Session 1:

Early Beginnings: Strengthening Parental Support in Pregnancy and the First Months

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Better Start CONFERENCE
Blackpool 5th March 26

Symposium One

betterstart.org.uk/conference

Prenatal Environmental Effects on Postnatal Outcomes (PEEPO): Can the prenatal environment set a cascading path for long-term educational outcomes?

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Infant and Child Development Lab (ICDL)

Better Start Conference, Blackpool

Who are we?

Durham University

WARWICK
THE UNIVERSITY OF WARWICK

BRADFORD INSTITUTE
FOR HEALTH RESEARCH
MAKING RESEARCH REAL

Lancaster University

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Nuffield Foundation

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PEEPO

Prenatal Environmental Effects on Postnatal Outcomes

Prof. Debbie Riby

Prof. Thijs van Rens

Dr Charlotte Rothwell

Dr Rebecca Hall

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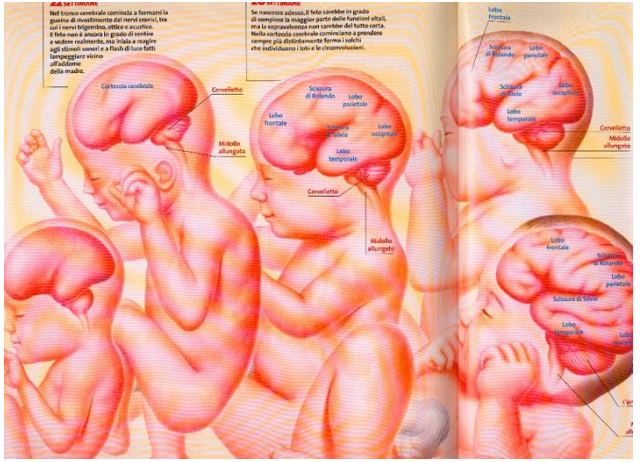
Investigating the origins of the ‘achievement gap’

- Much governmental investment into educational curricula globally.
- Despite these efforts, the overall educational attainment of children has only improved minimally (Bolden & Tymms, 2020).
- Important that we innovate and adopt alternate strategies, e.g:
  - Developmental Psychology - a wealth of published research that provides key insights on the environmental effects on brain development in the womb, long before children even reach school age (e.g. Kisilevsky et al., 2009).
- UK’s “Levelling Up” white paper (2022) - interventions from school age onwards,
- Chair of ‘The Early Years Healthy Development Review’, Rt Hon Andrea Leadsom, recognized that ‘despite the billions that are spent on school readiness, the building blocks begin at conception’.

Considering the Environment before birth

- E.g Long-term effects of maternal stress on offspring biological responses to stress.
  - Children whose mothers had higher levels of serum cortisol during their pregnancy had higher levels of serum cortisol on their first day of school and at 10-years of age (Gutteling et al., 2005; O'Connor et al., 2005)
  - suggesting long-term changes in hypothalamic-pituitary-adrenal (HPA) axis function that are responsive to maternal stress.



Complexity of Maternal Stress

- Umbrella term with inherent complexities.
- Unique to individuals
- Can manifest in multiple ways, with physiological, physical, psychological, emotional and behavioral sequelae.
- The causal factors for maternal stress are multitudinous and diverse, ranging from financial pressures, abusive relationships, war, famine, illness, or the inherent stress of modern daily life.
- Multiple measures (including physiological and self-reported measures).

Further Complexity - Co-occurance

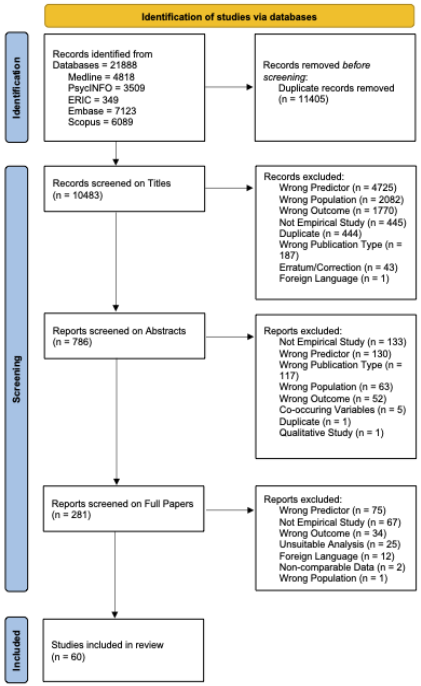
- 20% of pregnant women in the UK suffer from mental health problems either during their pregnancy or within the first year after birth, according to the ‘Maternal Mental Health Services’ (MMHS) Progress Report [2024].
- May go undiagnosed and untreated.
- Maternal stress often co-exists with depression and adverse lifestyle behaviors (including impaired nutrition and sleep).
- Within the UK, maternal depression has increased from 11% pre-COVID to 19% post-COVID (Nielson, D et al., 2021).
- Maternal nutrition and sleep are highly influential environmental factors that influence fetal development (Pires et al., 2021; Tonietti et al., 2015), neural plasticity (Chango et al., 2015).

Aims

- Current literature highlights an important role for maternal stress on fetal brain development.
- Relatively few studies that explore the effects of maternal stress on the educational attainment of offspring during their childhood years.
- In this systematic review, we examine how different forms and measures of maternal stress during pregnancy influence early perceptual and cognitive development and, ultimately, educational attainment.
- To systematically review the evidence on how prenatal maternal stress affects children's:
  - Cognitive development (e.g., attention, IQ)
  - Academic attainment (e.g., literacy, numeracy, school readiness).

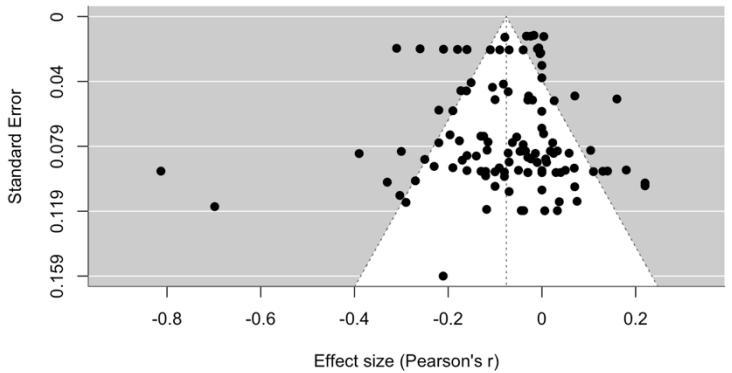
Search Strategy

- The protocol was preregistered on PROSPERO (CRD42024596588).
- Scopus, PsycINFO, ERIC, MEDLINE, and Embase were searched up to February 2024.
- Search terms focused on the broad areas related to the prenatal period (e.g., pregnancy, antenatal); maternal stress (e.g., distress); childhood (e.g., infant, preschooler); and cognitive development (e.g., cognition, attention) or academic success (e.g., school readiness, literacy).
- *Inclusion criteria*
  - Assess maternal stress during pregnancy.
  - Measure child development outcomes including attention, intelligence, cognitive development, or educational attainment.
- *Exclusion criteria*
  - Postnatal stress assessments, non-behavioural measures (e.g., neuroimaging), or children with neurodevelopmental diagnoses.
- *Quality control*
  - Study screening, data extraction, and quality assessment were undertaken independently and in duplicate, with inter-rater reliability ≥90%.
  - The NIH Quality Assessment Tool classified all included studies as fair to good.



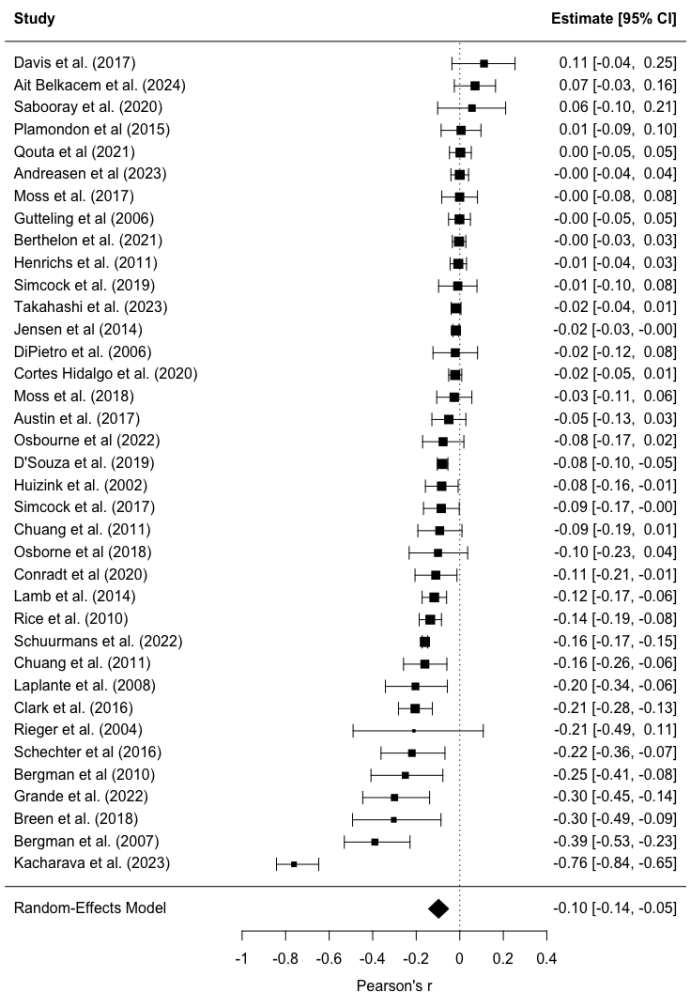
Data Analysis

- Where sufficient data was available, meta-analysis was performed using random mixed-effects models using RStudio (Posit team, 2024).
- 114 datapoints across 36 studies for analysis.
- Effect sizes were transformed to Fisher's z and synthesised using multilevel random-effects meta-analysis with inverse-variance weighting and REML estimation. Clustering of multiple effects within studies was accounted for in the model.



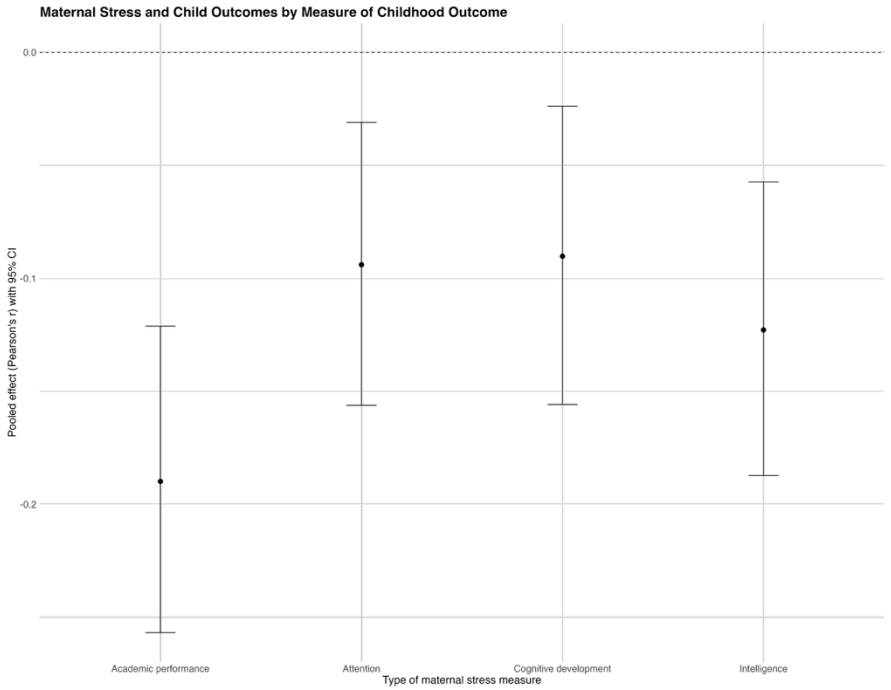
Findings – Overall

- Considerable heterogeneity
  - ($I^2 > 85\%$)
- Small positive or near-null associations (e.g., Ait Belkacem et al., 2024; Davis et al., 2017),
- Moderate negative associations (e.g., Bergman et al., 2007; Breen et al., 2018)
- Many confidence intervals overlapped zero (Simcock et al., 2019; Moss et al., 2023),



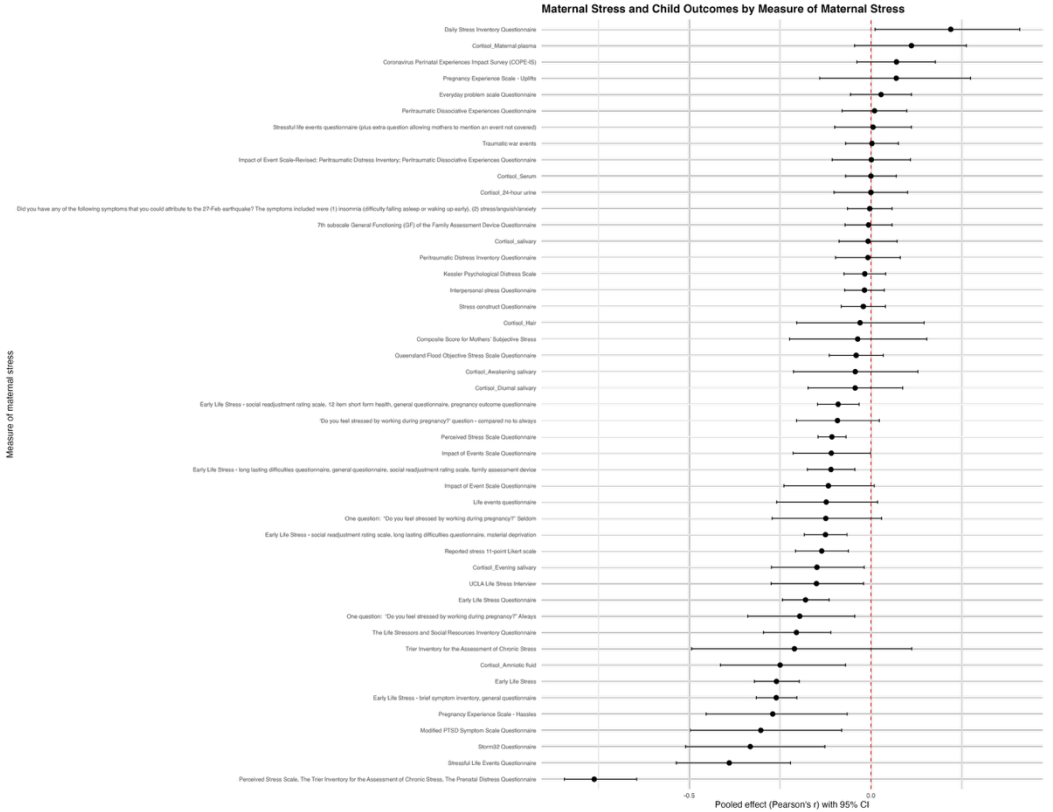
Findings – Type of Childhood Outcome Measure

- Significant variation in effect magnitude as a function of assessment, $QM(3) = 32.58$, $p < .001$
- Strongest effect for academic performance
- A downstream manifestation of earlier attentional and cognitive vulnerabilities, accumulating across development into educational performance differences?



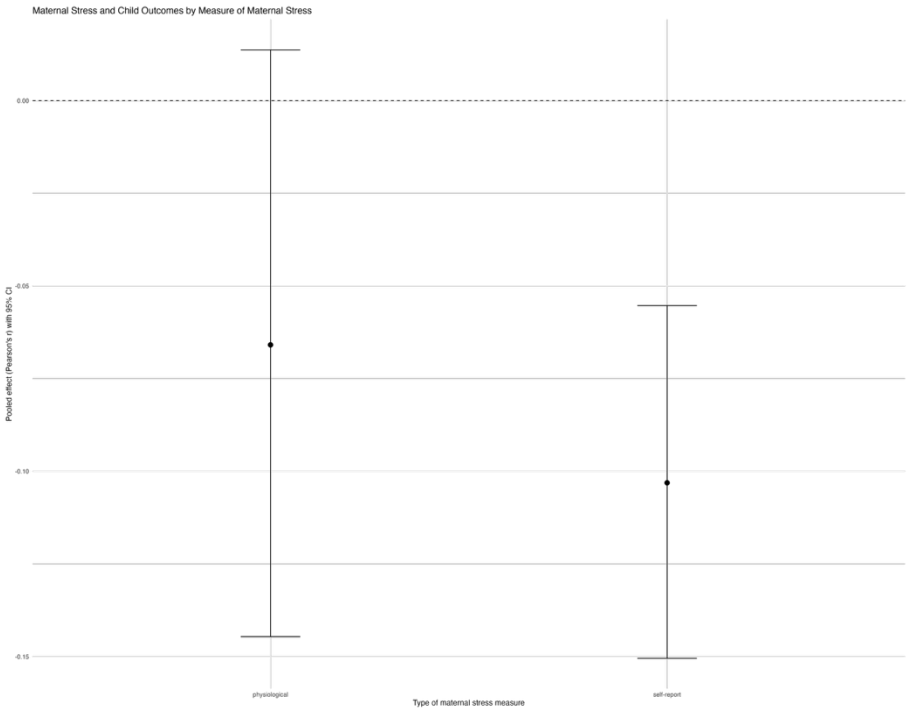
Findings – Type of Maternal Stress Measure

- As a fine-grained categorical moderator (47 levels), type of measure significantly explained variability in effect sizes, QM(46) = 317.26, p < .001, indicating substantial heterogeneity across measures.



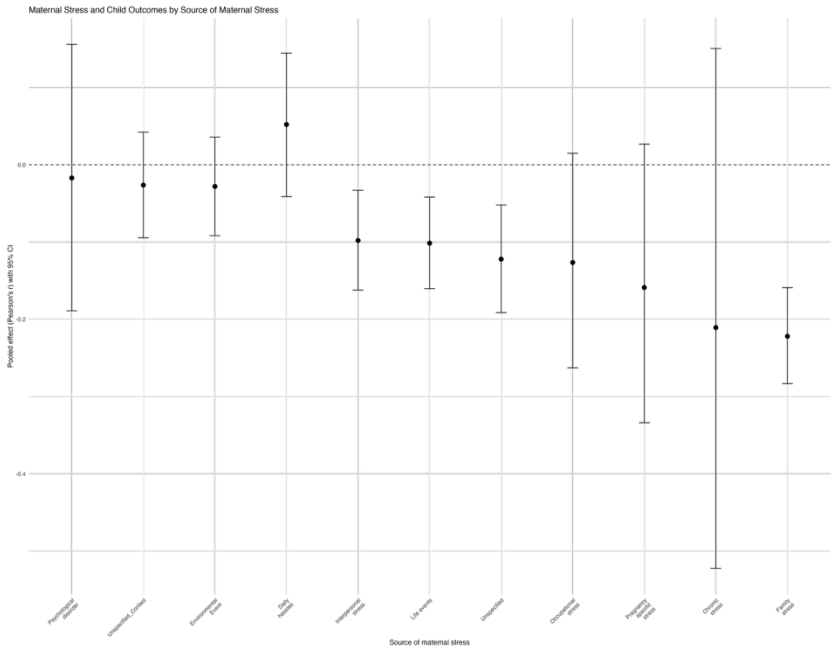
Findings – Type of Maternal Stress Measure

- As a broader physiological versus self-report distinction, the moderator was not statistically significant, QM(1) = 0.92, p = .339, likely a reflection of the large confidence intervals within the physiological category limiting power to detect between-group differences.



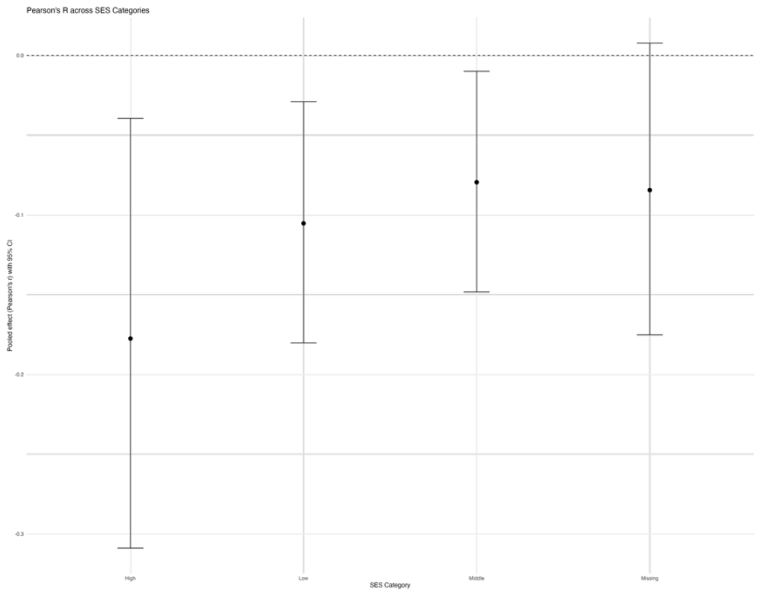
Findings – Source of Maternal Stress Measure

- The association between maternal stress and child outcomes varied significantly as a function of stress source, $QM(10) = 81.49$, $p < .001$
- Not all stress exposures relate to equivalent developmental risk.
- Stressors related to transient daily irritations may be less developmentally consequential.



What we did not find

- Reliable differences in
  - SES
  - Location
  - Timing of Exposure
- Large heterogeneity in reporting leading to large Nas and unstable directional effects



Conclusions

- We provide evidence for a negative correlation between early childhood cognitive development and educational attainment with maternal stress during *in utero* development.
- Self-reporting was an important driver of negative correlation with offspring outcomes. Maternal perceptions of stress are a more reliable indicator of later childhood outcomes than physiological measures.
- Not all stress is equal
- Effects may amplify either over time or by measure of child outcome
- SES and timing of exposure rarely reported
- Majority of world geography remains under represented

The effect of prenatal maternal malnutrition on children's cognitive development and attainment: a systematic review

Background

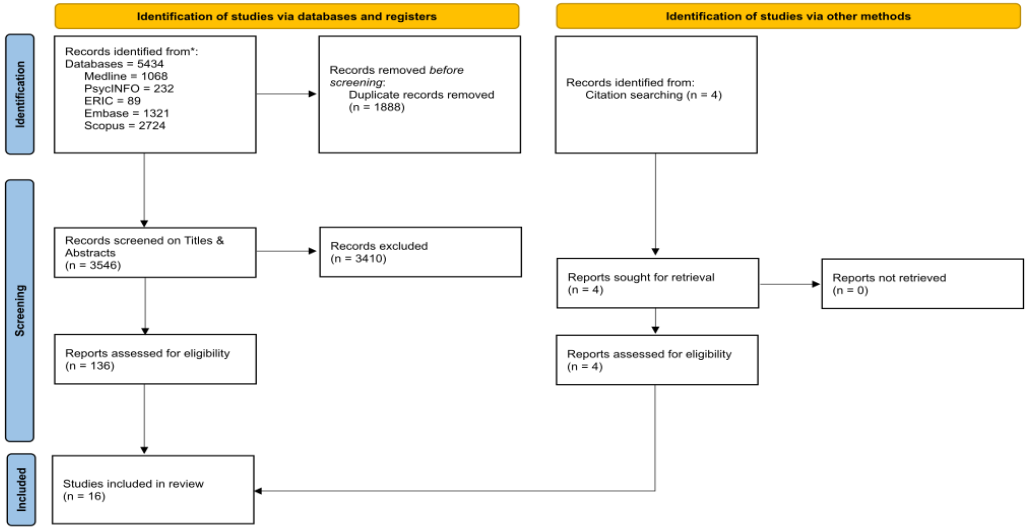
- Adequate maternal nutrition during pregnancy is essential for foetal brain development (Kirolos et al., 2022; De Matos Reis et al., 2024)
- Malnutrition, including deficiencies in nutrients like vitamin D, iron, and folate, may be associated with altered cognitive and educational outcomes in offspring (De Matos Reis et al., 2024).
- Despite growing public health concern, findings across studies remain mixed, often due to variability in how nutritional status and cognitive outcomes are measured.
- To systematically review the evidence on how prenatal maternal malnutrition affects children's:
  - Cognitive development (e.g. attention, IQ)
  - Academic attainment (e.g. literacy, numeracy, school readiness)

Search Strategy

- Reviews, case reports, theses, or grey literature
- Search strategy:
  - Pre-registered protocol on PROSPERO: CRD42024596445
  - Databases: MEDLINE, Embase, Scopus, PsycINFO, ERIC
  - Search terms:
    - Exposure: pregnancy, maternal nutrition, malnutrition, nutrient deficiency
    - Outcomes: IQ, attention, cognitive development, academic attainment
- Search restricted to studies published up to October 2024

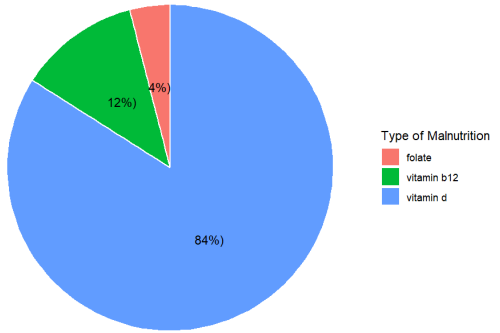
Search Strategy

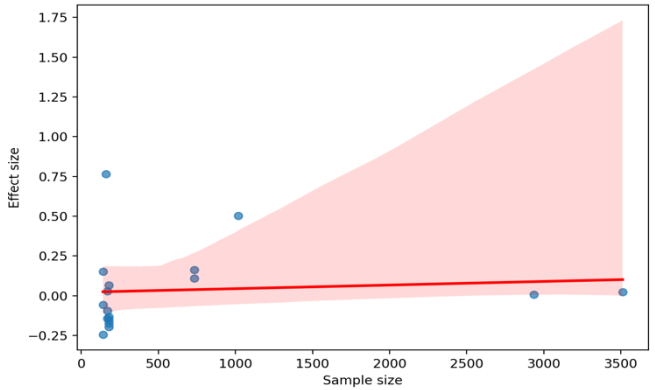
- Inclusion criteria:
  - Human studies with malnourished maternal populations, including defined nutrient deficiencies (e.g. vitamin D, iron, folate)
  - Exposure measured during pregnancy using biomarkers or validated tools
  - Postnatal child cognitive or academic outcomes measured using standardised or experimental tools
- Exclusion criteria:
  - Studies without clearly defined malnourished or deficient groups
  - Postnatal-only maternal measures
  - Neurodivergent populations
  - Outcomes assessed solely with neuroimaging



Preliminary Results

- A large proportion of studies focused on vitamin D deficiency
  - Vitamin D deficiency and insufficiency is still common in sun-rich countries like Spain and Vietnam
  - There is no clear scientific consensus on what classes as deficiency
- There does not appear to be a clear pattern indicating an impact of malnutrition on cognitive development or intelligence





Preliminary Conclusion

- Across reviewed studies, no consistent association was found between maternal malnutrition and child cognitive or academic outcomes
  - Variability in outcome measures, age at testing, and postnatal environment may explain the heterogeneity

- The majority of studies focused on vitamin D, while evidence for other micronutrients (e.g. iron, iodine, folate) remains limited
  - Broader research is needed to clarify the roles of underrepresented nutrients in neurodevelopment, as well as overall diet factors

- Greater consistency in cognitive and nutritional assessment tools will enhance the comparability and impact of future findings.

Recommendations for Research

- Future studies should explore the effects of self-reported maternal stress on measures of fetal development:
  - e.g, newborn infants show a preference for stories that have been read to them in the womb (DeCasper & Spence, 1986). Furthermore, pregnant women with symptoms of depression interact less with their fetuses including less reading, talking and singing (Hernandez-Reif et al., 2018), although it is not clear how much speech is required for normal fetal development.
- There is a clear need for future longer-term studies, to gain key insights into the broader implications of maternal stress beyond early childhood.
- Researchers should continue to investigate using more homogeneous methods and stronger practice in methodology reporting

Recommendations for Support

- Our traditional approach is too late. Support for the learning environment should begin much earlier in development
- Not doing so may set a cascading path to educational attainment gaps later in childhood
- Clear links between childhood educational attainment and future income (Duflo, 2001; Psacharopoulos et al., 2004), and an estimated net economic benefit of £490 million to the NHS over ten years through properly addressing unmet maternal mental health needs during pregnancy (Bauer et al., 2022).
- Emotional effects of academic attainment persist into adulthood, with university students associating academic failure with embarrassment, shame, and devastation (Ajjawi, 2020).
- We should support maternal perception of stress to mitigate the effects of stress early on in child development, with a focus on specific types of stress.
- Multi-sectoral policies that integrate nutrition, education, and psychosocial support may provide the most robust improvements in early childhood development outcomes, yet major potential factors remain wildly understudied

Many thanks…

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