

Project Title:

Maternal Biopsychosocial Stress and Subsequent Fertility Behavior in Norway

Research Questions:

How do cumulative stress exposures in mothers (biological and perceived) around the time of a child's birth affect subsequent fertility decisions?

What are the relative contributions of the distinct stress domains to these fertility outcomes?

Introduction:

The sustained decline in fertility rates across high-income countries represents one of the most significant demographic shifts of the 21st century [1]. Within this global trend, the Nordic region presents a particularly interesting puzzle. Long considered a model of how generous family policies and high levels of gender equality could sustain fertility near replacement level [2], countries like Denmark and Norway have, since the early 2010s, experienced a notable and persistent downturn in birth rates [3]. While much focus has been on the postponement and reduction of first births, recent research suggests that declines in second and third births also contribute to these trends across the Nordic countries [4]. This development challenges established theoretical assumptions and suggests that the mechanisms driving contemporary fertility behavior are not yet fully understood.

The low and late fertility of high-income countries is often seen as a rational response to the economic uncertainties and unstable gender norms of our time [5]. Much of the existing literature has sought to explain these trends through an economic lens, focusing on factors such as economic uncertainty, precarious employment, and the rising direct and opportunity costs of childbearing [6, 7, 8]. While these factors are undoubtedly important, their explanatory power appears to be insufficient. The continuation of fertility declines well into periods of economic recovery suggests that focusing solely on economic constraints is inadequate to capture the full complexity of modern reproductive decision-making [9]. This points to a critical gap in literature and a need to move beyond the economic lens to consider a wider array of influences.

Theoretical Framework:

This doctoral project proposes an alternative yet complementary framework to investigate how the cumulative exposure to biopsychosocial stress experienced by a mother during a pivotal period of transition to parenthood constitutes a powerful yet under-examined pathway influencing subsequent fertility outcomes. It hypothesizes that the 'wear and tear' of navigating complex social and economic landscapes manifests in perceived psychological distress and physiological dysregulation [10], which accumulate over time to shape fertility decisions following the transition to parenthood, such as having additional children.

To conceptualize the mechanism linking stress to fertility, this study integrates principles from **stress theory**, particularly the concept of *allostatic load*. Allostatic load refers to the physiological consequences of chronic exposure to fluctuating or heightened neural or neuroendocrine responses resulting from repeated or chronic stress. This ‘wear and tear’ can manifest as dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and elevated levels of systemic inflammation [10]. Recent studies have operationalized the cumulative measure of biological dysregulation (allostatic load) to examine demographic outcomes [11, 12]. By combining biological markers with measures of social and psychological stress, this project seeks to create a proxy for an individual's cumulative stress load.

This project aims to implement this concept by using measures of:

Psychological stress: validated measures of perceived distress, depression/anxiety scores, and personality traits like neuroticism.

Social stress: Measures of loneliness, partnership dissatisfaction, and the absence of social support.

Biological stress: an allostatic load score derived from biomarkers of inflammation, metabolic, and neuroendocrine function (e.g., hs-CRP, IL-6, cortisol, alpha-amylase, HbA1c, DHEA-S, albumin, fibrinogen, serum creatinine, BMI, systolic/diastolic BP).

This project hypothesizes that a higher maternal stress burden may influence subsequent fertility through two distinct pathways: a biological pathway, by potentially impacting fecundity and a behavioral pathway, whereby the experience of chronic stress during the transition to parenthood shapes partnership stability, the perceived stress of having another child, and the desire and intention for family completion. By doing so, this research reframes the inquiry from a focus on external shocks to an examination of the embodied, cumulative consequences of life experiences. This approach allows for a deeper understanding of how broad, societal-level shifting priorities are translated into individual-level reproductive trajectories.

Emerging evidence suggests that higher stress is associated with adverse pregnancy outcomes, longer time to conception, and greater risk of infertility [13, 14]. Research demonstrated the applicability of using allostatic load to measure post-reproductive maternal health [15]. A study reported that higher allostatic load scores across nine biomarkers were linked to lower fecundability [16], while another showed that preconception allostatic load was associated with increased risks of pregnancy outcomes like preterm birth and low birthweight [17]. A systematic review discussed that pre-natal allostatic load measured during the second trimester presented a critical window for capturing the physiological effects of stress on birth outcomes [18], which this project aims to replicate.

This project emphasizes that developmental trajectories and major life transitions, such as parenthood, are shaped by the accumulation of experiences over time. Within this view, subsequent fertility decisions are not made in a vacuum but are the culmination of a long process influenced by the life conditions and events surrounding prior birth. Psychological mechanisms like high

neuroticism are shown to be linked to a delay in the first-birth timing [19] and perceived stress amplified fertility postponement [20], while emotional stability in men showed positive associations with fertility [21]. Loneliness and the absence of instrumental social support also relate to lower childbearing intentions [22]. This framework is therefore essential for understanding how biopsychosocial stress experienced during a critical life event - the birth of a child - may have lasting consequences on individuals' reproductive health and behavior. This study aims to illuminate how such stress experienced by mothers influences their subsequent reproductive trajectory.

Methods and Data Sources:

First, a comprehensive, multi-domain stress index for mothers will be developed and validated, with two key components (*social stress* and *psychological stress*: indicators of loneliness, unavailability of social support, partnership dissatisfaction, perceived distress, depression, and anxiety). This psychosocial stress index, measured around the time of a child's birth, will be the primary predictor for two key subsequent fertility outcomes: the *timing of the next birth* and the *likelihood of not having a subsequent child within 5 years*.

Next, an allostatic load using stress biomarkers will be constructed, primarily utilizing neuroendocrine and inflammatory biomarkers for mothers: (hs-CRP, IL-6, cortisol, alpha-amylase, HbA1c, DHEA-S, albumin, fibrinogen, serum creatinine, BMI, systolic/diastolic BP), and will be used to validate the above findings.

Finally, aside from a composite index of stress, the relative importance of distinct biological, psychological, and social stress domains in relation to fertility outcomes will be explored to assess whether certain types of stress exert stronger effects than others.

This project will utilize data from the high-quality longitudinal cohort study, *MoBa: the Norwegian Mother, Father and Child Cohort*. This data crucially allows for **linkage** to comprehensive **Norwegian national administrative registers**. Specifically, the analysis will draw upon **biological samples collected from mothers mid-pregnancy (week 17-20)** [*hs-CRP, Albumin, HbA1c, HDL, Cortisol* and *Creatinine* already available in maternal dataset] and **questionnaire data (6-and 18-months postpartum)**. Biomarkers from 0-3 days after birth may reflect the acute wear and tear effect on the mother's body and may not be a stable or reliable indicator of long-term physiological state.

Analytical Strategy:

The analytical strategy will proceed in five steps:

1. **Index Construction:** All biological, psychological, and social indicators will be standardized. **Latent Profile Analysis (LPA)** will be used to identify distinct, empirically derived biopsychosocial stress profiles. This person-centered approach moves beyond the limitations of traditional summed scores to capture the heterogeneity of stress manifestation [23].

2. **Event History Analysis:** To analyze the chances of subsequent births over time (Chapter 2), we will use Cox proportional hazards models. This analysis will use a mother's specific *stress profile* as the main predictor, comparing each stress group to the 'low stress' group. This approach lets us see if different *patterns* of stress, not just the total amount, are linked to subsequent fertility.
3. **Likelihood Analyses:** The likelihood of **not having a subsequent child** within 5 years postpartum will be assessed using **logistic regression**, as a complementary approach to the event history models.
4. **Robustness Checks:** The validity of findings will be enhanced through: (a) sibling fixed-effects models; (b) inverse-probability weighting for attrition; and (c) comparison to models using a traditional summed z-score index.

Expected Findings and Contribution:

Based on the theoretical framework integrating stress theory and the concept of allostatic load, we hypothesize that higher levels of cumulative biopsychosocial stress experienced by mothers around childbirth will be associated with *delayed subsequent births* and a *lower likelihood of having another child within five years*. We anticipate that mothers falling into profiles characterized by 'high combined psychosocial and biological stress' will exhibit the most significant postponement of subsequent births and the highest probability of not progressing to a higher parity compared to the 'low overall stress' reference group.

Regarding the relative contributions of different stress domains, we hypothesize that while both psychosocial stress (loneliness, low support, psychological distress) and biological stress (allostatic load) will independently predict fertility outcomes, the biological component may show a particularly strong association, reflecting the physiological constraints ('wear and tear') on reproductive capacity or health.

This research addresses the mechanisms behind falling fertility by proposing and testing a novel, non-economic explanation rooted in biopsychosocial health. Additionally, it relates directly to the question of rising social inequalities in fertility. As both stress exposure and the resources to deal with it are unevenly distributed across social groups, this research can investigate whether biopsychosocial stress acts as a mechanism through which social disadvantage is translated into *delayed subsequent births* and *lower completed family sizes*, a pattern of growing concern in the Nordic context.

The proposed research further aligns with the work of the MoBa-BIOSFER team at the Norwegian Institute of Public Health (NIPH), building the Global Questionnaire, under the leadership of **Siri Eldevik Håberg**, and the psychosocial and demographic expertise of key researchers like **Fartein Ask Torvik**, **Jonathan Wörn**, and **Martin Flatø**. Ethical approvals from relevant review boards (e.g., REK in Norway) will be secured.

Bibliography:

- [1] Lesthaeghe, R. (2014). The second demographic transition: A concise overview of its development. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(51), 18112–18115. <https://doi.org/10.1073/pnas.1420441111>
- [2] Joshi, H. (2010). The incomplete revolution: Adapting to women's new roles by Gosta Esping-Andersen. *Population Studies*, *64*(2), 199–200. <https://doi.org/10.2307/25749150>
- [3] Jalovaara, M., Neyer, G., Andersson, G., Kreyenfeld, M., & Dommermuth, L. (2019). Education, gender, and cohort fertility in the Nordic countries. *European Journal of Population*, *35*(3), 563–586. <https://doi.org/10.1007/s10680-018-9492-2>
- [4] Hellstrand, J. (2021). Not just later, but fewer? Novel trends in cohort fertility in the Nordic countries. *Demography*, *58*(4), 1373–1399. <https://doi.org/10.1215/00703370-9366810>
- [5] Vignoli, D., Guetto, R., Bazzani, G., Drefahl, S., & Franck, R. (2020). A reflection on economic uncertainty and fertility in Europe: The narrative framework. *Genus*, *76*(1), Article 28. <https://doi.org/10.1186/s41118-020-00094-3>
- [6] Sobotka, T., Skirbekk, V., & Philipov, D. (2011). Economic recession and fertility in the developed world. *Population and Development Review*, *37*(2), 267–306. <https://doi.org/10.1111/j.1728-4457.2011.00411.x>
- [7] Matysiak, A., & Vignoli, D. (2008). Fertility and women's employment: A meta-analysis. *European Journal of Population*, *24*(4), 363–384. <https://doi.org/10.1007/s10680-007-9146-2>
- [8] Balbo, N., Billari, F. C., & Mills, M. (2013). Fertility in advanced societies: A review of research. *European Journal of Population*, *29*(1), 1–38. <https://doi.org/10.1007/s10680-012-9277-y>
- [9] Comolli, C. L., Neyer, G., Andersson, G., Dommermuth, L., Fallesen, P., Jalovaara, M., & Jónsson, A. K. (2021). Beyond the economic gaze: Childbearing during and after recessions in the Nordic countries. *European Journal of Population*, *37*(2), 473–520. <https://doi.org/10.1007/s10680-020-09570-0>
- [10] McEwen, B. S., & Stellar, E. (1993). Stress and the individual: Mechanisms leading to disease. *Archives of Internal Medicine*, *153*(18), 2093–2101. <https://doi.org/10.1001/archinte.1993.00410180039004>
- [11] Seeman, T. E., Crimmins, E., Huang, M. H., Singer, B., Bucur, A., Gruenewald, T., Berkman, L. F., & Reuben, D. B. (2004). Cumulative biological risk and socio-economic differences in mortality: MacArthur studies of successful aging. *Social Science & Medicine*, *58*(10), 1985–1997. [https://doi.org/10.1016/S0277-9536\(03\)00402-7](https://doi.org/10.1016/S0277-9536(03)00402-7)
- [12] Dowd, J., Simanek, A., & Aiello, A. (2009). Socio-economic status, cortisol and allostatic load: A review of the literature. *International Journal of Epidemiology*, *38*(5), 1297–1309. <https://doi.org/10.1093/ije/dyp277>

- [13] Miodownik, S., & Sheiner, E. (2024). Stress and pregnancy outcomes: A review of the literature. *Seminars in Thrombosis and Hemostasis*, 51(4), 412–422. <https://doi.org/10.1055/s-0044-1792002>
- [14] Lynch, C. D., Sundaram, R., Maisog, J. M., Sweeney, A. M., & Buck Louis, G. M. (2014). Preconception stress increases the risk of infertility: Results from a couple-based prospective cohort study—The LIFE study. *Human Reproduction*, 29(5), 1067–1075. <https://doi.org/10.1093/humrep/deu032>
- [15] Leone, T., Väisänen, H., & Witoelar, F. (2023). Women’s fertility and allostatic load in the post-reproductive years: An analysis of the Indonesian Family Life Survey. *Population Studies*, 78(1), 127–149. <https://doi.org/10.1080/00324728.2022.2160004>
- [16] Hong, X., Yin, J., Zhao, F., Wang, W., Ding, X., Yu, H., & Wang, B. (2022). Female fecundability is associated with pre-pregnancy allostatic load: Analysis of a Chinese cohort. *Acta Obstetrica et Gynecologica Scandinavica*, 101(11), 1300–1307. <https://doi.org/10.1111/aogs.14443>
- [17] Vitek, W., Barrett, E. S., Mbowe, O., Thurston, S. W., Santoro, N., & Diamond, M. P. (2017). Pre-conception allostatic load is associated with pregnancy outcomes, but not fertility, among women with unexplained infertility. *Fertility and Sterility*, 108(3), e102–e103. <https://doi.org/10.1016/j.fertnstert.2017.07.313>
- [18] Premji, S. S., Pana, G. S., Cuncannon, A., Ronksley, P. E., Dosani, A., Hayden, K. A., Lalani, S., Musana, J. W., Shaikh, K., Yim, I. S., & MIGTHCiR. (2022). Prenatal allostatic load and preterm birth: A systematic review. *Frontiers in Psychology*, 13, Article 1004073. <https://doi.org/10.3389/fpsyg.2022.1004073>
- [19] Reis, O., Dörnte, M., & von der Lippe, H. (2011). Neuroticism, social support, and the timing of first parenthood: A prospective study. *Personality and Individual Differences*, 50(3), 381–386. <https://doi.org/10.1016/j.paid.2010.10.028>
- [20] Zhao, J., Qi, W., Cheng, Y., Li, Y., Hao, R., Yuan, M., ... Hu, J. (2024). Influence of perceived stress on fertility intention among women of childbearing age without children: Multiple mediating effects of anxiety, family communication and subjective well-being. *Reproductive Health*, 21, Article 135. <https://doi.org/10.1186/s12978-024-01855-5>
- [21] Peters, S. (2024). *Who starts a family? The prospective association between psychological factors and family formation processes* (Doctoral dissertation, Stockholm University, Department of Sociology). <https://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-227448>
- [22] Artamonova, A., Sorsa, T., Berg, V., Häggglund, A. E., & Rotkirch, A. (2024). Social resources are associated with higher fertility intentions in contemporary Finland. *Comparative Population Studies*, 49, Article 4. <https://doi.org/10.12765/CPoS-2024-04>
- [23] Carbone, J. T., Clift, J., & Alexander, N. (2022). Measuring allostatic load: Approaches and limitations to algorithm creation. *Journal of Psychosomatic Research*, 161, 111050. <https://doi.org/10.1016/j.jpsychores.2022.111050>