BMC Pregnancy and Childbirth

STUDY PROTOCOL Open Access

EMBRACE COMPASS: protocol for a multi-country cross-sectional comparative analysis of pregnancy and postnatal care architecture

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Abstract

Background Maternal morbidity and mortality remain major global health challenges, with substantial variation in maternity care delivery across health systems. Although clinical guidelines are widely available, there is limited systematic, multi-country mapping of maternity care systems as integrated architectures. Evidence linking system design and implementation to population outcomes is also limited. This study aims to compare maternity care systems across countries for gestational diabetes, hypertensive disorders of pregnancy, perinatal depression, and uncomplicated pregnancy using a structured, multi-layered care architecture framework.

Methods This is a multi-country, cross-sectional, mixed-methods comparative study including twenty countries across all World Health Organization regions and income groups, selected using purposive sampling. Data will be collected using a standardised instrument with more than 140 items mapped to a nine-layer care architecture framework, covering policy, clinical standards, guidelines, models of care, care pathways, clinical protocols, digital systems, patient experience, and financing. Data sources will include structured country submissions, systematic document review, and validation interviews with clinicians and policymakers.

Each domain will be independently scored by two reviewers using a four-point ordinal scale, with assessment of inter-rater reliability. Country profiles will be validated through member checking and triangulation of documentary and interview data. Comparative analyses will include descriptive profiling, cross-country comparisons, clustering to identify system typologies, and gap analysis against international benchmarks. Implementation and equity dimensions will be assessed using established frameworks, and physical activity guidance will be examined as a cross-cutting domain.

Exploratory ecological analyses will assess associations between system characteristics and publicly available outcomes, including maternal mortality, preterm birth, stillbirth, and caesarean section rates, using regression models. A structured consensus process will be used to develop minimum care architecture standards and harmonisation recommendations.

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Discussion This study will provide a structured and reproducible approach to characterising and comparing maternity care systems globally. By identifying variation in system design, implementation, and equity considerations, the findings will inform policy, support harmonisation of care, and guide improvements in maternal and perinatal outcomes across diverse settings.

Registration Open Science Framework.

Keywords Pregnancy, Prenatal care, Gestational Diabetes, Hypertensive disorders of pregnancy, Depression, Guidelines, Policy

Background

Global burden and opportunity

In 2020, an estimated 287,000 women died from pregnancy-related causes globally, with substantially higher numbers experiencing severe morbidity [1]. Most of these outcomes are preventable through timely, appropriate care. However, the organization of maternity services, including clinical pathways, standards, workforce models, digital infrastructure, and financing—varies enormously across and within countries.

At the same time, changing population characteristics, including multimorbidity, obesity, increasing maternal age, and mental health conditions, have added the complexity of antenatal and postnatal care, placing new demands on care systems that were often designed for a different epidemiological profile.

Key conditions illustrate this variation. Gestational diabetes mellitus (GDM) affects approximately 14% of pregnancies globally, with reported prevalence varying widely due to differences in diagnostic criteria [2]. Hypertensive disorders of pregnancy (HDP), complicate 5–10% of pregnancies worldwide and remain a leading cause of maternal mortality, yet classification systems, diagnostic thresholds, and escalation protocols differ substantially [3]. Perinatal depression affects approximately 10–20% of women, but screening instruments, timing, thresholds for referral, and access to specialist services vary from mandated universal screening to no routine assessment [4].

Despite the availability of clinical guidelines, there is limited systematic, multi-country mapping of maternity care systems as integrated architectures, and little evidence linking system design and implementation to population outcomes. This study aims to characterise and compare maternity care systems using a structured and reproducible framework.

Variation across health systems

Variation in pregnancy care occurs across multiple layers, including policy frameworks, clinical standards, guidelines, models of care, diagnostic criteria, protocols, digital systems, workforce structures, governance, patient engagement, and financing. Such multi-layered variation can drive differences in measured prevalence, service burden, clinical outcomes, and patient experience, and can impede cross-country learning and interoperability of research findings.

Physical activity and exercise in pregnancy are examined as a cross-cutting lifestyle domain relevant to all four index conditions. Lifestyle and physical activity guidance during pregnancy represents a particularly variable domain. The World Health Organization (WHO) 2020 guidelines on physical activity included pregnancy-specific recommendations for the first time (≥ 150 min per week of moderate-intensity aerobic activity. However, adoption, specificity, and condition-specific adaptation differ substantially across countries [5]. Variation is evident in the use of exercise as a first-line intervention for GDM, activity modification in HDP, and exercise as an adjunct treatment for perinatal depression, as well as in equity of delivery. National guidance also differs in detail and implementation approaches, with implications for outcomes across GDM, HDP, and perinatal depression [6, 7].

Evidence supports exercise for glycaemic control in GDM, cardiovascular health and pre-eclampsia risk reduction in HDP, and mood regulation in perinatal depression, while routine physical activity remains a core component of healthy pregnancy guidance (ref). Despite this evidence base, guidance varies considerably across countries and health systems in terms of specificity, dose prescriptions, contraindication frameworks, condition-specific modifications, delivery mechanisms, and equity considerations.

This variability makes physical activity a particularly informative domain for structured comparative analysis, warranting dedicated assessment beyond general lifestyle guidance.

Knowledge gap

Previous comparative studies have typically focused on single conditions or isolated domains, such as diagnostic criteria or guideline concordance, rather than examining maternity care systems as integrated architectures [8]. Few studies map care from policy through to patient experience [9, 10]. In addition, most assess formal guidance ("work as imagined") rather than implementation in practice ("work as done"), and rarely incorporate equity

considerations or the digital and financing constraints that shape real-world delivery [11].

Study rationale

EMBRACE COMPASS (Enhanced Maternal and Baby Results with AI-supported Care and Empowerment Comparative study of Pregnancy Architectures, Standards & Systems) addresses these gaps with a structured 9-layer Care Architecture Framework, multi-source triangulation (instrument, documents, expert validation, consumer input), established reporting standards (Strengthening the Reporting of Observational Studies in Epidemiology (STROBE), Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Extension for Scoping Reviews (PRISMA-ScR), Consolidated Criteria for Reporting Qualitative Research (COREQ) and an analytic strategy designed to produce outputs that are directly actionable for policymakers, clinicians, and international organisations [12–17]. For this study, pregnancy care encompasses antenatal, intrapartum, and immediate postpartum care.

Objectives

Primary objective

To systematically compare maternity care systems across countries using a structured care architecture framework.

Secondary objectives

- To develop country-level care architecture profiles.
- To compare diagnostic criteria for GDM, HDP, and perinatal depression.
- To assess physical activity guidance in pregnancy and concordance with international recommendations.
- To assess implementation fidelity and identify key barriers.
- To map equity adaptations using PROGRESS-Plus.
- To assess guideline and pathway document quality using AGREE II-informed appraisal and transparency indicators.
- To explore ecological associations between system features and outcomes.
- To produce consensus-based recommendations.

Methods

Study design

EMBRACE COMPASS is a multi-country, cross-sectional, mixed-methods comparative study combining: (1) structured country-level data collection; (2) systematic document review and coding; (3) validation with expert and consumer informants; (4) cross-country comparative analyses; (5) exploratory ecological linkage to population outcomes; and (6) a structured consensus process to generate recommendations.

The study integrates quantitative and qualitative methods, including structured survey instruments, document analysis, and semi-structured interviews, to enable both measurement and contextual interpretation of maternity care systems.

Reporting will follow established guidance for observational, qualitative, and scoping review components (STROBE, PRISMA-ScR, COREQ), with checklists provided in Appendix A.

Setting and country selection

Countries are selected using purposive sampling to maximise diversity across WHO regions, World Bank income classifications, health system types, diagnostic practices, and digital maturity. Eligibility criteria include the availability of national maternity care guidance, accessible data sources, and the ability to assemble a multidisciplinary country team including a consumer representative.

The initial sample includes 20 countries spanning all six WHO regions, four income groups, and diverse health system models (Table 1), collectively representing approximately 60 million births annually. Countries experiencing active conflict or major disruption to routine maternity services or lacking accessible national-level guidance for the index conditions, are excluded.

Additional countries may join through an open expression-of-interest process, subject to eligibility criteria and steering committee approval, to enhance diversity and representation.

Each country team will include at minimum: (i) an obstetric or maternal–fetal medicine specialist, (ii) a midwife or midwifery academic, and (iii) a health systems or public health researcher.

The full list of collaborators is provided in Appendix B.

Conceptual framework

The study applies a 9-layer Care Architecture Framework to systematically map maternity care systems from policy to clinical delivery, patient experience, and financing. The framework spans: (1) policy and regulation, (2) clinical standards, (3) clinical guidelines, (4) model of care, (5) clinical pathways, (6) protocols and standard operating procedures, (7) data and digital systems, (8) patient experience, and (9) financing and resource allocation.

Each of the 9 domains will be scored at the country level using a predefined 4-point scale: 0—absent (no evidence of structured provision); 1—limited (fragmented or inconsistently implemented); 2—moderate (formally defined but variably implemented); 3—comprehensive (nationally standardised and consistently implemented). Scoring will be based on triangulation of (i) structured instrument responses, (ii) source documents, and (iii) validation interviews. Two independent

Table 1 Participating countries and rationale for inclusion

Country	WHO Region	Income	System Type	Rationale for Inclusion
United Kingdom	EURO	High	Tax-funded (NHS)	NICE guidelines as global reference; strong midwifery tradition; NHS as single-payer archetype
Spain	EURO	High	Social insurance	17 autonomous communities = major subnational variation; EU comparator
Croatia	EURO	High	Social insurance	Small, centralised system; comprehensive national data; EU member
Bulgaria	EURO	Upper-middle	Social insurance	Eastern European comparator; ongoing health system reform; variation in maternal care indicators
Canada	AMRO	High	Tax-funded (provincial)	Provincial variation; Indigenous health priority; bilingual
United States	AMRO	High	Mixed/insurance	Largest insurance-based system; ACOG guidelines as global reference; maximum contrast with single-payer systems
Argentina	AMRO	Upper-middle	Mixed public–private	Public–private fragmentation; Spanish-speaking comparator
Peru	AMRO	Upper-middle	Mixed public–private	Rural/Indigenous variation; Quechua-speaking populations
South Africa	AFRO	High	Mixed public–private	Dual health system; high inequality; HIV burden influencing maternal care
Ghana	AFRO	Lower-middle	Mixed/NHIS	Sub-Saharan Africa; TBA ecosystem; limited digital infrastructure
Ethiopia	AFRO	Low	Mixed/tiered public	Second-largest African population (~ 120 M); low-income representation; tiered health extension worker model; high MMR with documented improvement trajectory
Australia	WPRO	High	Tax-funded	Nationwide universal coverage via Medicare; strong primary care and midwifery-led maternity models; key high-income comparator within Western Pacific region; mixed urban–rural access patterns and Indigenous health equity focus
China	WPRO	Upper-middle	State-administered	Unique care ecosystem; frequent visit schedules; WeChat-enabled
Philippines	WPRO	Lower-middle	Mixed/social insurance	Archipelagic geography; decentralised delivery; UHC reforms underway
Japan	WPRO	High	Social insurance	Advanced health system; low maternal mortality; intensive antenatal care model
India	SEARO	Lower-middle	Mixed/Ayushman Bharat	Massive scale; extreme public–private divide; state-level variation; WHO SEARO anchor
Indonesia	SEARO	Lower-middle	Social insurance (JKN)	Largest SE Asian population; universal health coverage reform; archipelago geography
Bangladesh	SEARO	Lower-middle	Mixed/community	Community health worker model; rapid MMR reduction; South Asian comparator
Saudi Arabia	EMRO	High	Government-funded	Gulf state healthcare model; high-resource; cultural context for exercise/lifestyle guidance
Pakistan	EMRO	Lower-middle	Mixed	High MMR; access barriers; WHO EMRO anchor alongside Saudi Arabia/Qatar

Income classifications based on World Bank 2024 classifications. Low-income: GNI per capita ≤ $1,135; Lower-middle: $1,136-$4,465; Upper-middle: $4,466-$13,845; High: ≥ $13,846

AFRO African region, *AMRO* Region of the Americas, *EMRO* Eastern Mediterranean Region, *EURO* European Region, *SEARO* South-East Asia Region, *WPRO* Western Pacific Region

reviewers will score each country. Discrepancies will be resolved through discussion; unresolved disagreements will be adjudicated by a third reviewer. Inter-rater reliability will be assessed using weighted kappa or intra-class correlation coefficients. All scores will be linked to supporting evidence (document citation or interview extract), forming a complete audit trail.

Two cross-cutting lenses are applied across all layers: (i) implementation (CFIR-informed constructs [12], focusing on fidelity, barriers/enablers, adaptation vs. drift), and (ii) equity (PROGRESS-Plus [13]). Physical activity and exercise guidance is captured as a dedicated sub-domain within the lifestyle and clinical pathways layers, with condition-specific items embedded in each index condition pathway. Guideline quality will be assessed using AGREE II-informed criteria [17].

Data collection instruments and procedures

Data will be collected using a structured instrument aligned to the 9-layer framework and cross-cutting implementation and equity domains. The instrument includes > 140 items comprising closed-ended variables and structured free-text fields.

Data collection will follow a standardised four-stage process: (1) Instrument completion: country teams complete the structured data collection tool with mandatory source citations. (2) Independent document retrieval: the core team conducts systematic document searches to verify, and supplement submitted data. (3) Data validation and cleaning: centralised consistency checks are performed, and queries are resolved with country teams and finally (4) Dataset finalisation: a locked, version-controlled dataset is created prior to analysis. All collaborators will receive a detailed instruction manual and

training materials to ensure consistent interpretation of variables.

All responses require source attribution (e.g., policy documents, guidelines, or expert input), enabling verification and auditability. A document inventory with metadata will be maintained for each country. Data will undergo central consistency checks and query resolution with country teams prior to analysis.

Variables will include binary (e.g., presence of national guideline), categorical (e.g., model of care type), and continuous measures (e.g., number of antenatal visits). All variables are defined in a codebook (Appendix D), including explicit definitions for key constructs such as "national guideline", "implementation", and "digital system".

The full instrument and REDCap data dictionary are provided in Appendices C and D.

Document acquisition

To minimise reliance on collaborator-supplied documents alone, the core team will augment document collection using a systematic retrieval approach aligned with PRISMA-ScR methodology. Sources include official ministry/agency websites, national guideline repositories (e.g., NICE), professional society portals, WHO guideline library, and bibliographic databases. Retrieval terms and sources will be logged. A structured PRISMA-ScR inclusion log will record all documents identified via collaborators and independent retrieval, with reasons for exclusion. Documents will be classified into copyright tiers (open-access, publicly available with restricted redistribution, copyright-restricted) and handled accordingly. The full document acquisition protocol is provided in Appendix E.

Validation

Country Care Architecture Profiles will be validated through: (a) member-checking by country teams and (b) structured validation interviews with 1–2 independent expert informants per country (clinicians or policymakers not on the core team). This multi-perspective validation reflects the emphasis on quality of care as spanning both provision and experience domains across the continuum of maternal and newborn care [18]. Interviews follow a semi-structured guide (Appendix F) and will be reported in accordance with COREQ [16].

Where documents are not available in English, a bilingual collaborator summary plus professional translation for key sections will be used.

Analysis plan

Analyses will proceed in six predefined streams: (i) descriptive country profiling; (ii) cross-country comparison; (iii) domain scoring, typology development, and gap analysis; (iv) implementation and equity synthesis; (v) exploratory ecological analysis; and (vi) consensus synthesis.

For each country, a standardised profile will summarise the 9-layer care architecture, including clinical pathways, diagnostic criteria, physical activity guidance, digital systems, financing, implementation fidelity, and equity adaptations. Profiles will be member-checked by country teams and presented using domain-level radar plots. Cross-country comparisons will include cross-tabulations, heatmaps, and concordance assessments against international reference standards, alongside qualitative framework synthesis. Countries will be scored across domains using a predefined ordinal scale with independent dual rating and assessment of inter-rater reliability.

Gap analyses will map countries against WHO benchmarks [19] and consensus-derived standards. Cluster analyses will be used to identify system typologies, with sensitivity analyses to assess robustness [20]. Hierarchical clustering will be used as the primary approach. Robustness will be assessed through sensitivity analyses using alternative methods.

Physical activity will be examined as a cross-cutting comparative domain, with sensitivity analyses exploring the influence of guideline quality on observed variation.

All analyses will be conducted using reproducible scripts. De-identified datasets, codebooks, scoring rubrics, and analytic code will be made publicly available at publication.

Ecological outcome linkage

Country-level domain scores and typology membership will be examined in relation to publicly available population outcomes, including maternal mortality ratio, severe maternal morbidity proxies, preterm birth, neonatal intensive care unit admission, stillbirth, and primary caesarean section rates.

Associations between system characteristics and population outcomes will be explored using country-level ecological analyses. Regression models (linear or generalised linear models, depending on outcome distribution) will be used. Outcome variables may be transformed (e.g., log transformation for maternal mortality ratio) where appropriate.

Given the limited sample size, models will be parsimonious, with a small number of pre-specified predictors. Missing data will be handled using complete-case analysis. Sensitivity analyses will include (1) exclusion of outlier countries, (2) stratification by income group and (3) alternative outcome definitions. These analyses are explicitly exploratory and hypothesis-generating. No causal inference will be made and findings will be interpreted cautiously in light of known limitations in cross-country data comparability [21].

Consensus process

A structured consensus method (modified Delphi with RAND/UCLA-style appropriateness elements) will produce: (i) Minimum Viable Care Architecture (MVCA) statements defining minimum acceptable elements for each domain; (ii) harmonisation priorities for diagnostic criteria and pathway elements; and (iii) implementation-ready recommendations. This approach is grounded in global calls for high-quality, integrated health systems capable of delivering consistent, evidence-based, and people-centred care across settings [20]. The MVCA will serve as the normative benchmark for gap analysis, creating a direct link between the consensus process and the quantitative comparative output.

The Delphi process will include 2–3 rounds. Participants will include multidisciplinary experts from participating countries. Consensus will be defined a priori as ≥ 70% agreement. Items not reaching consensus will be revised and re-circulated.

Timeline

Total planned duration: approximately 12 months from instrument finalisation to dissemination, adaptable to recruitment pace and translation needs. Study phases and timeline are available in Appendix G.

Ethics and dissemination

The study involves system-level data and policy documents only and does not include individual patient data The application to the NHS Health Research Authority resulted in a decision that this protocol does not require ethical approval.

Data will be stored on secure institutional platforms with role-based access. De-identified datasets, codebooks, and analytic code will be made publicly available at the time of publication, subject to copyright restrictions on source documents. Country teams will review outputs prior to publication.

Findings will be disseminated through peer-reviewed publications, country-level profiles, open datasets, policy briefs, and an interactive visualisation platform. The consensus process will produce Minimum Viable Care Architecture recommendations to inform policy and practice.

Discussion

This study addresses a critical gap in global maternal health by moving beyond isolated clinical comparisons to examine maternity care systems as integrated architectures spanning policy, clinical practice, implementation, and patient experience. The variation identified across diagnostic criteria, care pathways, workforce models, and digital and financing structures will highlight the complexity of delivering consistent, high-quality maternity care in diverse settings. By incorporating cross-cutting perspectives on implementation and equity, the study will provide a more realistic understanding of how care is delivered in practice, rather than how it is intended in guidelines. The inclusion of physical activity as a tracer domain further will illustrate how evidence-based interventions are variably translated into care, with implications for outcomes across multiple conditions. The findings are expected to support more coherent cross-country learning, improve comparability of research, and inform the development of minimum standards for maternity care system design. While ecological analyses will be exploratory, they may generate important hypotheses regarding the relationship between system characteristics and maternal and perinatal outcomes. Overall, this work offers a scalable and reproducible framework to guide policy, strengthen health systems, and advance equitable, evidence-based maternity care globally.

Abbreviations

AFRO	African region
AMRO	Region of the Americas
EMRO	Eastern Mediterranean Region
EURO	European Region
GDM	Gestational diabetes mellitus
HDP	Hypertensive disorders of pregnancy
MVCA	Minimum Viable Care Architecture
NICE	National Institute for Health and Care Excellence
SEARO	South-East Asia Region
WHO	World Health Organization
WPRO	Western Pacific Region

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12884-026-09433-2.

Supplementary Material 1.

Acknowledgements

Not applicable.

Authors' contributions

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. All authors read and approved the final manuscript.

Funding

AA, YW, KN, JC acknowledge the generous philanthropic support of Inkfish to establish the EMBRACE research programme. EMBRACE is dedicated to advancing maternal, early childhood, and parental health by harnessing the power of artificial intelligence and human support to deliver personalised precision interventions that have positive intragenerational health outcomes.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study involves system-level data and policy documents only and does not include individual patient data. The application to the NHS Health Research Authority resulted in a decision that this protocol does not require ethical approval.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 18 May 2026 / Accepted: 3 June 2026
Published online: 04 July 2026

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