal or external review type	Multiple review types	Includes all potential events	Includes individual primary causes	Primary cause(s)	Number of SMM events reviewed	Include blood transfusions only
DellaTorre et al, 2011[46]	United States	Illinois	Multiple facilities	University of Illinois at Chicago regional perinatal network of 11 hospitals: 5 level III, 2 level II+ (extended neonatal capabilities), 4 level II	01/06–12/06	Internal	(1) Level III hospitals(2) Level II/II+ hospitals	No	Yes	Obstetric hemorrhage	Level III: 45Level II/+: 18	Yes
Nastasia et al, 2011[47]	Romania	NA	Single facility	One tertiary referral obstetrical unit at the Clinical Hospital in Bucharest	01/01–12/08	Internal	Single review	No	Yes	Obstetric hysterectomy	19	NA
Lawton et al, 2014[37]	New Zealand	NA	Multiple facilities	Three urban tertiary centers and one rural tertiary center in 4 out of 20 district health boards (DHB)	03/11–08/12	External	Single review	Yes	Yes	All	98	NA
Ozimek et al, 2016[35]	United States	Los Angeles, California	Single facility	Cedars–Sinai Medical Center, a nonprofit, tertiary, teaching hospital	01/12–06/14	Internal	Single review	Yes	Yes	All	150	Yes
Kominiarek et al, 2017[48]	United States	Illinois	Multiple facilities	Nine hospitals	01/06–12/06; 01/10–12/10	Internal	(1) Preintervention(2) Postintervention	No	Yes	Obstetric hemorrhage	Pre: 63Post: 71	Yes
Lepine et al, 2018[49]	New Zealand	NA	National	All hospitals with an ICU or HDU and cases in New Zealand	08/13–01/15	External	Single review	No	Yes	Sepsis	50	NA
Lawton et al, 2019[28]	New Zealand	NA	National	All intensive care units (ICUs) or high-dependency units (HDUs) with cases in New Zealand	08/13–01/15	External	Single review	Yes	Yes	Sepsis, PE, major blood loss	National: 538Sample: 339	Yes
MacDonald et al, 2019[50]	New Zealand	NA	National	National coverage of hospital obstetric teams across New Zealand's 20 DHBs is funded by the Ministry of Health	08/13–01/15	External	Single review	No	Yes	SMM in cases of PE	89	NA
Ogunyemi et al, 2019[51]	United States	Michigan	Single facility	One academic hospital	01/15–06/17	Internal	Single review	Yes	No	NA	45	Yes
Al Abri, 2020[52]	Oman	NA	National	23 healthcare facilities, both governmental and private, comprising 90.7% of births	10/16–09/17	Both	Levels: (1) Hospital(2) Regional(3) National(4) Int'l	Yes	Yes	All	156	Yes
Jayaratnam et al, 2020[53]	Australia	Far North Queensland	Single facility	Cairns Hospital, the main referral center for complex maternity care in the region	01/13–12/17	Internal	Single review	Yes	No	NA	31	Yes
Lepine et al, 2020[54]	New Zealand	NA	National		08/13–01/15	External	Single review	No	Yes	Hemorrhage	120	Yes

(*Continued*)

© 2026. The Author(s).

Table 1 (*Continued*)

Publication	Study population					SMM review characteristics		Preventability of SMM assessment				
Citation	Country	Region/ city	Scope of review	Hospital count and type	Reporting period	Internal or external review type	Multiple review types	Includes all potential events	Includes individual primary causes	Primary cause(s)	Number of SMM events reviewed	Include blood transfusions only
				All hospitals with an ICU or HDU and cases in New Zealand								
Pfaller et al, 2020[55]	Canada	Toronto and Vancouver	Multiple facilities	Two large tertiary centers.	01/14–12/14	Internal	Single review	No	Yes	Cardiovascular	47	NA
Geller et al, 2021[36]	United States	Illinois	Statewide	All 117 obstetric hospitals in Illinois, each belonging to one of ten perinatal networks	01/18–12/18	Internal	Single review	Yes	Yes	Hemorrhage, PE, eclampsia	408	Yes
Ozimek et al, 2022[56]	United States	California	Single facility	Cedars–Sinai Medical Center, a nonprofit, tertiary, teaching hospital	03/12–09/16	Internal	(1) Preintervention(2) Postintervention	Yes	Yes	All	Pre: 125Post: 129	Yes
Wolfson et al, 2022[57]	United States	Maryland	Multiple facilities	Six birthing hospitals: 1 level IV, 4 level III, and 1 level I, including 25%+ of state births	08/21–12/21	Internal	(1) With COVID-19 only cases (2) Without COVID-19 only cases	Yes	No	NA	With: 192Without: 134	Yes
Ding et al, 2023[58]	United States	Rhode Island	Single facility	One tertiary obstetric teaching hospital with a stand-alone emergency room	01/09–03/20	Internal	Single review	No	Yes	Stroke	15	NA
Garland et al, 2023[29]	United States	Chicago area and Illinois	Statewide	All birthing hospitals in Illinois	01/18–01/21	Both	1) Facility-level2) State-level	Yes	No	NA	81	Yes
Grechukhina et al, 2023[59]	United States	New Haven, Connecticut	Single facility	The Yale–New Haven Hospital (a large academic referral center)	08/15–12/19	Internal	Single review	Yes	Yes	All	156	Yes

Abbreviations: NA, not applicable; PE, preeclampsia.

Alfonso YN et al. 2026; 43: 2127–2140. doi: 10.1055/a-2874-8557

© 2026. The Author(s).

Table 2 Severe maternal morbidity and primary cause definitions

Study	Definition
Lawton et al, 2014[37]	Severe acute maternal morbidity: A very ill pregnant or recently delivered woman who would have died had it not been for luck or good care on her side
Al Abri, 2019[52]	Maternal "near miss": Modified World Health Organization definition of underlying cause of maternal death, i.e., the disease or condition that initiated the morbid chain of events that led to the maternal near miss event
Lawton et al, 2019[28]	Severe maternal morbidity: Centers for Disease Control and Prevention ICD-10 algorithm
Jayaratnam et al, 2020[53]	Maternal "near miss" or severe obstetric morbidity: Very ill pregnant or recently delivered woman who nearly died but survived a complication during pregnancy, childbirth, or within 42 d of termination of pregnancy
Wolfson et al, 2022[57]	Severe maternal morbidity: Potentially life-threatening conditions or complications resulting from labor and delivery that can significantly affect a woman's health

Note: Studies excluded did not provide a definition.

maternal morbidity," "maternal near miss"), primarily citing WHO or CDC sources (Table 2). Four studies provided specific clinical definitions for potentially life-threatening conditions like cardiac events, obstetric hysterectomy, postpartum hemorrhage, and sepsis, incorporating measurable criteria and specialized guidelines (not shown in the table).

Severe Maternal Morbidity Identification Processes

Most studies (78.9%, $n = 15$) used administrative or claims hospital data to identify SMM events, while a few used electronic health record (10.5%, $n = 2$), or did not specify the data source (10.5%, $n = 2$; Table 3). There were five distinct SMM identification approaches used across the 19 studies: two-factor criteria using ICU admission and/or blood transfusion criteria (36.8%, $n = 7$), single-factor criteria based on ICU or HDU admission (21.1%, $n = 4$), condition-specific criteria (21.1%, $n = 4$), ICD codes with additional criteria (10.5%, $n = 2$), and WHO "near-miss" criteria (10.5%, $n = 2$). For primary cause determination, 47.4% ($n = 9$) used formalized criteria (including ICD codes or standardized definitions and abstraction forms), while 42.1% ($n = 8$) relied on review committee judgment without specific guidelines specified. Thirteen studies (68.4%) documented SMM event validation by expert review panels. Studies in the United States primarily used the two-factor criteria (90%, $n = 9$), New Zealand studies exclusively used single-factor systems, and WHO criteria appeared only in non-U.S. settings (e.g., Oman, Australia).

Table 3 Summary of SMM identification approaches ($n = 19$)

Approach characteristics	*n*	%	Description/examples
Data source			
Administrative/claims hospital data	15	78.9	Generated from claims submitted to insurance companies or government payers
Electronic health record (EMR)	2	10.5	Generated and maintained by healthcare providers during patient encounters: include EMR, clinical notes, medical record, and admission database
Other	2	10.5	Not specified
Screening criteria for SMM			
Two-factor criteria	7	36.8	ICU admission and/or blood transfusion thresholds (typically 4+ units)
Single-factor criterion	4	21.1	ICU/HDU admission within 42 d of delivery
Condition-specific criteria	4	21.1	Presence of indicators for specific conditions like stroke, cardiac events, obstetric hysterectomy, or sepsis
ICD codes with additional criteria	2	10.5	ICD-9/10 CDC codes, prolonged length of stay, and hospital readmission within 30 d
WHO's "near-miss" criteria	2	10.5	Clinical, laboratory, and management-based criteria
Identification of the primary cause			
ICD codes or standardized definitions and abstraction forms	9	47.4	Formalized criteria using standardized diagnostic codes or definitions and structured forms to determine primary causes
Committee judgment without clear, specific guidelines	8	42.1	Expert committee determination without documented standardized criteria or guidelines
Not applicable	2	10.5	Studies that did not assess the primary causes of SMM
Used in-depth clinical case reviews by an expert panel to confirm SMM events?			
Yes	13	68.4	Expect panel review to be clearly noted/described

© 2026. The Author(s).

Preventability Assessment Approaches

Table 4 summarizes five key methodological components that emerged from the analysis of preventability assessment approaches: (1) preventability definitions, (2) preventability assessment approaches (e.g., models or tools used), (3) confirmation of preventability assessment, (4) common types of preventability classifications, and (5) the derived categorization of preventability used in this analysis.

The preventability definition proposed by Geller et al[60] "any action or inaction on the part of the healthcare provider, system, or patient that may have caused or contributed to progression to more severe morbidity" was used in 47.4% ($n = 9$) of studies, while 42.1% ($n = 8$) provided no explicit definition and 15.8% ($n = 3$) used other definitions. For identification methodologies, studies cited six different models. The preventability assessment approach proposed by Geller et al[60] and later validated in Geller et al,[10] which identifies specific actions/inactions across provider, system, and patient levels, was most commonly used (47.4%, $n = 9$), followed by the Koch et al model[61] that builds on Geller's framework (10.5%, $n = 2$) by adding additional system-level actions/inactions specific to the study population in Illinois (United States). Four other approaches were each represented in single studies: Leape et al[59] and Vincent et al,[62,63] adapting the Harvard Medical Practice Study methodology; Zaharatos et al[61] and Petersen et al,[64,65] using the maternal mortality review logic model; Knight et al,[66] applying UK Confidential Enquiry methods; and Ozimek et al,[35] employing committee consensus on outcome alterability. Four studies did not specify an approach. The confirmation of preventability categorization for SMM events relied on committee consensus in 26.3% ($n = 5$) of studies and standardized criteria in 15.8% ($n = 3$), while 57.9% ($n = 11$) did not clearly specify their process.

Three common preventability classification approaches emerged: binary (yes/no) assessment (31.6%, $n = 6$); tiered categories (21.1%, $n = 4$)—for example, "strong preventability" and "potential or possible preventability"; and, combined preventability and quality of care improvement assessment (47.4%, $n = 9$)—for example, "not preventable, but opportunity to improve care." The combined approach was used in all New Zealand studies, while all three approaches were used in U.S. studies.

As described in the data analysis section, this study derived a four-category classification of preventability by combining the unique categorizations reported across studies. Half of the studies (47.4%, $n = 9$) reported category one ("preventable"), 68.4% ($n = 13$) reported category two ("potentially or possibly preventable"), 47.4% ($n = 9$) provided category three ("not preventable, but opportunity to improve care"), and all studies (100%, $n = 19$) either reported or provided sufficient data to calculate the events classified as category four ("not preventable, no opportunity to improve care").

Preventability Rates for Overall Severe Maternal Morbidity

Figs. 2 and 3 were created using the four-category classification of preventability derived in this study. Fig. 2 displays SMM preventability rates from 11 studies (comprising 17 distinct review exercises) that assessed preventability for all potential SMM events. The figure shows the considerable variability in how preventability is categorized and reported across studies. Each column represents a different review exercise, with colors designating the distinct preventability categories. Two composite measures facilitate comparison: "preventable, potentially preventable, or care improvement" (categories 1–3) captures all improvement opportunities, while "preventable or potentially preventable" (categories 1–2) represents clear preventability, excluding care improvement only cases. When examining "preventable, potentially preventable, or care improvement," the overall SMM preventability rate for this category yielded a weighted average of 47.9%. This weighted average should be interpreted with caution, given methodological heterogeneity across studies, including variations in SMM definitions, review processes, and preventability assessment frameworks.

External reviews consistently identified higher rates in this category (range: 56–76%) compared with internal reviews (range: 21–71%). This pattern was particularly evident in studies with direct comparisons. Al Abri's international-level review (external) found 57% preventability, while the hospital-level review (internal) found only 21% in the same cases.[52] Similarly, Garland's state-level review (external) identified 74% preventability compared with 56% at the facility level (internal).[29]

Table 4 Summary of preventability assessment approaches ($n = 19$)

Approach characteristics	*n*	%	Description/examples
Preventability definitions and data sources[a]			
Geller et al (2006) and Geller et al (2007)	9	47.4	"Any action or inaction on the part of the healthcare provider, system, or patient that may have caused or contributed to progression to more severe morbidity"
Simpson (2023) and the Agency for Healthcare Research and Quality (AHRQ) Quality Indicators (2003)	1	5.3	Patient safety indicators: "Absence of patient harm due to the process of care" or "freedom from potentially preventable complications, iatrogenic events, accidental injury or illness resulting from the process of care"[46]
Foster et al (2003), Thomas et al (2000a), and Thomas et al (2000b)	1	5.3	Adverse events affecting patients: "Deviations in standard care that could have led to adverse events"[55]

© 2026. The Author(s).

Table 4 (*Continued*)

Approach characteristics	*n*	%	Description/examples
Knight et al (2018)	1	5.3	Lessons learned to inform maternity care from the United Kingdom and Ireland Confidential Enquiries into Maternal Deaths and Morbidity: To assess the quality of care for women with MNM, and "areas for which improvements could be made"[52]
Not specified	8	42.1	NA
Preventability assessment approaches			
Geller et al (2006) and Geller et al (2007)	9	47.4	Validated model identifying actions/inactions across provider, system, and patient levels; Geller et al model adaptations in the New Zealand-specific context[37]
Koch et al (2018)	2	10.5	Builds on the Geller et al[10] model and the Council on Patient Safety in Women's Healthcare SMM Review Form to determine whether the woman had to get as sick as she did[29,36]
Leape et al (1991) and Vincent et al (2001)	1	5.3	Adapted a tool based on the Harvard Medical Practice Study, originally classifying preventability into six categories, to use a simplified approach with two groups: preventable and not preventable[55]
Zaharatos et al (2018) and Petersen et al (2019)	1	5.3	Adopted a systematic approach based on the Building U.S. Capacity to Review and Prevent Maternal Deaths logic model, classifying events as preventable only if the committee determines that there was some chance of the event being averted by one or more reasonable changes to patient, community, provider, health facility, and/or system factors. A conservative approach was also adopted, where an event was considered preventable only if a specific preventable element was documented in the electronic medical records, without assuming preventability based on probability[58]
Knight et al (2018)	1	5.3	Quality of care assessment with multi-level reviews using the classification used followed the UK Confidential Enquiry into Severe Maternal Morbidity[52]
Ozimek et al (2016)	1	5.3	Self-referential method based on the opportunity to alter outcomes, as determined by committee consensus[56]
Not specified	4	21.1	NA
Confirmation of the preventability assessment			
Committee consensus	5	26.3	Multidisciplinary review committees use discussion to reach a consensus
Standardized review criteria	3	15.8	Expert panels apply specific criteria to evaluate preventability
Not specified	11	57.9	NA
Common preventability classifications			
Binary (yes/no) preventable event	6	31.6	"Preventable" vs. "Not preventable" without addressing care quality
Tiered classification	4	21.1	Multiple levels indicating degrees of confidence about preventability, such as "Not likely preventable" to "Likely preventable"
Combinations of preventability and quality of care assessment classifications	9	47.4	"(Potentially) preventable" vs. "Not preventable, but care improvement identified" incorporating potential to improve care quality
Derived categorization of preventability used in this analysis[a]			
Category 1: Preventable	9	47.4	Determinations, including strong, definitive, or binary (yes/no) preventable events
Category 2: Potentially or possibly preventable	13	68.4	Determinations stating potentially or possibly preventable events
Category 3: Not preventable, but an opportunity to improve care	9	47.4	Determination stating not preventable events, but for which care improvements are identified
Category 4: Not preventable, no opportunity to improve care	19	100.0	Determination stating not preventable events for which care improvements are not identified

[a]Values are not mutually exclusive. Percentages may not sum to 100% due to rounding.

© 2026. The Author(s).

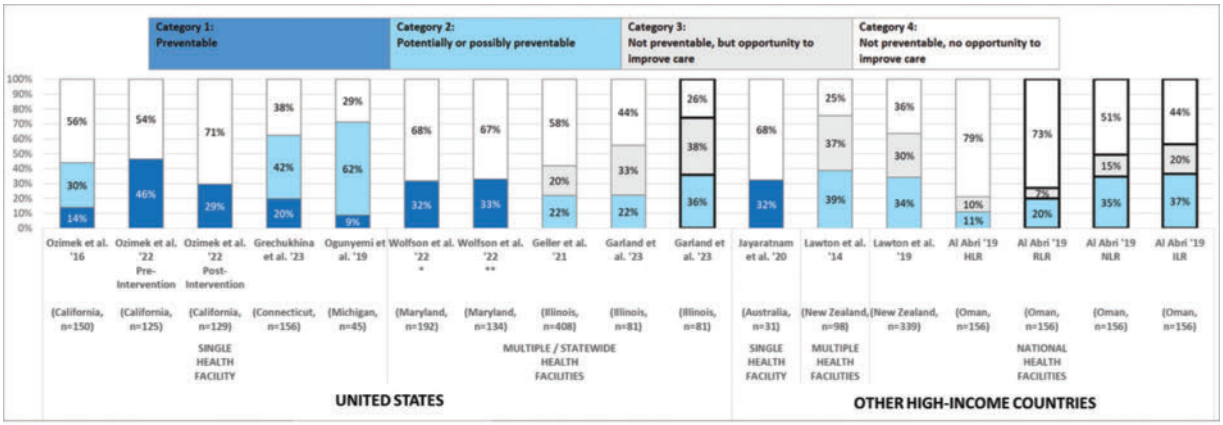


Fig. 2 Overall preventability rates by preventability categories, review type, and country based on the determination of SMM review committees. Notes: This figure presents estimates for each of the four preventability categories from studies that assessed all potential SMM events rather than only specific subsets or primary causes. Some studies present results from multiple reviews; thus, each bar depicts data for one review type. Bars with thick black borders indicate an external review process; thin gray borders indicate an internal review process; *indicates the study included COVID-19 only cases; **indicates the study excluded COVID-19 only cases.

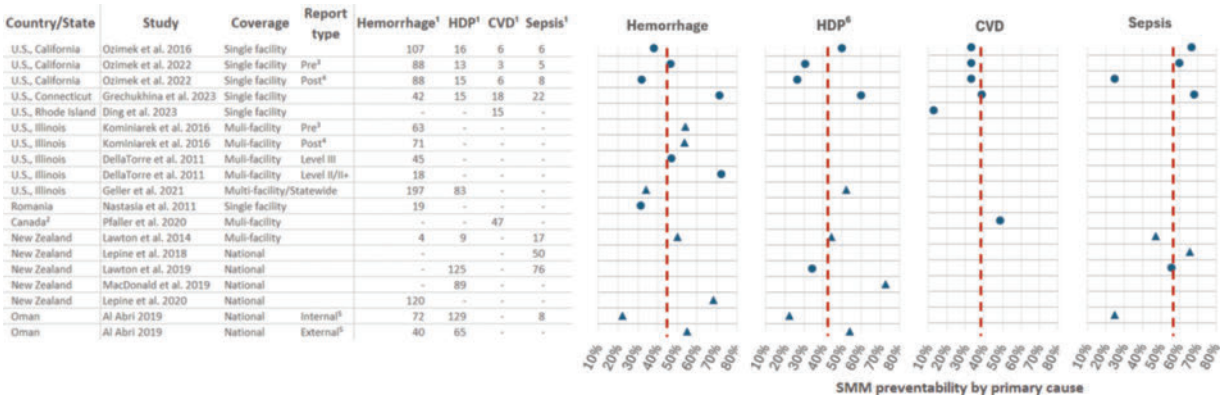
For the more conservative "preventable or potentially preventable" SMM preventability category (i.e., after excluding both Ogunyemi et al[46] and Grechukhina et al[55]), overall rates showed a weighted average of 30.6%, with a 22 to 46% rate range in U.S. studies and 11 to 39% in other HICs. Again, external reviews generally identified higher preventability rates (range: 36–39%) than internal reviews (range: 11–46%), except for Ozimek's preintervention assessment.

Preventability Rates by Primary Cause

Fig. 3 shows preventability rates by primary cause across 15 studies comprising 19 different review exercises. Preventability rates varied substantially by primary cause. Sepsis-related SMM showed the highest overall preventability with a weighted average of 57.1% (range: 25–68%), followed by SMM from obstetric hemorrhage at 45.2% (range: 22–72%) and hypertensive disorders at 43.6% (range: 22–73%); cardiovascular events demonstrated the lowest preventability at 38.9% (range: 13–49%). Consistent with overall SMM findings, external reviews identified higher preventability rates than internal reviews, as exemplified by Al Abri[52] reporting 55% versus 22% preventability for hemorrhage SMM.

Discussion

This scoping review synthesized SMM preventability evidence across HICs, revealing substantial methodological heterogeneity.



Country/State	Study	Coverage	Report type	Hemorrhage[1]	HDP[1]	CVD[1]	Sepsis[1]
U.S., California	Ozimek et al. 2016	Single facility		107	16	6	6
U.S., California	Ozimek et al. 2022	Single facility	Pre[3]	88	13	3	5
U.S., California	Ozimek et al. 2022	Single facility	Post[4]	88	15	6	8
U.S., Connecticut	Grechukhina et al. 2023	Single facility		42	15	18	22
U.S., Rhode Island	Ding et al. 2023	Single facility		-	-	15	-
U.S., Illinois	Kominiarek et al. 2016	Muli-facility	Pre[3]	63	-	-	-
U.S., Illinois	Kominiarek et al. 2016	Muli-facility	Post[4]	71	-	-	-
U.S., Illinois	DellaTorre et al. 2011	Muli-facility	Level III	45	-	-	-
U.S., Illinois	DellaTorre et al. 2011	Muli-facility	Level II/II+	18	-	-	-
U.S., Illinois	Geller et al. 2021	Multi-facility/Statewide		197	83	-	-
Romania	Nastasia et al. 2011	Single facility		19	-	-	-
Canada[2]	Pfaller et al. 2020	Muli-facility		-	-	47	-
New Zealand	Lawton et al. 2014	Muli-facility		4	9	-	17
New Zealand	Lepine et al. 2018	National		-		-	50
New Zealand	Lawton et al. 2019	National		-	125	-	76
New Zealand	MacDonald et al. 2019	National		-	89	-	-
New Zealand	Lepine et al. 2020	National		120	-	-	-
Oman	Al Abri 2019	National	Internal[5]	72	129	-	8
Oman	Al Abri 2019	National	External[5]	40	65	-	-

Fig. 3 Preventability of SMM by primary cause and country. Notes: This figure presents preventability rates for SMM by primary cause. Data point shapes indicate the type of preventability classification included: ● circular points = categories 1 and 2 (i.e., definitely preventable or potentially/possibly preventable events); ▲ triangular points = categories 1 to 3 (i.e., care improvement identified in conjunction with events that are either definitely preventable, potentially/possibly preventable, or not preventable but with identified opportunity to improve care). Red dashed vertical lines indicate the preventability weighted average for each primary cause: Obstetric hemorrhage 45.2%, hypertensive disorder of pregnancy 43.6%, cardiovascular condition 38.9%, and infection (non-COVID) 57.1%.[1] Number of cases by primary cause.[2] Data from Toronto and Vancouver[3]; preintervention[4]; postintervention[5]; review level[6]; hypertensive disorders as defined by the various authors: preeclampsia/eclampsia,[28,35,36,50,56] hypertensive disorder,[59] hypertensive disorders of pregnancy,[52] and uncontrolled hypertension.[37] CVD, cardiovascular condition; HDP, hypertensive disorder of pregnancy; SMM, severe maternal morbidity.

© 2026. The Author(s).

When including all improvement opportunities ("preventable, potentially preventable, or care improvement"), rates ranged from 21 to 76% (weighted average: 47.9%), while more conservative ("preventable or potentially preventable") estimates excluding care improvement opportunities ranged from 11 to 46% (weighted average: 30.6%). These ranges—spanning over 50 percentage points for all improvement opportunities and 35 percentage points for preventable events—reflect the methodological diversity across studies. Despite these varying estimates that limit direct cross-study comparisons, the findings demonstrate significant preventability opportunities across all studies. Standardizing definitions and assessment methods will facilitate pattern identification and support the development of evidence-based quality improvement targets from SMM reviews.

Principal Findings

Evidence concentration in the United States (52.6%) and New Zealand (26.3%), with predominantly internal review processes (63.2%), highlights gaps in SMM preventability assessment in HICs. This geographic limitation suggests most of these countries lack systematic SMM preventability assessments despite international recognition of SMM as a maternal health quality indicator. New Zealand's systematic approach to implementing national surveillance for SMM demonstrates successful implementation in different countries and at the national level.

SMM identification approaches varied systematically by country, being based on diverse screening methods—from administrative codes to clinical criteria—which may capture different patient populations, limiting cross-national preventability comparisons. Such methodological variability reveals important standardization gaps. While approximately half of the studies (47.4%) used the framework developed by Geller et al,[10,60] a validated model identifying specific actions/inactions across provider, system, and patient levels, the remaining studies employed various approaches. These included adaptations of the Geller framework,[58] patient safety models from the Harvard Medical Practice Study originally designed to identify preventable adverse events in healthcare,[62,63] maternal mortality review logic models used for determining if deaths could be averted through reasonable system changes,[64,65] UK Confidential Enquiry employed to identify areas for care improvement,[66] and committee consensus approaches.[35] Notably, 21.1% of studies did not specify their assessment approach.

Similarly, the distinct classification approaches highlight notable regional patterns, with New Zealand exclusively using the combined (event preventability and quality of care) approach while U.S. studies employed various methods. This methodological diversity emphasizes the need for recommendations regarding preferred classification systems with clear advantages and disadvantages to enable meaningful cross-study comparisons.

The high SMM preventability rates identified (21–76%) demonstrate both the substantial opportunities to improve maternal outcomes and the feasibility of conducting these assessments despite methodological variation. External reviews consistently identified higher preventability rates than internal reviews in identical event pools. This pattern, consistent across four studies, reflects the broader and more objective perspective of external reviewers.

Cause-specific findings also reveal expected patterns: SMM from sepsis had the highest preventability, followed by hemorrhage and hypertensive disorders, while cardiovascular SMM events demonstrated lower preventability rates. These findings show similar patterns to pregnancy-related and pregnancy-associated death data from 40 U.S. states and two cities, with high preventability rates for preeclampsia-eclampsia (>90%), hemorrhage or cardiovascular conditions (>80%), and sepsis (68%), though sepsis ranked differently.[30]

Comparison with Previous Studies

The Maryland (United States) SMM Surveillance and Review Program,[67] which systematically follows ACOG/SMFM-recommended processes for facility-based surveillance and is considered gold-standard, documented 34% overall SMM preventability in 2024 with condition-specific rates of 50.0% for sepsis (non-COVID), 42.4% for hypertensive disorders, 27.9% for obstetric hemorrhage, and 20.0% for cardiovascular conditions.[67] U.S. studies in this review demonstrated mixed patterns relative to the Maryland (United States) surveillance findings, with most exceeding Maryland's (United States) preventability for "all improvement opportunities," while overall and for specific causes, the more conservative "preventable or potentially preventable" rates varied around Maryland's (United States) figures. SMM preventability rates by specific causes remain lower than estimates of pregnancy-related and pregnancy-associated death preventability across 40 U.S. states and two cities (i.e., >90% preventability for preeclampsia–eclampsia and >80% for hemorrhage and cardiovascular conditions).[30] These findings likely reflect differences in event severity, review processes, and use of different preventability assessments. However, the substantial overlap in preventability rates between SMM (21–76%) and maternal mortality (53–93.8% from recent MMRC data[30]) suggests common underlying factors.

This review builds upon Geller et al's [6] global review, which reported SMM preventability rates between 6.5 and 74.6%[6] confirming persistent variation. The current review incorporates a decade of additional evidence, providing the first scoping review comparing SMM preventability assessment methodologies. The development trajectory from Geller's initial 5-factor scoring system (2004) to CDC's 21-indicator SMM measure (2014) and the various statewide and national SMM surveillance implementations demonstrates important advancements.[34,61]

Strengths and Limitations

This review was based on comprehensive database searches, JBI scoping review methodology[39–42] ensuring systematic evidence mapping, multi-reviewer data abstraction to reduce bias, and synthesis across multiple countries. The review's focus on methodological heterogeneity provides actionable insights for standardization efforts. Limitations include our inability to conduct meta-analysis due to methodological diversity, though this heterogeneity provided valuable practice insights. Data abstraction rather than extraction allowed for synthesis of diverse reporting

© 2026. The Author(s).

formats while potentially introducing interpretation variability, mitigated through multi-reviewer verification. Restriction of the review to HICs limits generalizability to other settings, though findings remain highly relevant for the included and like countries.

Future Directions

Despite wide variation in SMM preventability estimates, our findings demonstrate both substantial opportunities for improvement across all primary causes and the feasibility of conducting SMM preventability reviews at the facility, state, and national levels. Maryland is the only state in the United States with legislation (HB-1051/2024)[68] requiring all hospitals to participate and systematically identify and review SMM cases using the ACOG/SMFM guidance. This model can be replicated across other U.S. states. Also, the existing state-level maternal mortality review infrastructure provides a strong model for such implementation—49 U.S. states have legislation supporting maternal mortality reviews,[30] and CDC's Enhancing Reviews and Surveillance to Eliminate Maternal Mortality (ERASE-MM) Initiative, currently active in 46 states, offers support for standardized data collection systems for adverse maternal outcomes like SMM.

Additional priorities informed by our findings include developing national and international consensus on SMM preventability definitions and assessment tools, establishing precise and standardized categories, and clearly distinguishing preventability from quality improvement in SMM review processes. Implementation research should evaluate review effectiveness, particularly comparing internal versus external models, given the consistent disparities our reviews identified.

Conclusion

We demonstrate that up to three-quarters of SMM events are preventable or have improvement opportunities. The findings support both implementing systematic SMM preventability reviews using current methods, which successfully identify areas of needed care improvement, and developing standardized approaches to enable meaningful cross-study comparisons. Given the substantial preventability demonstrated across studies, prioritizing the identification of modifiable factors and evidence-based prevention strategies remains critical for improving maternal outcomes.

Author Affiliations

1 Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, United States

2 Department of Gynecology and Obstetrics, Johns Hopkins University, School of Medicine, Baltimore, Maryland, United States

Statements and Additional Information

Conflict of Interest The authors declare that they have no conflict of interest.

Contributors' Statement Y.N.A contributed to conceptualization, data curation, formal analysis, investigation, methodology, project administration, supervision, and writing—original draft, review, and editing. Q.L contributed to data curation, methodology, supervision, and writing—review and editing. P.M contributed to data curation and writing—review and editing. A.A.C contributed to conceptualization, data curation, funding acquisition, investigation, methodology, supervision, and writing—review and editing.

Acknowledgement The authors acknowledge Elisheva (Ellie) Wecke for her comprehensive expert medical library assistance. They also extend their gratitude to Dr. Saifuddin Ahmed and Dr. Kelly Bower, members of the dissertation review committee, for their detailed guidance and invaluable advice in the development and refinement of this research.

Funding Information This study was funded by the Eunice Kennedy Shriver National Institute of Child Health & Human Development of the National Institutes of Health (Grant No.: U24HD113136)

Note The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

© 2026. The Author(s) This is an open access article published by Thieme under the terms of the Creative Commons Attribution License, permitting unrestricted use, distribution, and reproduction so long as the original work is properly cited. (https://creativecommons.org/licenses/by/4.0/).

Supplementary Material is available at https://doi.org/10.1055/a-2874-8557

References

1 Say L, Souza JP, Pattinson RCWHO working group on Maternal Mortality and Morbidity classifications. Maternal near miss–towards a standard tool for monitoring quality of maternal health care. Best Pract Res Clin Obstet Gynaecol 2009;23(03):287–296

2 Tunçalp Ö, Souza JP. Maternal near-miss audits to improve quality of care. BJOG 2014;121 (suppl 4):102–104

3 Troiano NH, Witcher PM. Maternal mortality and morbidity in the United States: classification, causes, preventability, and critical care obstetric implications. J Perinat Neonatal Nurs 2018;32(03):222–231

4 Pattinson R, Say L, Souza JP, Broek Nv, Rooney CWHO Working Group on Maternal Mortality and Morbidity Classifications. WHO maternal death and near-miss classifications. Bull World Health Organ 2009;87(10):734–734A

5 World Health Organization. Evaluating the Quality of Care for Severe Pregnancy Complications: the WHO Near-Miss Approach for Maternal Health. Geneva: World Health Organization; 2011

6 Geller SE, Koch AR, Garland CE, MacDonald EJ, Storey F, Lawton B. A global view of severe maternal morbidity: moving beyond maternal mortality. Reprod Health 2018;15(1, suppl 1):98

7 U.S. Centers for Disease Control and Prevention. Identifying Severe Maternal Morbidity (SMM). Accessed August 2024 at: https://www.cdc.gov/maternal-infant-health/php/severe-maternal-morbidity/icd.html

8 Declercq E, Zephyrin L. Severe maternal morbidity in the United States: a primer. New York: Commonwealth Fund; 2021

9 Kern-Goldberger AR, Howell EA, Srinivas SK, Levine LD. What we talk about when we talk about severe maternal morbidity: a call to action to critically review severe maternal morbidity as an outcome measure. Am J Obstet Gynecol MFM 2023;5 (05):100882

10 Geller SE, Adams MG, Kominiarek MA, et al. Reliability of a preventability model in maternal death and morbidity. Am J Obstet Gynecol 2007;196 (01):57.e1–57.e6

11 Kilpatrick SK, Ecker JLAmerican College of Obstetricians and Gynecologists and the Society for Maternal–Fetal Medicine. Severe maternal morbidity: screening and review. Am J Obstet Gynecol 2016;215(03):B17–B22

12 Euro-Peristat. Euro-Peristat indicators of perinatal health. Accessed May 2025 at: https://www.europeristat.com/indicators/indicators-of-perinatal-health/

13 Centre de Recherche en Epidémiologie et Statistiques. Epidemiology of severe maternal morbidity (EPIMOMS). Accessed May 2025 at: https://cress-umr1153.fr/en/project/epidemiology-of-severe-maternal-morbidity-epimoms/

14 Knight M, Lewis G, Acosta CD, Kurinczuk JJ. Maternal near-miss case reviews: the UK approach. BJOG 2014;121 (suppl 4):112–116

15 Mothers and Babies. Reducing Risk through Audits and Confidential Enquiries across the UK (MBRRACE-UK). Maternal confidential enquiries. Accessed August 2025, at: https://www.npeu.ox.ac.uk/mbrrace-uk/maternal-programme/maternal-confidential-enquiries

16 Schaap T, Bloemenkamp K, Deneux-Tharaux C, et al; INOSS. Defining definitions: a Delphi study to develop a core outcome set for conditions of severe maternal morbidity. BJOG 2019;126(03):394–401

17 Nik Hazlina NH, Norhayati MN, Shaiful Bahari I, Mohamed Kamil HR. The prevalence and risk factors for severe maternal morbidities: a systematic review and meta-analysis. Front Med (Lausanne) 2022;9:861028

18 Henderson I, Lynch R, Gerry S, McLeish J, Watkinson P, Knight M. Severe maternal morbidity in the high income setting: a systematic review of composite definitions. EClinicalMedicine 2025;81:103105

19 Dzakpasu S, Deb-Rinker P, Arbour L, et al; Canadian Perinatal Surveillance System (Public Health Agency of Canada). Severe maternal morbidity in Canada: temporal trends and regional variations, 2003–2016. J Obstet Gynaecol Can 2019;41 (11):1589–1598.e16

20 Hitti J, Sienas L, Walker S, Benedetti TJ, Easterling T. Contribution of hypertension to severe maternal morbidity. Am J Obstet Gynecol 2018;219(04):405. e1–405.e7

21 Siddiqui A, Azria E, Howell EA, Deneux-Tharaux CEPIMOMS Study Group. Associations between maternal obesity and severe maternal morbidity: findings from the French EPIMOMS population-based study. Paediatr Perinat Epidemiol 2019;33 (01):7–16

22 Fink DA, Kilday D, Cao Z, et al. Trends in maternal mortality and severe maternal morbidity during delivery-related hospitalizations in the United States, 2008 to 2021. JAMA Netw Open 2023;6(06):e2317641

23 Hirai AH, Owens PL, Reid LD, Vladutiu CJ, Main EK. Trends in severe maternal morbidity in the US across the transition to ICD-10-CM/PCS from 2012–2019. JAMA Netw Open 2022;5(07):e2222966

24 Neerland C, Slaughter-Acey J, Behrens K, et al. An evidence map for social and structural determinants for maternal morbidity and mortality: a systematic review. Obstet Gynecol 2024;143(03):383–392

25 Kaskun O, Greene R. A systematic review of severe maternal morbidity in high-income countries. Cureus 2022;14(10):e29901

26 Bouvier-Colle MH, Mohangoo AD, Gissler M, et al; Euro-Peristat Scientific Committee. What about the mothers? An analysis of maternal mortality and morbidity in perinatal health surveillance systems in Europe. BJOG 2012;119 (07):880–889, discussion 890

27 Geller SE, Rosenberg D, Cox SM, et al. The continuum of maternal morbidity and mortality: factors associated with severity. Am J Obstet Gynecol 2004;191 (03):939–944

28 Lawton BA, Jane MacDonald E, Stanley J, Daniells K, Geller SE. Preventability review of severe maternal morbidity. Acta Obstet Gynecol Scand 2019;98 (04):515–522

29 Garland CE, Craemer KA, Koch AR, Locher S, Geller SE. Comparing state-level and facility-based review to assess quality of severe maternal morbidity reviews. J Public Health Manag Pract 2023;29(03):361–368

30 Qian J, Wolfson C, Kramer B, Creanga AA. Insights from preventability assessments across 42 state and city maternal mortality reviews in the United States. Am J Obstet Gynecol 2025;232(04):394.e1–394.e10

31 Ray JG, Park AL, Dzakpasu S, et al. Prevalence of severe maternal morbidity and factors associated with maternal mortality in Ontario, Canada. JAMA Netw Open 2018;1(07):e184571

32 Callaghan WM, Grobman WA, Kilpatrick SJ, Main EK, D'Alton M. Facility-based identification of women with severe maternal morbidity: it is time to start. Obstet Gynecol 2014;123(05):978–981

33 Kilpatrick SJ, Berg C, Bernstein P, et al. Standardized severe maternal morbidity review: rationale and process. Obstet Gynecol 2014;124(2 Pt 1):361–366

34 Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. Obstet Gynecol 2012;120(05):1029–1036

35 Ozimek JA, Eddins RM, Greene N, et al. Opportunities for improvement in care among women with severe maternal morbidity. Am J Obstet Gynecol 2016;215 (04):509.e1–509.e6

36 Geller SE, Garland CE, Horne AA. Statewide severe maternal morbidity review in Illinois. Obstet Gynecol 2021;137(01):41–48

37 Lawton B, MacDonald EJ, Brown SA, et al. Preventability of severe acute maternal morbidity. Am J Obstet Gynecol 2014;210(06):557.e1–557.e6

38 van Dillen J, Mesman JA, Zwart JJ, Bloemenkamp KW, van Roosmalen J. Introducing maternal morbidity audit in the Netherlands. BJOG 2010;117 (04):416–421

39 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005;8(01):19–32

40 Peters M, Godfrey C, McInerney P, Munn Z, Tricco A, Khalil H. Scoping reviews (2020). In: Aromataris E, Lockwood C, Porritt K, Pilla B, Jordan Z, eds. JBI Manual for Evidence Synthesis. Adelaide: JBI; 2024

41 Peters MDJ, Marnie C, Tricco AC, et al. Updated methodological guidance for the conduct of scoping reviews. JBI Evid Synth 2020;18(10):2119–2126

42 Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med 2018;169 (07):467–473

43 World Bank. World Bank country classifications by income level for 2024–2025. Accessed 2025 at: https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025

44 Covidence systematic review software. Melbourne: Veritas Health Innovation; 2024. Accessed May 21, 2026, at: www.covidence.org

45 Pollock D, Peters MDJ, Khalil H, et al. Recommendations for the extraction, analysis, and presentation of results in scoping reviews. JBI Evid Synth 2023;21 (03):520–532

46 Della Torre M, Kilpatrick SJ, Hibbard JU, et al. Assessing preventability for obstetric hemorrhage. Am J Perinatol 2011;28(10):753–760

47 Nastasia Ș, Russu M, Marin J, Butuc S, Hudiță D. Obstetric hysterectomy–patient's profile in a tertiary obstetrical unit. Gineco Ro 2011;23(01):46–49

48 Kominiarek MA, Scott S, Koch AR, et al. Preventing maternal morbidity from obstetric hemorrhage: implications of a provider training initiative. Am J Perinatol 2017;34(01):74–79

49 Lepine S, Lawton B, Geller S, Abels P, MacDonald EJ. Severe maternal morbidity due to sepsis: the burden and preventability of disease in New Zealand. Aust N Z J Obstet Gynaecol 2018;58(06):648–653

50 MacDonald EJ, Lepine S, Pledger M, Geller SE, Lawton B, Stone P. Pre-eclampsia causing severe maternal morbidity - a national retrospective review of preventability and opportunities for improved care. Aust N Z J Obstet Gynaecol 2019;59 (06):825–830

51 Ogunyemi D, Hage N, Kim SK, Friedman P. A multidisciplinary model for reviewing severe maternal morbidity cases and teaching residents patient safety principles. Jt Comm J Qual Patient Saf 2019;45(06):423–430

52 Al Abri J. National Survey and Review of Maternal Near Miss in Oman [PhD dissertation]. Liverpool, UK: University of Liverpool; 2020

53 Jayaratnam S, Jacob-Rodgers S, de Costa C. Characteristics and preventability of obstetric intensive care unit admissions in Far North Queensland. Aust N Z J Obstet Gynaecol 2020;60(06):871–876

54 Lepine SJ, Geller SE, Pledger M, Lawton B, MacDonald EJ. Severe maternal morbidity due to obstetric haemorrhage: potential preventability. Aust N Z J Obstet Gynaecol 2020;60(02):212–217

55 Pfaller B, Sathananthan G, Grewal J, et al. Preventing complications in pregnant women with cardiac disease. J Am Coll Cardiol 2020;75(12):1443–1452

56 Ozimek JA, Greene N, Geller A, et al. Routine multidisciplinary review of severe maternal morbidity is associated with a reduction in preventable cases of severe maternal morbidity. Am J Perinatol 2022;39(03):307–311

57 Wolfson C, Qian J, Chin P, et al. Findings from severe maternal morbidity surveillance and review in Maryland. JAMA Netw Open 2022;5(11):e2244077

58 Ding JJ, Mitta S, Kole-White M, Roth J, Malhamé I. Preventability of stroke during pregnancy and postpartum. Obstet Med 2024;17(04):208–212

59 Grechukhina O, Lipkind HS, Lundsberg LS, et al. Severe maternal morbidity review and preventability assessment in a large academic center. Obstet Gynecol 2023;141(04):857–860

60 Geller SE, Cox SM, Kilpatrick SJ. A descriptive model of preventability in maternal morbidity and mortality. J Perinatol 2006;26(02):79–84

61 Koch AR, Roesch PT, Garland CE, Geller SE. Implementing statewide severe maternal morbidity review: the Illinois experience. J Public Health Manag Pract 2018;24(05):458–464

62 Leape LL, Brennan TA, Laird N, et al. The nature of adverse events in hospitalized patients. Results of the Harvard Medical Practice Study II. N Engl J Med 1991;324 (06):377–384

63 Vincent C, Neale G, Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. BMJ 2001;322(7285):517–519

64 Zaharatos J, St Pierre A, Cornell A, Pasalic E, Goodman D. Building US capacity to review and prevent maternal deaths. J Womens Health (Larchmt) 2018;27 (01):1–5

© 2026. The Author(s).

65 Petersen EE, Davis NL, Goodman D, et al. Vital signs: pregnancy-related deaths, United States, 2011–2015, and strategies for prevention, 13 states, 2013–2017. MMWR Morb Mortal Wkly Rep 2019;68(18):423–429

66 Knight M. Studies using routine data versus specific data collection: What can we learn about the epidemiology of eclampsia and the impact of changes in management of gestational hypertensive disorders? Pregnancy Hypertens 2011;1(01):109–116

67 Severe Maternal Morbidity Surveillance & Review Program in Maryland. SMM Surveillance and Review: Findings from Maryland, 2023. Baltimore: MDmom; 2024

68 Maryland General Assembly.. Maryland House Bill 1051, Maternal Health – Assessments, Referrals, and Reporting (Maryland Maternal Health Act of 2024). 2024 Md Laws Ch 799

© 2026. The Author(s).