



STUDY PROTOCOL

Electroencephalographic signatures during pregnancy and their role on parenting-related measures: a scoping review protocol

[version 1; peer review: awaiting peer review]

Patrícia Vilela Braga ^{1*}, Sofia Amaoui ^{1*}, Diogo Lamela ¹, Inês Jongenelen ¹, Raquel Costa ^{1,2}, Jorge Oliveira ¹, Rita Pasion ¹, Tiago Miguel Pinto ¹, Tiago Oliveira Paiva ¹, Carlos Campos ^{1,3}

¹Lusófona University, HEI-Lab: Digital Human-Environment Interaction Labs, Porto, Portugal

²EPIUnit ITR, Institute of Public Health of the University Porto, University of Porto, Porto, Portugal

³LabRP/CIR, E2S, Polytechnic of Porto, Porto, Portugal

* Equal contributors

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Abstract

Objective

This scoping review aims to map and synthesise the current research evidence targeting the electroencephalography (EEG) neural correlates during pregnancy and its association with parenting-related measures during pregnancy and postpartum period.

Introduction

Pregnancy is characterised by a wide range of biological changes associated with adaptation to parenthood. A growing body of literature has examined the neural correlates of pregnancy using EEG, revealing distinct patterns in pregnant females, with these EEG metrics changing throughout gestation and postpartum. Due to the heterogeneity of the evidence, the current literature lacks an organised synthesis, making it difficult to understand the neural correlates during pregnancy and their association with parenting-related measures during pregnancy and postpartum period.

Inclusion criteria

Studies will be included if they contain a quantitative EEG metric in their assessment in pregnant women. Studies will be included if they involve clinical or community samples. No sociodemographic, obstetric, or health exclusion criteria will be applied.

Methods

The scoping review will be conducted following the Joanna Briggs Institute's (JBI) guidelines and will be reported following Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines. Searches will be conducted in 7 databases (Cochrane for Trials and Reviews, PsycInfo, PubMed, Psychological and Behavioural Science Collection, Scopus and Web of Science Core Collection) for articles published in English, Portuguese, or Spanish with no limitation on the region or publication time frame. Two independent reviewers will screen each record following a standardised flowchart using asreview lab. Data extraction will be performed by the two reviewers using charting tables in Excel. Disagreements at any step will be resolved via consensus or by a third reviewer. Results will be reported using tables and graphs along with a descriptive analysis, according to the research questions.

Keywords

EEG; Gestation; Neurophysiology; Prenatal; Parenthood; Parenting; Postpartum

Corresponding author: Carlos Campos (carlos.campos@ulusofona.pt)

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Introduction

Pregnancy is a significant life event associated with biological, psychological, and social changes. Biologically, the women's body undergoes large changes across all physiological systems to support fetal development (Kazma et al., 2020; Pascual & Langaker, 2023). These changes include core anatomical and functional adaptations in the brain, which play a crucial role in the adjustment to parenthood (Abraham & Feldman, 2022).

Studies in animal models have reported that changes in synaptic plasticity (Celik et al., 2022; Leno-Durán et al., 2014; Galea et al., 2014), neurogenesis (Hillerer et al., 2014), and white and grey matter volume (Servin-Barthet et al., 2023; Kinsley et al., 2014) occurs during pregnancy. Consistent with this evidence, neuroimaging studies in humans have shown that pregnancy induces both structural and functional brain changes within the so-called maternal brain network. This network includes subcortical areas that are connected through multiple projections to cortical networks (Gholampour et al., 2020; Hoekzema et al., 2022). Specifically, structural changes involve an increase in grey matter volume in regions associated with caregiving, such as the hypothalamus, thalamus, amygdala, prefrontal cortex, and inferior parietal lobule (Kim et al., 2016). Functional changes have also been observed in mothers, who, compared to non-mothers, exhibit a distinct pattern of brain activation when exposed to infant-related stimuli (Abraham & Feldman, 2022; Feldman, 2016). This pattern includes cortical areas involved in empathy, emotion regulation, embodied simulation, and mentalizing (Bernhardt & Singer, 2012; Kanat et al., 2014).

Considering the complexity of the maternal brain, electroencephalography (EEG) emerges as an essential methodology for investigating the neural underpinnings of pregnancy by offering greater temporal precision. The EEG technique records the electrical activity generated by the sum of postsynaptic potentials (Luck, 2014; Sadaghiani et al., 2022). When a large number of these potentials align, they generate current dipoles that can be detected by electrodes located on the scalp, ultimately allowing to measure cortical brain activity (Nunez & Srinivasan, 2006). The high temporal resolution of EEG is a particular strength of the technique as it is derived from electrical currents rather than metabolic activity, unlike neuroimaging methods. When applied to maternal brain research, this enables the tracking of neural fluctuations in brain activity under controlled experimental conditions (Penner et al., 2023). Considering this information, several researchers have focused on analysing and extracting different EEG metrics for exploring neural correlates during pregnancy and its association with parenting-related measures (Maupin et al., 2015).

Event-related potentials (ERPs) are the most studied EEG metrics during pregnancy, reflecting neural responses to specific stimuli/events (Sadaghiani et al., 2022). Research has highlighted that viewing emotional infant cues elicits distinct patterns of early and late ERP components in pregnant female (Cárdenas et al., 2023) also when compared to women with multiple pregnancies (Rutherford et al., 2018). Moreover, some of these ERPs were associated with parenting-related measures, namely antenatal mentalizing, postnatal sensitivity, and mother-to-infant bonding (Dudek, 2018; Rutherford et al., 2018).

Further EEG metrics that have drawn researchers' interest include the estimation of the spatial location of the recorded neural activity when pregnant women perform a behavioral task (Trentini et al., 2020) and how EEG oscillations (e.g., alpha, beta, theta and, delta waves) are modulated during pregnancy (Sandoval et al., 2023). Beyond these more "targeted analyses", recent studies examined how EEG neural dynamics change throughout pregnancy and the postpartum period. This research reveals that pregnant women not only display different EEG functional connectivity compared to non-pregnant but also that these connectivity patterns change across the three trimesters (Almanza-Sepúlveda et al., 2018) and the postpartum period (Sandoval et al., 2023).

Overall, these studies backup sets of findings: (1) pregnant groups display distinct patterns of EEG metrics compared to non-pregnant groups; (2) EEG metrics change across the stages of gestation and after birth; and (3) EEG metrics have been associated with parental measures during pregnancy and/or after birth.

Although there is evidence showing that pregnancy induces neural changes measurable by EEG, it is essential to consider the heterogeneity across the studies, which arises from the diverse cognitive and socio-emotional processes examined (Almanza-Sepúlveda et al., 2018; Peoples et al., 2022; Trentini et al., 2020). Additionally, these neural changes may differ at various stages of pregnancy and the postpartum period (Lesniara-Stachon et al., 2023), and the diversity of EEG recording settings and preprocessing pipelines employed to extract different EEG metrics further contributes to this variability. As a result, the existing body of literature falls short of providing an organised and integrated synthesis of the evidence necessary for a comprehensive overview of the EEG neural correlates involved in pregnancy.

A preliminary search on PubMed, PROSPERO, Open Science Framework, and Cochrane Database of Systematic Review was conducted in February 2025, and while some reviews of the literature are available (Corner et al., 2023;

Lövgren, 2022; Maupin et al., 2015; Sweet et al., 2020; Vasiljeva et al., 2002; Yatziv et al., 2021), no current or on-going systematic review on the present topic was found except for one that focused on hypertensive pregnancy (Brussé et al., 2010). Therefore, the present scoping review protocol aims to systematically map and summarize the current state of the art on EEG-neural correlates during pregnancy and its association with parenting-related measures during pregnancy and postpartum period. This will allow us to identify gaps in previous studies and guide potential pregnancy-related reviews of interest. We expect that this review will assist researchers in developing new evidence-based hypotheses and designing reliable methodological approaches targeting EEG measurement during pregnancy associated with the adaptation to parenthood.

Review question

The research question(s) are as follows:

Primary research question:

RQ 1: What is the current body of evidence assessing EEG-neural correlates during pregnancy and its association with parenting-related measures?

Specific research questions:

RQ 1.1: What is the evidence regarding differences in EEG metrics when comparing pregnant vs. non-pregnant participants?

RQ 1.2: Are there differences in EEG metrics across pregnancy stages and postpartum period (i.e., six weeks after birth)?

RQ 1.3: Are EEG metrics during pregnancy associated with parenting-related measures?

RQ 1.4: What are the demographic, clinical, and obstetric characteristics of the samples in pregnancy-related EEG research?

RQ 1.5: What are the EEG recording characteristics, data preprocessing and feature extraction procedures being employed in EEG research during pregnancy?

Protocol

Inclusion criteria

Participants

Considering the broad nature of the primary research question, any empirical study encompassing a group of pregnant women who completed EEG recordings at any stage of gestation will be included. No sociodemographic, obstetric, or clinical exclusion criteria will be employed. Non-human studies will be excluded.

Concept

Considering the defined research questions, three main concepts need to be closely addressed:

1. Pregnancy

Pregnancy will be considered from the moment of reported conception until the end of gestation. Longitudinal studies contrasting assessments during pregnancy with measurements attained before conception and/or postpartum will also be included.

2. EEG-based neural correlates

Only **EEG-neural correlates** related to pregnancy will be assessed. Several classification frameworks have been proposed for EEG signals. Here, we will use two different levels of classification to synthesise the literature depending on whether the focus is on spontaneous or stimulus-driven brain dynamics. For the first level, we will classify the studies based on the type of EEG recordings (Zhang et al., 2023). That is, (a) *resting-state EEG* (i.e., to study the brain's intrinsic electrical activity when the subject is not engaged in any specific task), and (b) *task-based EEG* (i.e., to investigate brain

responses during specific activities or after exposure to a given set of stimuli). When it comes to analysing these recordings, several EEG metrics can be employed depending on the research focus. Therefore, for the second level of classification, we will divide the EEG metrics depending on the analysis: (a) *Power spectrum analyses*, which allow for studying the frequency components of a signal and understanding how power is distributed across different frequencies (Dressler et al., 2004); (b) *Time-frequency analyses* that enable to measure the temporal dynamic changes of the neural activity across frequencies (Morales & Bowers, 2022); (c) *Event-related potentials* that allow for analysing the neural correlates of mental processes by time-locking amplitude changes in EEG to specific task events (Sur & Sinha, 2009); (d) *Connectivity analyses*, which give the means to assess correlations in electrical activity recorded at different electrode sites. These analyses help to understand how different brain regions communicate with each other and are putatively organised in specific neural networks (Zhang et al., 2023); (e) *Source localization analyses* which are used to estimate/infer the brain location where the electrical signals are generated. This second classification is essential for categorising the current state of evidence based on the neural phenomena of interest (Stancin et al., 2021).

3. Parenting-related measures

A broad conceptualization of parenting-related measures will be employed for the purpose of this review. After screening for recent systematic reviews on the subject, parenting-related measures will be defined as any indicator that captures beliefs, attitudes, expectations, and behaviors related to parenting and/or transition to motherhood. This will include parental bonding (also known as parental attachment, parent-fetal bond, or parent-child bond), mother-infant interaction (infant- and adult-initiated interactive behaviours as well as dyadic interaction measures), parenting style, positive and/or negative parenting measures, parental mentalizing or reflective functioning, parental self-efficacy, parental adaptation, parenting competence, parenting self-esteem, parental involvement, parental mastery, motherhood expectations, or other analogous measures (Best et al., 2023; Georg et al., 2023; Savage et al., 2019; Tesson et al., 2021; Beeck et al., 2023; Wittkowski et al., 2020).

Parenting-related measures can be attained through *self-report* by the pregnant participant, *informant-report* (e.g., partner, other family members, healthcare professional) and/or *observational-based coding tools*. Importantly, as some of these variables are more likely to occur before birth (e.g., motherhood expectations), while others after birth (e.g., mother-infant interaction), specification regarding the assessment moment will be provided.

Context

To provide a comprehensive overview of EEG-based research in female pregnant participants, this review will include samples recruited from the community (general population) and/or from healthcare settings (e.g., hospital-based, primary healthcare, home care). Studies will not be limited to a specific geographical location or social context.

Types of sources

Both **quantitative** and **mixed-method studies**, though only the quantitative data will be considered from mixed-method studies. More specifically, the review will encompass **observational studies** including prospective or retrospective cohort studies, cross-sectional studies, and case-control studies (i.e., pregnant vs non-pregnant) as well as **experimental** and **quasi-experimental** studies such as randomised controlled trials and non-randomized controlled trials (i.e., pre and post treatment). Qualitative studies (e.g., non-quantitative EEG analyses), case reports, case series, opinion articles, and letters to the editor will be excluded. Grey literature (e.g., conference abstracts, Ph. D. and master's thesis, preprints) will be considered if they meet the eligibility criteria. Finally, systematic reviews and meta-analyses directly associated with the topic will be included only for the full-text citation checking step (see search strategy section). Only records available in English, Portuguese, and/or Spanish will be deemed eligible for inclusion.

Methods

This scoping review will be conducted following the Joanna Briggs Institute's (JBI) recommendations for scoping reviews (Peters et al., 2020) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (Appendix 1; Tricco et al., 2018). All supplemental materials are available at <https://doi.org/10.17605/OSF.IO/6N7PY>.

Search strategy

The search strategy will follow the three-step method, as recommended by the JBI (Aromataris et al., 2014):

- The **first step** will involve developing a comprehensive search strategy. The search query will be organised into two key components: the first will define the population of interest (pregnant participants), and the second will focus on the outcomes of interest (EEG metrics). Keywords for the search were identified by reviewing five up-to-date systematic reviews related to each component (selected reviews were published between 2019 and 2025). For pregnancy-related terms, we identified systematic reviews published in different fields of expertise (public health, neurology, etc) to ensure a heterogeneous pool of search terms. For EEG metrics, we identified one systematic review for each type of measure (time-frequency, source localization, connectivity, power spectrum, and event-related potentials) to guarantee that all EEG methodological approaches are captured with the proposed query. Following keyword identification, Medical Subject Headings (MeSH) terms were reviewed for each one of them to determine how each term should be incorporated into the search query - either as a MeSH term or limited to the title and abstract fields (see Appendix 2 for the systematic reviews used and the preliminary full research syntax for each database).
- In the **second step**, the final search query will be adapted for implementation in the following databases: PubMed, Web of Science Core Collection, Scopus, Cochrane for Trials and Reviews, PsycInfo, PsycArticles and Psychological and Behavioural Science Collection (the latter 3 through EBSCOhost), and tailored to each one as needed to achieve equivalent searches (for instance, whenever MeSH Terms were unavailable, subject/topic search terms were included in the queries to maximize similarity). Searches will be performed for title and abstract and will not be restricted by region or publication timeframe but will be limited to the proficient languages of the authors (English, Portuguese, and Spanish).
- The **third step** will involve examining the reference lists of the full-text sources included in the review to ensure that no eligible studies are overlooked. Additionally, grey literature will be screened using the ProQuest database and the most recent 100 preprints on OSF will be checked using “pregnancy” and “EEG” terms.

As a final step, we will contact five experts in the field of pregnancy, identified through [Expertscape.com](https://www.expertscape.com) by email. We will request their input regarding the inclusion of any potentially relevant study that may have been overlooked.

Study/Source of evidence selection

We will use *asreview lab* (<https://asreview.nl/>), an open-source machine learning-aided pipeline applied to systematic reviews (Boetjé & van de Schoot 2024). The process is an active learning cycle that trains the model while records are classified as relevant or irrelevant. As records get labelled, the learning algorithm improves leading to reordering the screening queue where we prioritise those most likely to be relevant. Ultimately, this method significantly reduces the time required for screening large datasets, improves transparency in the decision-making process, and minimises the risk of bias, making it a reliable and robust review process (Khalil et al., 2022; Roth and Wermer-Colan, 2023).

Following the search strategy implementation, duplicates will be removed using EndNote and the remaining references will be imported into *asreview lab*. We will apply the Oracle mode with default settings to screen the database (Ferdinands et al., 2020; Van De Schoot et al., 2021). This default mode utilizes TF-IDF for feature extraction technique, a naive Bayes classifier, a dynamic resampling strategy, and certainty-based sampling for querying relevant records (Van De Schoot et al., 2021).

This algorithm will be employed after an expert researcher (CC) inputs 5 relevant and 5 irrelevant articles. The 5 eligible articles will ideally cover the different EEG metrics and approaches (time-frequency, resting-state, etc), while the 5 non-eligible studies will address different exclusion criteria (case reports, animal studies, etc).

The number of screened articles will be defined by the *knee method* (van Haastrecht., 2022). This method calculates the ratio between the slope before and after a critical inflection point in the gain curve, represented by the percentage of screened abstracts (x-axis) and the percentage of identified expected relevant abstracts (y-axis). As a stopping rule for the screening process, a slope ratio > 6 will be applied (Cormack & Grossman, 2016). Since this method is not directly implemented in *asreview lab*, the knee calculation will be computed at every 5% of screening citations.

The relevant/irrelevant classification in *asreview lab* will be based on a standardized flowchart for eligibility criteria (see Appendix 3). First, titles and abstracts will be screened, considering the following criteria: (a) Language: English, Portuguese, or Spanish; (b) Type of article: exclude if it is a case report/case series, opinion, or letter; (c) Population of interest: if it includes a group of pregnant participants; and (d) Outcome of interest: if it includes an EEG assessment of the pregnant group. After the screening of all records and disagreements resolved, potentially relevant sources will be retrieved from *asreview lab* so we can manually assess the full text in detail. At this point, any studies identified from the reference lists of the systematic review and meta-analyses that meet the eligibility criteria will also be included. Articles

will exceed the full text if: (a) includes a quantitative EEG metric; and (b) the full text is available. Both title/abstract and full-text screening will be conducted by two independent reviewers (SA and PB) with any disagreements resolved through discussion or by a third reviewer (TOP). To avoid the risk of discarding eligible articles, the reviewers will follow a more liberal approach during the title/abstract screening. That is, only studies that do not meet any criterion described below will be excluded; otherwise, they will be screened in the full-text step where a final decision will be made.

As recommended by the JBI guidelines (Peters et al., 2020), a pilot test will be conducted before starting each stage of the screening process to assess the flowchart implementation. The pilot will proceed as follows:

- (1) A random subset of 100 references will be retrieved from the first 2000 citations provided by the asreview lab algorithm order after an expert researcher (CC) includes 5 relevant and irrelevant studies. This procedure will ensure that the pilot study includes both eligible and non-eligible articles.
- (2) Two independent reviewers blind to the expert's decision (SA and PB) will screen the titles and abstracts using the standardized flowchart (Appendix 3).
- (3) A team meeting will be held to resolve any discrepancies, implement any necessary adjustments to the eligibility criteria or flowchart, and calculate the agreement rate. Cohen's Kappa statistic (McHugh, 2012) will be used to measure agreement.
- (4) Steps 1, 2 and 3 will be repeated until $\kappa > 0.8$ to ensure reliability. The formal screening process for titles and abstracts will only begin when this criterion is met.
- (5) After title/abstract screening is completed, a random set comprising 5% of the included studies (minimum 10) will be piloted for full-text screening.
- (6) Steps 2 and 3 will be replicated for full-text screening. If the $\kappa > 0.8$ criterion is not, an additional subset of studies (5%; minimum 10 studies) will be piloted until this criterion is met. The formal full-text screening process abstracts will only begin when this criterion is met.

Two reviewers (SA and CC) will extract the information from the eligible records using a data extraction matrix on Microsoft Excel (see Appendix 4). The data extraction tables will be developed based on the items detailed below. Initially, two reviewers will pilot the current data extraction matrices using a subset of five eligible studies covering different types of EEG analysis. This approach aims to better assess the effectiveness of the data extraction matrices. Any discrepancies will be resolved by consensus or by referring to a third reviewer (TOP) and any required modifications to the data extraction matrix will be performed. After this, the reviewers will proceed with data extraction and any additional modifications of the data extraction matrix will be reported in the final version of the scoping review. Unreported information will be asked by email to the authors of the record (each set of authors will be contacted three times, after which the requested data will be coded and reported as missing). The final version of this Excel spreadsheet will be made available on OSF.

Data items

To better organise the data extraction process, multiple charting tables will be developed, each containing specific information while sharing a common identifier (first author and year of publication):

1. General study information (RQ 1):

- 1.1. First Author
- 1.2. Year of publication
- 1.3. Title of the study
- 1.4. Country of the study
- 1.5. The language of the report
- 1.6. DOI

2. Study design and main findings (RQ 1.1, RQ 1.2 and RQ 1.3):

2.1. Objective of the study

2.2. Study design

2.3. Sample size

2.4. Parenting-related measures

2.4.1. Moment of assessment: before conception, during pregnancy, afterbirth

2.4.2. Type of measure: Self-Report Mother, Self-Report Informants (e.g., partner, healthcare professional), Observation-Based

2.5. Parenting-related measures

2.6. Statistical model (e.g., statistical analysis, controlled variables)

2.7. Main results:

2.7.1. Pregnant vs non-pregnant participants EEG metrics comparison

2.7.2. EEG metrics' changes across pregnancy stages, before pregnancy and after postpartum

2.7.3. Association of EEG metrics and parenting-related measures

3. Sample characteristics (RQ 1.4):

3.1. Sociodemographic information: age, ethnicity, residence in country of birth, sexual orientation, income, educational level, current relationship status, number of non-biological children.

3.2. Obstetric information: weeks of pregnancy, type of gestation (singular or multiple) obstetric or fetal medical complications, parity, history of miscarriage or stillbirth.

3.3. Health and clinical information: past or present diagnoses and/or treatment for mental health problems, past or present relevant medical illnesses, and potentially traumatic lifetime events.

3.4. Exclusion criteria used in the study

4. Methodological EEG information (RQ 1.5):

4.1. EEG Recording Characteristics

4.1.1. Recording system/Amplifier

4.1.2. Resting-state:

4.1.2.1. Conditions description

4.1.2.2. Duration

4.1.3. Experimental Task:

4.1.3.1. Task name and description

4.1.3.2. Target process: working memory, emotion processing

4.1.3.3. Experimental condition

4.1.3.4. Task duration: number of trials, timing, and total duration

4.1.3.5. Task type: active or passive

4.1.3.6. Stimuli Modality: visual, auditory, multimodal, ...

4.1.3.7. Stimuli description: pure tones, shapes, faces, words...

4.1.3.8. Type of stimuli category: cognitive vs. Affective/social vs non-social/infant vs non-infant

4.1.4. Electrode type (cap, non-cap, material)

4.1.5. Number of channels

4.1.6. Electrode Locations

4.1.7. Recording Reference

4.1.8. Sampling Rate

4.1.9. Impedance levels

4.2. EEG data Preprocessing

4.2.1. Software

4.2.2. Downsampling

4.2.3. Filtering

4.2.4. Artefact Removal Procedures

4.2.5. Data Rejection Procedures

4.2.6. Interpolation

4.2.7. Rereferencing

4.2.8. Epoching

4.2.9. Baseline Correction

4.3. EEG metrics¹

4.3.1. Event-Related Potentials

4.3.1.1. ERP metric (e.g., LPP, HEP, N100)

4.3.1.2. Time window

4.3.1.3. Electrodes (s), hemisphere, and region

4.3.1.4. Statistical features (e.g., baseline to peak, latency, mean)

4.3.2. Power Spectrum Analyses

- 4.3.2.1. Electrode(s), hemisphere, and regions
- 4.3.2.2. Power spectrum method (e.g., FFT, Welch, Multitaper)
- 4.3.2.3. Frequency band (Hz)
- 4.3.2.4. Statistical features (e.g., mean, median, kurtosis)

4.3.3. Time-frequency Domain Analyses

- 4.3.3.1. Electrode(s), hemisphere, and regions
- 4.3.3.2. Frequency band (Hz)
- 4.3.3.3. Time window
- 4.3.3.4. Time-Frequency method (e.g., STFT, WT, spectrogram)
- 4.3.3.5. Statistical features (e.g., baseline to peak, latency, mean)

4.3.4. Connectivity Analyses

- 4.3.4.1. Electrode(s), hemisphere, and regions
- 4.3.4.2. Type of connectivity: Effective, functional
- 4.3.4.3. Analysis (e.g., Granger causality, correlation, synchronization likelihood)
- 4.3.4.4. Connectivity features

4.3.5. Source Localization Analyses

- 4.3.5.1. Electrode(s), hemisphere, and regions
- 4.3.5.2. Inverse solution
- 4.3.5.3. SOZ localization approach (e.g., LORETA, FOCUSS, Dipole)
- 4.3.5.4. Power measure (e.g., source density, global relative/absolute power).

¹ The above classification assumes that each analysis type is independent; however, we are aware that connectivity and source localization analyses can be integrated within ERP, frequency, and frequency-time domain analyses. Therefore, if studies incorporate combined analyses, we will introduce new categories within the classification to account for them.

Data analysis and presentation

The search results and the eligibility process will be reported in the scoping review and presented in a PRISMA flow diagram (Tricco et al., 2018). The extracted data will be displayed in the form of tables and graphs according to the RQs. We will address each RQ in a synthesis paragraph using the theoretical framework proposed in the Concept Section pending possible post-hoc decisions that are likely to come from the specificities of included studies.

A first narrative summary will be conducted to provide an overview of the evidence (**RQ 1**), focusing on the number of studies, year of publication, and country of the study. Along with this description, we will include a line chart to represent the growing interest in the topic over time and a world map to visualise the geographical distribution of the research samples. This will allow us to underscore the importance of a transcultural approach in this field of research, by identifying whether there is an overrepresentation of studies from specific regions (i.e., western countries) and regions that may be underrepresented (i.e., non-western countries and low-income countries).

To answer **RQ 1.1**, **RQ 1.2**, and **RQ 1.3**, which focus on mapping the three main types of study results, we will provide separate tables for each of them (Appendix 5). Each of these tables will include key sample characteristics, data collection methods specificities, EEG metrics, and study findings. Concerning the synthesis paragraphs, **RQ1** we will categorise and quantify the studies based on whether reported: (1) Resting-state vs task-based approach; and (2) whether the stimuli are: cognitive vs emotional; social vs. non-social; infant vs non-infant.

For **RQ2**, the summary will categorise the studies based on the five timepoints assessments: before conception, 1st trimester, 2nd trimester, 3rd trimester of pregnancy, and postpartum period (six weeks after birth). We will report the percentage of studies that focused on each of these specific timepoints.

For **RQ3** we will report the number of studies that used a self-report or an observational-based methodology to assess parenting-related measures, and whether the self-reports are answered by the pregnant participants or by others (e.g., partner, healthcare professionals).

Due to the large amount of information needed to answer **RQ 1.4** and **R. Q 1.5**, only a quantitative summary for each topic will be included in the main text. Tables will be placed as supplementary material. More concretely, the summary answering **RQ 1.4** will present the distribution of sample sizes across studies, the percentage of studies: (a) focusing on early or late stages of pregnancy; (b) reporting pregnancy complications, and (c) addressing maternal mental health. The Supplementary table (Appendix 6) will cover sociodemographic characteristics of the sample (e.g., age, educational level, number of children), obstetric information (e.g., weeks of pregnancy, any obstetric or fetal complication) and clinical information (e.g., present or past health medical diagnosis or treatment).

RQ 1.5 encompasses a wide range of relevant EEG methodological information. To address this, two distinct tables will be used, following the approach adopted in a previous scoping review (Hu et al., 2024). Accordingly, Tables 4 and 5 (Appendix 7) will include EEG recording characteristics and EEG preprocessing information respectively. In the quantitative summary, we will detail the technical aspects of EEG by quantifying the average of the duration of EEG recording. We will analyse the percentage of the different main preprocessing steps implemented, that is including filtering (high and/or low-pass filters), artifact rejection methods, and baseline correction procedures. The summary will also include the frequency of each of the data analysis approaches used.

Ethics and consent

Ethics approval or consent are not applicable to the present scoping review protocol.

Author contributions

PVB and SA contributed equally to this manuscript (co-first authorship). PVB and SA contributed to Conceptualization, Methodology, Writing - Original Draft Preparation, and Writing - Review & Editing. CC contributed to Conceptualization, Funding Acquisition, Methodology, Project Administration, Writing - Original Draft Preparation, and Writing - Review & Editing. TOP contributed to Conceptualization, Methodology, and Writing - Review & Editing. DL, IJ, RC, RP and TMP contributed to Funding Acquisition, and Writing - Review & Editing. JO contributed to Writing - Review & Editing.

Data and software availability

No data associated with this article.

Extended data

supplemental materials are available at:

Open Science Framework: *EEG Signatures During Pregnancy and their Role on Parenting-Related Measures: Scoping Review* [Dataset]. <https://doi.org/10.17605/OSF.IO/6N7PY> (Braga et al., 2025).

This project contains the following underlying data:

- Appendix 1. PRISMA checklist.docx (PRISMA checklist for Scoping Reviews)
- Appendix 2. Search syntax.docx (inputs for query design & exact query for each database)

- Appendix 3. Standardized flowchart.tif (PRISMA flowchart for record screening)
- Appendix 4. Data extraction Chart tables.xlsx (data extraction spreadsheet)
- Appendix 5. Main results.docx (table synthesizing main results)
- Appendix 6. Sample characteristics.docx (table synthesizing sample characteristics)
- Appendix 7. EEG methodological data.docx (table synthesizing EEG methods information)
- Pregnancy EEG scoping review_vFinal.pdf (publicly available preprint)

All data files under the scope of this project are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

Reporting guidelines

As stated in Page 6, the present scoping review protocol follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines. This information is provided in Appendix 1 of the Supplemental Materials <https://doi.org/10.17605/OSF.IO/6N7PY> (Braga et al., 2025).

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