Dissertation

THE IMPACT OF PREGNANCY AND DELIVERY ON LIFESTYLE ASSOCIATED RISK FACTORS IN MOTHERS – A POSTPARTUM 1-YEAR FOLLOW-UP

submitted by

Bianca FUCHS-NEUHOLD BSc MSc

for the Academic Degree of

Doctor of Medical Science

(Dr. scient. med.)

at the

Medical University of Graz

Otto Loewi Research Center

Division of Immunology

under the Supervision of

Univ.-Prof. in Priv.-Doz. in Mag.a Dr. in Sandra HOLASEK

2025

Declaration

I hereby declare that this thesis is my own original work and that I have fully acknowledged by name all of those individuals and organisations that have contributed to the research for this thesis. Due acknowledgement has been made in the text to all other material used. Throughout this thesis and in all related publications I followed the “Guideline of the Medical University of Graz on Good Scientific Practice”.

Graz, February 2025 Bianca Fuchs-Neuhold

Disclosures

This thesis was guided by research aims that were pursued in a longitudinal project, which I was responsible for. As the first and corresponding author, I describe the overall protocol of the study including the first results (1).

Parts of this thesis have been published[1] in the first-author publication:

(1) **Fuchs-Neuhold B**[CA, 1, 2], Staubmann W[1], Peterseil M[1], Rath A[3], Schweighofer N[4,5], Kronberger A[6], Riederer M[4], van der Kleyn M[3], Martin J[6], Hörmann-Wallner M[1], Waldner I[3], Konrad M[1], Aufschnaiter AL[1], Siegmund B[7], Berghold A[8], Holasek S[#2], Pail E[#1]. Investigating New Sensory Methods Related to Taste Sensitivity, Preferences, and Diet of Mother-Infant Pairs and Their Relationship With Body Composition and Biomarkers: Protocol for an Explorative Study. JMIR Res Protoc. 2022 Apr 27;11(4):e37279. doi: 10.2196/37279. PMID: 35475790; PMCID: PMC9096638.

Authors' Contributions:

As the first author of this paper, I wrote the project grant and secured funding for the research. EP and me were responsible for the study and MR, MvdK contributed to developing the study design. WS, MP, AR, NS, AK, JM and I designed details of the study procedure, whereas the concept and protocol for the qualitative study was developed and carried out by me. BS and SH are members of the Advisory Group and offered strategic and academic counseling for the study. AB provided statistical advice and expertise. MK provided expert advice. I drafted the manuscript and were responsibility for the final manuscript content. WS, MP, AR, NS, AK, JM, MHW, ALA, and IW provided specific content to the manuscript. All authors of this paper gave feedback to the manuscript and read and approved the final version.

[CA] Corresponding author

Affiliations

[1]Health Perception Lab, Institute of Dietetics and Nutrition, FH JOANNEUM GmbH - University of Applied Sciences, Graz, Austria.

[2]Otto Loewi Research Center, Medical University of Graz, Graz, Austria.

[3]Institute of Midwifery, FH JOANNEUM GmbH - University of Applied Sciences, Graz, Austria.

[4]Institute of Biomedical Science, FH JOANNEUM GmbH - University of Applied Sciences, Graz, Austria.

[5]Department of Internal Medicine, Division of Endocrinology and Diabetology, Medical University of Graz, Graz, Austria.

[6]Institute of Design and Communication, FH JOANNEUM GmbH - University of Applied Sciences, Graz, Austria.

[7]Institute of Analytical Chemistry and Food Chemistry, Graz University of Technology, Graz, Austria.

[8]Institute for Medical Informatics, Statistics and Documentation, Medical University of Graz, Graz, Austria.

[#]Contributed equally.

All relevant co-authors have approved the use of the data in this thesis.

<u>Further publications that are thematically related to this thesis:</u>

Further publications, which are related to the overall study and thus, to this thesis include: i) a publication, where I am a corresponding and co-author, which addresses maternal biomarkers that can predict body fat mass and fat-free mass index in infants at 4 months of age (2), ii) a publication, me as a co-author, which focuses on specific distinct maternal amino acids and oxylipins as predictors of infant fat mass and fat-free mass indices (3), iii) a review article, where I am a corresponding and co-author, summarizing factors influencing taste development in infants (4). Additionally, the following conference proceedings are part to this thesis: i) a qualitative study involving 24 mothers one year postpartum, which I fully conducted and for which I am the first author, published as an abstract (5), ii) a comparison of the food-frequency questionnaire, used in this study, with a 24-hour recall conference published as an abstract, with me as last and co-author (6).

(2) Riederer M[CA], Wallner M, Schweighofer N, **Fuchs-Neuhold B**[CA], Rath A, Berghold A, Eberhard K, Groselj-Strele A, Staubmann W, Peterseil M, Waldner I, Mayr JA, Rothe M, Holasek S, Maunz S, Pail E, van der Kleyn M. Distinct maternal amino acids and oxylipins predict infant fat mass and fat-free mass indices. Arch Physiol Biochem. 2023 Dec 7:1-12. doi: 10.1080/13813455.2020.1846204. Epub ahead of print. PMID: 33283558.

Authors' Contributions:
Me, as a co-author and corresponding author for this paper, was part of the design of the study and I contribute to the descriptive analyses, as well as I approved and critically reviewed the paper.

(3) Riederer M, Schweighofer N, Trajanoski S, Stelzer C, Zehentner M, **Fuchs-Neuhold B**, Kashofer K, Mayr JA, Hörmann-Wallner M, Holasek S, van der Kleyn M. Free threonine in human breast milk is related to infant intestinal microbiota composition. Amino Acids. 2022 Mar;54(3):365-383. doi: 10.1007/s00726-021-03057-w. Epub 2021 Sep 3. PMID: 34477981; PMCID: PMC8948153.

Authors' Contributions:
Me, as a co-author for this paper, was part of the design of the study and I approved and critically reviewed the paper.

(4) Peterseil M, Gunzer W, & **Fuchs-Neuhold B**[CA]. Einflussfaktoren auf die Geschmacksentwicklung von Säuglingen. Paediatr. Paedolog. Austria 51, 156–161 (2016). https://doi.org/10.1007/s00608-016-0396-2.

[CA] Corresponding author

Authors' Contributions:

As the last and corresponding author of this paper, I contributed to the writing, as well as approved and critically reviewed the manuscript.

Conference proceedings, that are thematically related to this thesis:

(5) Fuchs-Neuhold B, Holasek S. Mothers' perceptions of barriers and opportunities for health-promoting lifestyle one year postpartum. Eur J Public Health. 2023 Oct 24;33(Suppl 2), doi: 10.1093/eurpub/ckad160.1509. PMCID: PMC10595545. [published Abstract; oral poster presentation]

(6) Gunzer W, Peterseil, M, Pilz R, Pail E, **Fuchs-Neuhold, B.** Assessment of maternal nutrition during pregnancy and early lactation period in Austria: Comparison of a Food-Frequency Questionnaire with a 24-hour Recall. 25th European Congress on Obesity, Vienna, Austria, May 23-26, 2018: Abstracts. Obes Facts. 2018;11(Suppl 1):1-364. doi: 10.1159/000489691. Epub 2018 May 26. PMID: 29804106; PMCID: PMC7019188. [published Abstract, oral poster presentation]

(7) Fuchs-Neuhold, B, Riederer M, van der Kleyn M, Gunzer W, Peterseil M, Schweighofer N, Rath A, Hofer E, Waldner I, Kronberger A, Martin J, Maunz S, Jahnel H, Wallner M, Aufschnaiter AL, Pail E. A pilot study on investigating sensory perception and the relation to body composition and biomarkers of mother-infant pairs: study design and lessons learned. International Conference on Childhood Obesity, 5.-8.7.2017, Lisbon, Portugal.

Acknowledgements

This thesis was performed within the **Doctoral School for Lifestyle-Related Diseases** [LIFEMED] and the Otto Loewi Research Center at the Medical University of Graz, Austria and written within project “Health Perception Lab” at the Institute of Dietetics and Nutrition, FH JOANNEUM, which was funded by the Austrian Research Promotion Agency (FFG) (grant no. 839098). I am very thankful for this possibility.

My special gratitude goes to my primary supervisor Professor Sandra Holasek, for her expert guidance and encouragement throughout this process, continuous support at every stage of my research, patience as well as her inspiring ideas. I would also like to thank my co-supervisors, Professor Andrea Berghold and Associate Professor (FH) Manuela Konrad, for their valuable support in critically reflecting on my work, helping me stay focused, and for the valuable feedback provided by Dipl.-Ing. Gudrun Pregartner. A special thank goes to the head at the Institute of Dietetics and Nutrition at FH JOANNEUM, Elisabeth Pail, who made it possible for me to write my dissertation as part of my full-time job. I am very grateful for this.

I would also like to thank my colleagues in the Health Perception Lab for their support. Finally, I thank all the participants and their children for their participation and cooperation in this study.

It was not easy to balance working a full-time job, the establishment of the Health Perception Lab, motherhood of my son Frederik and the completion of my dissertation. But with the support of my family, especially my husband, who always confirms to me what an equal partnership looks like, such successes can be achieved and celebrated together.

Table of Contents

ABBREVIATIONS

%FM	Fat mass percentage
24HR	24-hour recall
AA	Amino Acids
ADP	Air displacement plethysmography
BC	Body composition
BMI	Body Mass Index
DGE	German Nutrition Society
DHA	Docosahexaenoic acid
EPA	Eicosapentaenoic acid
FEG	General Health Behaviour Questionnaire
FFM	Fat free mass
FFMI	Fat free mass index
FFQ	Food frequency questionnaire
FM	Fat mass
FMI	Fat mass index
FU1	Follow-Up one year postpartum
GWG	Gestational weight gain
HPE	Health Passport Examination
IMFQ	Infant Milk Feeding Questionnaire
IEG	Inventar for Eating Behaviour and Weight Problems
IPAQ	International Physical Activity Questionnaire
MUFA	Monounsaturated fat
PUFA	Polysaturated fat
nut.s	Nutritional.software
PAL	Physical activity level
PrefQuest®	Preference Questionnaire
PUFA	Polyunsaturated fat
SCI	The Stress and Coping Inventory
SD	Standard Deviation
TP	Timepoint

LIST OF FIGURES

LIST OF TABLES

Zusammenfassung

Hintergrund: Schwangerschaft bietet die Gelegenheit, gesunde Lebensstile von Müttern zu etablieren, deren Aufrechterhaltung postpartum jedoch herausfordernd ist. Ziel dieser Arbeit war es, den Einfluss von Schwangerschaft und Geburt auf die mütterliche Anthropometrie und das Gesundheitsverhalten bis ein Jahr nach der Geburt zu untersuchen.

Methoden: In dieser longitudinalen Studie wurden Daten von 49 gesunden Schwangeren im Alter von 18-50 Jahren (BMI 18.5-30 kg/m², <28 Schwangerschaftswochen) bis zu einem Jahr nach der Geburt erhoben. Die Datenerhebung umfasste Fragebögen zum Ernährungsverhalten, zur körperlichen Aktivität, sowie zu lebensstilbezogenen und anthropometrischen Variablen sowie qualitative Interviews von 24 Frauen derselben Stichprobe 1 Jahr postpartum.

Ergebnisse: Ein präkonzeptioneller Body Mass Index (BMI) ≥25 (U=6.0, p<0.001) und eine übermäßige schrittweise Gewichtszunahme (IWG) ($\chi^2(2) = 12.836$, p = 0.002) waren signifikant mit einem höheren BMI ein Jahr nach der Geburt assoziiert. Die körperliche Aktivität nahm postpartum signifikant ab, wobei 30.6 % der Mütter die österreichischen Bewegungsempfehlungen ein Jahr postpartum erfüllten. Die Raucherinnenprävalenz sank von 26.5 % vor der Schwangerschaft auf 6.1 % postpartum, während der Alkoholkonsum signifikant anstieg ($p_{adj} < 0.001$). Die Energie- und Nährstoffzufuhr während Schwangerschaft und Stillzeit lag unter den Empfehlungen der Deutschen Gesellschaft für Ernährung (DGE). Postpartum war eine höhere Aufnahme von Ballaststoffen ($r_s = -0.41$, p = 0.008), DHA ($r_s = -0.33$, p = 0.040) und Vitaminen (z. B. A, K, B9, B12, C) invers mit der Veränderung des mütterlichen BMI assoziiert, ebenso wie mit dem Geburtsgewicht der Kinder ($r_s = -0.362$, p = 0.011) und dem Z-Score für Gewicht nach Alter bei der Geburt ($r_s = -0.300$, p = 0.036). Qualitative Ergebnisse zeigten Herausforderungen wie Stress, Zeitmangel und unzureichende Unterstützung nach der Geburt auf.

Schlussfolgerung: Schwangerschaft und Geburt beeinflussen den BMI, das Ernährungs- und Bewegungsverhalten sowie die psychische Gesundheit der Mütter. Individuelle Interventionen sind erforderlich, um gesundheitsförderliches Verhalten nach der Geburt zu stärken.

Schlüsselwörter: Müttergesundheit, Schwangerschaft, Postpartum, Anthropometrie, Ernährung, körperliche Aktivität

Abstract

Background: Pregnancy provides an opportunity to adopt healthier lifestyles, but maintaining these habits after birth remains challenging. The aim of this work was to investigate the impact of pregnancy and childbirth on maternal anthropometrics and health behaviours, up to one year postpartum.

Methods: In this longitudinal study, data were collected from 49 healthy pregnant women aged 18-50 years (BMI 18.5-30 kg/m², <28 weeks of gestation) up to one year postpartum. The data collection included questionnaires on dietary behaviour, physical activity, and general lifestyle-related and anthropometric variables. In addition, 24 qualitative interviews were conducted with women from the same sample one year after the birth.

Results: Pre-pregnancy BMI ≥25 (U=6.0, p<0.001) and excessive IWG ($\chi^2(2)$ = 12.836, p = 0.002) were significantly associated with higher BMI one year postpartum. Physical activity levels decreased significantly postpartum, with 30.6 % of mothers meeting guidelines at FU1. Smoking prevalence dropped from 26.5 % pre-pregnancy to 6.1 % postpartum, while alcohol consumption increased significantly (p_{adj} < 0.001). Energy and nutrient intakes during pregnancy and lactation were below recommendations by the German Nutrition Society. Postpartum, higher dietary fibre (r_s = -0.41, p = 0.008), DHA (r_s = -0.33, p = 0.040), and key vitamins (e.g. A, K, B9, B12, C) were inversely associated with Δ maternal BMI, as well as infants' birth weight (r_s = -0.362, p = 0.011) and the weight for age z-score at birth (r_s = -0.300, p = 0.036). Qualitative findings indicate challenges such as stress, time constraints, and insufficient support postpartum.

Conclusion: Pregnancy and childbirth influence the BMI, diet and exercise behaviour as well as the mental health of mothers. Individual interventions are required to promote healthy behaviour after birth.

Keywords: maternal health, pregnancy, postpartum, anthropometrics, nutrition, physical activity

1. INTRODUCTION

The first 1000 days, extending from conception through a child's second birthday, have been increasingly recognized as a crucial period for both maternal and child health. During this period, mothers experience substantial physiological changes across all organ systems, notably affecting the developing fetal cardiovascular, endocrine, gastrointestinal, hematological, respiratory, and skeletal systems. The goal of these adjustments is to maintain the pregnancy and get the mother's body ready for a safe birth and delivery. Simultaneously, the mother's optimal nutritional state becomes a critical element influencing several fetal development stages, such as early embryonic development, organogenesis, and neural maturation. Key nutrients like folate, iodine, iron, omega-3 fatty acids, and vitamin D are essential in supporting these complex developmental processes. These nutrients emphasize the importance of the mother's diet and nutritional supplements throughout the first 1000 days of life by contributing to build a solid basis for long-term health. In order to improve mother and child health, this period offers an invaluable opportunity for health interventions and prevention of chronic disorders like overweight and obesity (7). Yet, certain maternal behaviours during pregnancy can pose significant health threats for both mother and child. Addressing negative pregnancy outcomes is vital for their immediate and future health. Common risk factors that contribute to adverse pregnancy outcomes - such as maternal and perinatal mortality, low birth weight, and preterm birth - include smoking, alcohol consumption, poor diet, and physical inactivity, especially when combined with obesity (8–14).

Many factors contribute to the development of overweight and obesity. Based on the work of Barker and Osmond in 1986 (15), recent research indicates that the risk of becoming overweight or even obese may be programmed during the pre- and early postnatal phase.

1.1 Fetal Programming and Metabolic Syndrome

According to the theory of prenatal programming, dietary imbalances and metabolic disorders in the mother may have a long-lasting and generational impact on the health of offspring and the likelihood of developing conditions including obesity, type 2 diabetes, hypertension and cardiovascular disease. The concept of metabolic programming emerged from Barker's fetal origins hypothesis, which postulated a strong correlation between an increased risk of adult health outcomes and a newborn's disproportionate size at birth because of an unfavorable intrauterine environment. According to Barker's fetal origins concept, proper nutrition is essential for fetal growth. Overnutrition, a type of malnutrition in which there is an excess of energy and nutrients compared to what is needed for proper growth, development, and metabolism, has become more prevalent in the United States throughout the previous several decades. Critical prenatal, perinatal, and postnatal phases are examined to assess the evidence about the impacts of maternal obesity and overnutrition on metabolic programming (16). Changes in fetal gene expression during pregnancy brought on by metabolic problems and inadequate nutrition can make the fetus more susceptible to chronic illnesses later in life (17,18). The primary risk factors are smoking, high-fat diets, insulin resistance, age, physical inactivity, insulin resistance, and hormonal imbalance (19).

1.2 Impact of Maternal Factors on Infant Body Composition and Long-Term Obesity Risk

Besides genetic and hormonal factors, at the prenatal stage, the maternal environment further influences growth and can alter tissue function. To date, only limited data is available concerning pre- and postnatal biomarkers predicting metabolic programming (20). However, strong evidence suggests maternal pre-pregnancy weight and early pregnancy weight gain influence infant birth weight and body composition (BC) (21,22).

A mother's weight status and development, including higher pre-pregnancy BMI, excessive gestational weight gain, and having a large-for-gestational-age infant, are significant predictors of excess body weight. These factors concurrently affect both mothers and their children over a 6-year follow-up period. The risk of concurrent excess body weight in mother-child pairs increases with higher pre-pregnancy BMI and is further elevated for those experiencing excessive gestational weight gain and having large-for-gestational-age infants (23). In another study results reveal that one year after giving birth, women of all weights, including those who were normal before getting pregnant, are at an increased risk of obesity due to postpartum weight retention. Possible modifiable postpartum actions may reduce the risk (24).

Further, the BC of both mother and child undergoes significant changes in the first year after birth (25). Mothers often experience a gradual decrease in body fat accumulated during pregnancy, although the speed and extent of these changes can vary greatly (26). However, BMI does not provide information on the proportions of lean and fat mass and is not suitable for predicting infants obesity (27,28). But the measurement of infants fat and fat-free mass (FM, FFM)—especially when normalized to body length—is better for understanding of how obesity develops (29). Thus, infants show with a rapid rise in fat mass percentage (%FM) in the first 6 months of life being associated with higher fat mass percentage trajectories until the age of 2 years (30). Butte et al. reported a triplication of %FM from 2 weeks until 3 months of age, which thereafter drops to roughly 25 %FM until 24 months of age, highlighting very varied variations in BC during the first 2 years (31). Additionally, it was noted that breastfeeding at 3.4 months of age resulted with a greater FM and a lower FFM in contrast to infants fed formula. In contrast, this ratio was the opposite after a year. Thus, the time-point of around 4 months was chosen for our study's measurement of infants BC and may represent a potential milestone in the programming of later obesity onset (32). Further research indicates that the mode of infant feeding significantly influences early BC development. Breastfed infants tend to have higher fat mass and percentage at 3-6 months compared to formula-fed infants (31,33). Breastfeeding, apart from influencing subsequent eating habits (34,35), can moderate adequate weight gain during infancy, and a moderately lower risk for childhood obesity (36,37). Consequently, maternal breast milk or blood parameters (candidate biomarkers), which are connected to metabolic processes associated to growth, nutrition, and fat/energy, may show or even affect how the infant's FMI/FFMI develops during pregnancy and lactation. One of the most important nutrients for a fetus and a child, respectively, is maternal amino acids (AA). The findings of research suggest that variations in the protein supply of offspring before and after birth are associated with the growth and weight of the infant, regardless of the mother's BMI (38). Additionally, AA content in human breast milk has been linked to infant weight gain. Breast milk with high levels of branched-chain and insulinotropic amino acids has been associated with rapid growth in preterm infants (39,40). Therefore, we hypothesized that not only the overall protein content but also the specific composition of amino acids in maternal serum and breast milk plays crucial roles in influencing the BC of infants. To obtain insights into the possible underlying processes influencing the regulation of infants FMI/FFMI, our objective is to detect maternal biomarkers within the AA and oxylipins classes, specifically concentrating on eicosanoids. Thus, during pregnancy and after delivery, the maternal profiles of oxylipins (breastmilk) and AA (serum and breastmilk) should be identified, and their potential to forecast newborn FMI or FFMI at 4 months of age examined (2).

Furthermore, maternal weight status is thought to be marginally associated with the composition of the milk microbiome in several ways. According to studies, the gut microbiome and maternal nutrition are related. Dietary fibre (g/d), fat-soluble vitamins (mg/d), and a high-fat diet (% fat of total calories) were the three nutrients most strongly linked to the composition of the neonatal and maternal gut microbiota. A low microbial diversity was strongly correlated with a high-fat diet. While a diet high in fat may reduce microbial diversity, a diet high in fibre may actually increase it (41). Additionally, a healthier maternal diet during pregnancy has a marginally positive correlation with a child's neurodevelopment, with more trustworthy findings reported for cognitive development (42). Furthermore, gestational hypertension was found to be connected with lower maternal adherence to a healthy diet (43) and a maternal diet index during pregnancy was linked to the outcomes of offspring allergies indicating that the diet during pregnancy enhanced the likelihood of an offspring allergy diagnosis (44). Thus, maternal nutrition, particularly concerning blood glucose levels and the intake of macro- and micronutrients, significantly impacts the fetal environment. A systematic review and meta-analysis by Kibret et al. (2018) suggest that dietary patterns with higher intake of fruits, vegetables, legumes, whole grains, and fish are associated with a lower likelihood of adverse pregnancy and birth outcomes (10). A cohort study by Fernández-Barrés et al. (2018) examines the association between maternal diet during pregnancy and the risk of obesity and cardiometabolic disorders in offspring. The study shows that a balanced maternal diet during pregnancy is associated with a lower risk of overweight and metabolic disorders in children (45). In addition, research suggests that dietary quality tends to decline in the postpartum period, particularly after 12 months. This decline may be due to increased pressure to balance childcare and work responsibilities (46,47). Further research is needed, with better coordination of dietary measurement times during pregnancy and postpartum, and standardisation of dietary assessment tools, so that future studies can be compared. Additionally, longitudinal cohort studies evaluating micronutrient intake with longer follow-up are intake with longer follow-up are lacking (48).

Maternal diet is also linked to taste inclinations in infants, such as a predisposition for sweet foods or an aversion to bitter ones and the liking for salty foods in infants and children are well known (49–51). However, taste preferences may be programmed in utero, could be modified early in life and may play an important role in food choices later in life (51–55). During the prenatal phase, taste buds recognizing and transmitting information to the central nervous system develop in the last trimester (56). Maternal dietary diversity contributes to the intrauterine environment which is rich in flavors transmitted from the maternal diet to the amniotic fluid (57–59) and mother’s milk composition, respectively (60). Further breast milk plays an important role in the development of infants' sensory perception. Studies reveal that the composition of breast milk is influenced by the mother's diet, which results in a greater range of flavors for breastfed infants. Human milk offers babies a variety of chemosensory experiences by transmitting food flavors including garlic, mint, and vanilla (58). Previous data showed that, during the milk-feeding period, flavor stimulation may enhance later food acceptance. Breastfed infants compared to formula-fed infants are more likely to accept new tastes in early childhood (61), reinforcing the effect of variety early in weaning. Thus, predispositions and preferences can be modified early through repeated exposure to flavors in amniotic fluid, mother’s milk, formula, and solid foods (62). Furthermore, children are naturally inclined towards high-energy, sugary, and salty foods, impacting their dietary habits and weight (63,64). European children, when choosing fat-enhanced or sugar-sweetened options, have a 50 % chance of being overweight or obese (65–67). However, the underlying mechanisms for possible protection against later obesity by breastfeeding and the influence of early feeding practices should be further explored (68), especially to enhance the understanding of how preferences can be modified to promote a healthy diet for children (69). As a result, it is important to address the complex relationship between taste preferences, sensitivities, and overweight and obesity as well.

Regarding exercise, physical activity levels in women are influenced by a variety of factors, including lifestyle choices, educational attainment, pregnancy experiences, and dietary habits. Women who engage in healthier lifestyles, possess lower levels of education, avoid pregnancy complications, experience vaginal deliveries, and refrain from smoking tend to exhibit higher levels of physical activity. Conversely, sedentary activity tends to increase, and moderate activity decreases with higher educational attainment. Additionally, lower levels of sports activity are associated with the delivery of large-for-gestational-age infants. In contrast, higher levels of vigorous and sports activity are more common among women who have vaginal deliveries compared to those who undergo cesarean sections. Furthermore, adherence to the Mediterranean diet is notably lower among women with only primary education (70). A systematic review by Silva-Jose et al. (2022) shows that higher rates of insufficient physical activity have been recorded in high-income countries while East and Southeast Asia maintain better physical levels. In contrast, women and populations with limited economic resources tend to be less physically active than those with greater resources so this trend could be similar with the pregnant population (71). However, fatigue, nausea or back pain as well as general weight gain, a lack of free time, and childcare obligations are common obstacles to physical activity during this time. Also pregnancy-related inactivity caused by anxiety and frustration may have unfavorable effects, including increased postpartum weight retention and excessive maternal weight gain (72,73).

Furthermore, the mental health status of mothers during the first year postpartum is a critical factor for the well-being and health of both mother and child. Postpartum depression affects an estimated 10-20 % of mothers and can have long-term impacts on child development (74). Maternal psychological distress is also common pre- and postnatal and can influence the mother-child relationship as well as lactation and breastfeeding behaviour (75). Supportive interventions targeting maternal mental health have proven effective in improving the overall well-being of the family, however, a lack of research was noted in the outcomes related to infant health, morbidity and mortality, and early childhood development (76).

Thus, women's lifestyle choices throughout pregnancy and early infancy have a substantial impact on the health outcomes of their offspring. A 75 % decreased incidence of childhood obesity is linked to maternal adherence to a healthy lifestyle, like balanced nutrition and a healthy BMI, engaging in regular exercise, and abstaining from smoking (62). Therefore, a healthy maternal diet and balanced nutritional status before and during pregnancy as well as lifestyle factors like physical activity have positive effects on preventing excessive gestational weight gain (GWG) and a sustained impact on infants' and adults' health (77–79).

Significant efforts are channeling into understanding the relationship between maternal lifestyle, nutrition, and health outcomes regarding overweight and obesity (80,81). However, long-term research is essential to understand mothers health behaviour and diet-related data on BC, weight, and nutritional intake in infants and children (64,82). Further, only few studies in industrialized nations have looked at nutritional intake throughout all trimesters of pregnancy and breastfeeding period (83). Therefore, the pre- and early postnatal periods, particularly the first 1000 days from conception on, are critical, wherein changes in maternal lifestyle may have far-reaching impacts (12). Although the focus of the first 1000 days approach is primarily on strengthening health parameters in children, these measures are mostly implemented by the mothers. They are encouraged to adopt healthy behaviours such as exclusive breastfeeding as well as a focus on their own nutrition during pregnancy and breastfeeding. Unfortunately, the health effects of these interventions on the mothers themselves are rarely systematically recorded. This gap in data collection represents a missed opportunity to increase the evidence for the impact of maternal nutrition on the health of women themselves. The lack of such data also complicates policy advocacy and ultimately leads to lower prioritization and reduced research in this important area (84).

However, mothers' postpartum lifestyle adjustments are influenced by a variety of obstacles and enablers. According to Makama et al. (85) and Ryan et al. (86), individual factors like emotional eating and physical limitations, as well as time constraints and prioritizing maternal responsibilities, are significant barriers. On the other hand, social support, knowledge, and childcare needs are important facilitators. Study findings emphasize the need for intervention frameworks and expert assistance to address these barriers. These findings underscore the need for comprehensive, multilevel interventions that target environmental and personal elements to help postpartum women establish and maintain healthy lifestyles (87,88).

Consequently, the objective of this research is to examine, through a longitudinal approach, the impact of pregnancy and childbirth on maternal health behaviours, including nutrition and physical activity, as well as health outcomes such as postpartum weight retention and mental health. The study further aims to explore mothers' perceptions of barriers and opportunities to health-promoting lifestyles one year after birth. Additionally, the research investigates the factors influencing their children's anthropometric outcomes.

1.3 Aims and outline of the doctoral thesis

The objective of the present study was to examine the impact of pregnancy and childbirth on lifestyle-related risk factors in mother-child pairs. This study specifically examined the effects of pregnancy and childbirth on maternal physical activity, dietary intake, smoking behaviour, and general health behaviour. Furthermore, the relationship between these lifestyle factors and maternal weight gain during pregnancy, as well as weight maintenance one year postpartum, was investigated. Additionally, child-related variables and their effects on the aforementioned lifestyle factors are considered. The primary outcome variable for this study is the change in maternal BMI measured from before pregnancy to one year after delivery.

The overarching hypotheses are that pregnancy and childbirth have a significant impact on lifestyle factors and that these factors change substantially in the postpartum period.

Main Hypothesis are as follows:

> *Null hypothesis: Pregnancy and childbirth do not significantly impact the pre-pregnancy maternal body weight (BMI) to one year after delivery.*
> Alternative Hypothesis: *Pregnancy and childbirth significantly impact the pre-pregnancy maternal body weight (BMI) to one year after delivery.*

Secondary Hypothesis are as follows:

> Null hypothesis 1: *Pregnancy and childbirth significantly do not impact several lifestyle factors in mothers, including physical activity, dietary habits, smoking habits, and sleep patterns.*
> Alternative Hypothesis 1: *Pregnancy and childbirth significantly impact several lifestyle factors in mothers, including physical activity, dietary habits, smoking habits, and sleep patterns.*

> Null hypothesis 2: *From the third trimester of pregnancy to one year postpartum, lifestyle-related risk factors in mothers do not change.*
> Alternative Hypothesis 2: *From the third trimester of pregnancy to one year postpartum, lifestyle-related risk factors in mothers change*.

The qualitative part of the study will investigate women's health-related attitudes and beliefs one year after childbirth, focusing on changes in dietary behaviour and physical activity postpartum. The research questions for the qualitative approach are as follows:

1. *What are mothers' subjective health beliefs one year postpartum?*
2. *What are women's subjective experiences of lifestyle changes in nutrition, physical activity, mental health, and social health in the first year after childbirth?*
3. *How do resources and stresses affect mothers' lifestyle and health behaviours?*
4. *What advice is given to cope with these changes?*

The study will exclusively consider women subjects due to its focus on gender-related issues.

2. MATERIALS AND METHODS

In this thesis "The impact of pregnancy and delivery on lifestyle associated risk factors in mothers – a postpartum 1-year follow-up", a mixed-methods approach was used, combining quantitative analysis and qualitative analysis. Firstly, data were collected within the framework of the prospective observational study "Monocentric pilot study for healthy pregnant women and their children: New sensory methods in relation to body composition and biomarkers" conducted at the Health Perception Lab of FH JOANNEUM – University of Applied Sciences, including healthy pregnant women who were monitored from pregnancy up to one year after birth. Secondly, to enhance the dataset for this thesis and adopt a mixed-methods approach, a qualitative component was carried out, consisting of 24 semi-structured interviews from the same sample (see Figure 1).

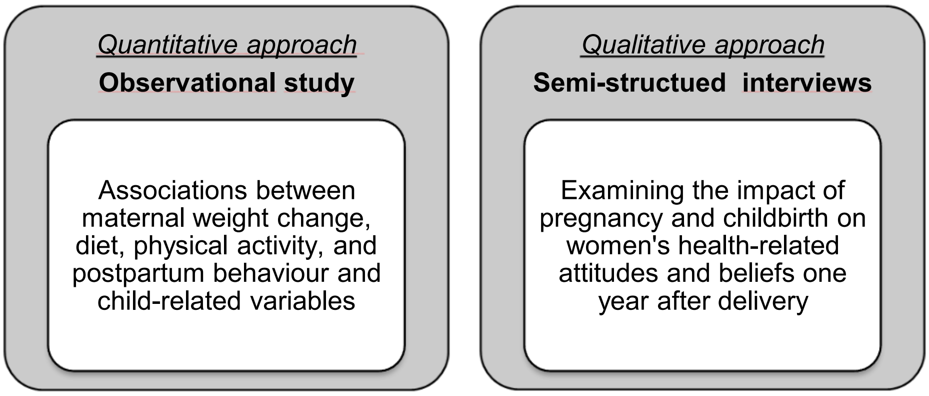

Figure 1: Scheme of the mixed-methods approach for the thesis.

In Table 1 and Table 2 the aims, designs, setting & sample, data collection and data analysis strategies are summarized. Detailed information concerning the methods within the framework of the prospective observational study, see page 29-39 and the related peer-reviewed publication (1,2).

2.1. Study design and population

This dissertation is part of a prospective longitudinal study of 57 enrolled healthy pregnant women (≥ 18 years) and their offspring, with an embedded qualitative design, performed at the Health Perception Lab – Laboratory for health-relevant

Sensory Research in Graz, Austria. The recruitment and enrollment process for low-risk pregnant women lasted from January 2014 to October 2014 in a prenatal clinic at the Styrian State Health Insurance Fund, where women underwent an oral glucose tolerance test (< 28 weeks of gestation). During this visit, all pregnant women were informed face-to-face about the study details and were given written information with contact details. To support the recruitment of participants, the study was additionally advertised on social media channels such as Facebook, on the website and in mailings of the FH JOANNEUM - University of Applied Sciences and the Medical University of Graz as well as in newspapers during January and October 2014. All documents for recruitment like posters, information folders and advertisements were submitted within the Ethics Approval (EC No.26-066 ex 13/14). The main inclusion criteria were pregnancy less than 28 weeks, unobtrusive oral glucose tolerance test, nonsmoking, BMI ≥18.5 kg/m2 to ≤30.0 kg/m2, age between 18 and 50 years and written informed consent. Detailed inclusion and exclusion criteria for the study are shown in Table 1.

Table 1: Inclusion and exclusion criteria of the study.

Inclusion criteria	**Exclusion criteria**
Pregnant women 18–50 years of age	Birth before 37th week or after 42nd week of gestation
Pregnancy < 28 weeks of gestation	Multiple pregnancy
Written informed consent	Children with severe congenital malformations or diseases
Pre-pregnancy BMI ≥18.5 kg/m^2 to ≤30.0 kg/m^2	Congenital metabolism disorders
Unobtrusive oral glucose tolerance test	Drug abuse
Nonsmoking until 16 weeks postpartum	Drug-administered mental illnesses
	Metabolic diseases of the mother (e.g., thyroid disorders)
	Autoimmune diseases of the mother (e.g., Crohn's disease)
	Birth complications (Postpartum Hemorrhage > 1000ml or eclampsia)
	Preconceptional diabetes (type 1 or 2)
	Celiac disease and/or wheat protein allergy of the mother
	Breast surgery and/or hypomasty

Three of the 57 recruited women were not included in the study, because of drug-administered mental illnesses and preterm birth. Therefore, a total of 54 women were eligible to participate in two center visits during their pregnancy, the first between 24- and 28 weeks of gestation (TP1) and the second in the third trimester of pregnancy, preferably between 32- and 34 weeks of gestation (TP2). Further, two visits were conducted with the same mother-infant-pairs between 6 and 8 weeks (TP3) and between 14 and 16 weeks after delivery (TP4). The study participants were subsequently followed up by i) an online questionnaire survey and a stool sample 1 year postpartum (FU1). For the qualitative approach, one year after delivery, a purposive sampling strategy was used to obtain a wide variation of experiences and perspectives to get greater insights into women's attitudes and beliefs regarding lifestyle changes. Within the first-year follow-up, qualitative semi-structured interviews were conducted with a sub-sample of 24 women from the study population. Sociodemographic factors like income, educational and migration background, and age as well as further gravidity were considered and self-reported by the participants at the first center visit and updated regularly (see Figure 2).

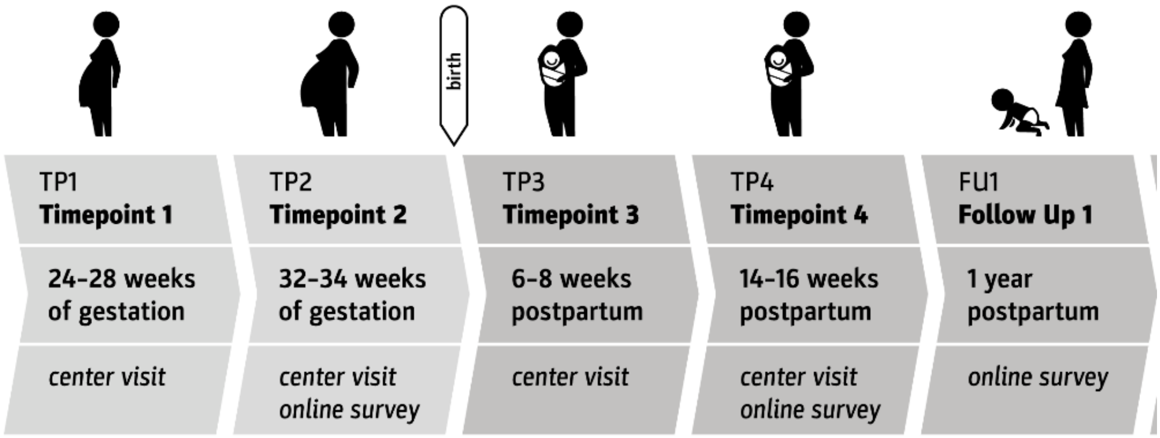

Figure 2: Study outline and timepoints of measurements.

2.2. Ethics approval

The overall study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the local ethics committee of the Medical University of Graz (EC No 26-066 ex 13/14). All participants were informed in detail about the procedures and measurements through a medical doctor and gave written consent. Access to generated data was restricted to the immediate research team, and only coded data were used for analysis stored on a secure internal server of the FH JOANNEUM.

2.3. Sample size

The number of participants was chosen according to similar studies where sample sizes reached approximately 50–70 persons (82,89). Additionally, feasibility reasons and recruitment experiences were considered for the laboratory setting and the geographical region. Thus, we aimed to include up to 60 women. For the embedded qualitative study, 24 mothers of one-year-old children were recruited from the sample pool by the author.

2.4. Data collection

The overall study was conducted by both the author of this thesis and an interdisciplinary team of dietitians, midwives, health scientists, information managers, nutritionists, statisticians, and biomedical analysts. Data were collected by trained health professionals two times in pregnancy, during the second and fourth month postpartum, and within the follow-up phase 1 year. Data and biological samples collected during each stage included blood, stool and urine sampling, anthropometry, questions about health, and smoking and drug status as well as changes regarding sociodemographic information. The qualitative study and thus the collection of qualitative data was carried out exclusively by the author of this thesis between September 2015 to February 2016.

2.4.1. Anthropometry and body composition

Maternal pre-pregnancy-BMI was calculated from height measured with a stadiometer (seca® 213, seca, Hamburg, Germany), without shoes, and pre-pregnancy weight was obtained from the medical records or was self-reported at the first study visit at the laboratory. Data on weight during pregnancy was entirely taken from the medical records (national mother-child booklet), whereas weight measurements after delivery were collected with a calibrated scale (seca® 877, seca, Hamburg, Germany), lightly dressed and without shoes.
Infants' length, weight, head circumference, and BC were collected in the laboratory by trained midwives. Infants' BC, FM, FFM, and weight at TP3 and TP4 were

assessed using Air displacement plethysmography (ADP) (PEA POD®, COSMED, Rome, Italy). Length was measured with a mobile measuring board (seca® 210, seca, Hamburg, Germany) and head circumference with a nonflexible head circumference tape measure for infants (seca® 212, seca, Hamburg, Germany). The BMI, FMI, and FFMI were calculated in kg/m² by the system using following equations: *BMI = body mass (kg)/ body height (m)²*, *FMI = fat mass (kg)/ body height (m)², FFMI = fat-free mass (kg)/ body height (m)²*. The variable, Δ maternal BMI (ΔBMI) was calculated as BMI at FU1 minus BMI before pregnancy. GWG was determined by subtracting the women's pre-pregnancy weight and, if not available, the early first trimester weight from her last measured weight before delivery. Total postpartum weight retention (kg) was calculated with postpartum weight at FU1 minus pre-pregnancy weight.

Follow-up data collection of the BC for the mother-child pairs is measured likewise by ADP (BOD POD®, COSMED, Rome, Italy). Additionally, triceps skinfold thickness measurements of the children are performed by trained nutritional experts using a Harpenden Skinfold Caliper in triplicate on the left arm with it slightly bent. In addition, the upper arm circumference of the child is determined using a tape measure. Further data on weight, length, and head circumference at birth and beyond were obtained through the medical records.

2.4.2. Taste perception

As a measure of taste sensitivity threshold, tests for sweet and salty taste were performed with women at TP2 and after delivery at TP3 and TP4. To keep the time burden low for participants, a simplified, modified version from the original DIN ISO 3972 and to the Busch-Stockfisch version (2012) was used. The aqueous solutions were prepared according to DIN ISO 3972, using sucrose and iodine-free sodium chloride. The number of samples for the determination of taste sensitivity was modified from ten to five for each stimulus, whereby concentrations were not changed. Each sample was prepared from the respective stock solution (50 g sucrose/500 ml; 25 g sodium chloride/250 ml). Sensory tests were performed under standardized conditions in sensory booths to keep external influences as low as possible.

Preferences for the sensations of fat, sweet-and-fat, and salt-and-fat were assessed in women by tasting crackers. Pretests aimed to find a common/well-known food item that provided the potential for experimentally modifying the fat, sugar, and salt concentrations. Considering the storage and preparation possibilities, crackers were found to be suitable. The cracker contained wheat flour, water, refined plant oil, salt, and sugar in specified concentrations. The basic recipe was adapted from Knof et al. (2011) (90). Three pairwise comparisons 2-alternative forced-choice tests with specified amounts of salt, sugar, and fat, respectively, were performed to assess the participants' preferences (sweet: sucrose high 30 % vs. low 15 % and fat 15 % each; salty: sodium chloride high 2.5 % vs. low 1 % and fat 15 % each; fatty: fat high 25 % vs. low 10 % and salt 0.7 % each). Concentrations of sugar, salt, and fat content were selected according to the amounts derived from the available range of crackers in Austrian stores.
Infants' taste preferences for sweet and salty taste were assessed at TP3 and TP4. Droplets of aqueous solutions with different concentrations (low–high) of lactose (0.2 ml; 0.4 ml) and sodium chloride (0.085 ml; 0.17 ml) were administered by a researcher with a transparent 1 ml pipette while the infants' reactions to the stimuli were audiovisually recorded. Two servings of water served as a control condition to familiarize the infant with the test setting and method.

The sensory preferences for specific food items rich in salt, sugar, and fat were additionally assessed by a recently developed and validated questionnaire, called PrefQuest® (91). The PrefQuest® has been translated into German, typical food items were adopted to the Austrian region, and it was subsequently used with kind permission from Deglaire et al. (2012). The PrefQuest® quantify recalled the participant's liking for the sensations of fat, fat-and-salt, and fat-and-sweet and includes four types of items: 1) liking for sweet, fatty-sweet, and fatty-salty foods, 2) preferences in the level of seasoning by adding salt, sweeteners, or fat, 3) preferences for types of dishes on a restaurant menu, and 4) overall questions about sweet-, salt- and fat-related behaviour (91).

2.4.3. Laboratory analyses of biochemical parameters

Maternal plasma and serum samples were taken at TP1 and TP2 in pregnancy and at TP3 and TP4 after delivery. Maternal breast milk was collected at TP3 and TP4. Stool samples from mother and child were collected at each of the center visits in the laboratory and from the child at the follow-up visits. Blood and breast milk samples were immediately stored at -20°C until frozen and were then stored at -80 °C until analysis. Before analysis, all samples were kept at room temperature, except the samples for the determination of eicosanoids, which were kept at 4 °C.

2.4.3.1. Blood/Urine

Eicosanoids

Blood eicosanoids were analyzed by liquid chromatography/mass spectrometry (DNA). The extraction was performed as described previously [50]. In brief, 500 µl plasma was immediately treated with 500 µl 5 % methanol/0.1 % formic acid and spiked with 20 µl of internal standards (ISTDs, Cayman Europe, Estonia; 95 nM). Compound extraction was performed with solid phase extraction using Oasis HLB (60 mg/30 µm, Waters, Austria). Samples were loaded onto the cartridges preconditioned with 2 × 1 ml methanol and equilibrated with 2 x 1 ml 5 % methanol/0.1 % formic acid. Each column was washed with 2 x 1 ml of 5% methanol/0.1% formic acid. The column was dried under vacuum and the eicosanoids were eluted with 2 × 0.75 ml volumes of methanol. The eluent was reduced to dryness under vacuum at 55°C. The dried extract was subsequently reconstituted in 0.1 ml of methanol for measurement. Samples were analyzed by liquid chromatography (Agilent 1290, Agilent, Austria) coupled to electrospray ionization on a triple quadrupole mass spectrometer (Agilent 6460, Agilent, Austria). For analysis 4 µl of the extract were injected at 5 °C. Chromatographic separation was achieved on a Waters BEH C18 column (Waters, Austria) using a flow rate of 0.4 ml/min at 40 °C during a 13 min gradient (0–13 min from 25 % B to 75 % B), while using the solvents A, 0.1 % formic acid, and B, 90:10 v/v acetonitril/isopropanol. Electrospray ionization was performed in the negative ion mode. To detect the individual eicosanoids, dynamic Multiple Reaction Monitoring (MRM) was performed with individually optimized MRM transitions. Data pre-processing, peak determination and peak area integration was performed with Mass Hunter Quan (Agilent, Version B.06.00) while auto-integration was manually inspected and corrected if necessary. The obtained peak areas of targets were corrected by appropriate ISTD and calculated response ratios were used throughout the analysis. Breast milk eicosanoids were determined by Lipidomix GmbH, Berlin, Germany using LC/MS.

Lipid parameters

Lipid parameters (total cholesterol, high density lipoprotein, and triglycerides) were analysed by enzyme immunoassay (DF27, DF48A and DF69A, respectively) using the Siemens Dimension Xpand Clinical Chemistry Analyzer (Siemens Healthcare GmbH, Erlangen, Germany) according to the manufacturer's instructions (Siemens AG Österreich, Vienna, Austria). Low density lipoprotein was calculated according to the formula of Friedewald (92).

Hormones

The hormones estradiol and progesterone were analysed by enzyme immunoassays using the Abbot Architect i2000SR, Abbott GmbH, Vienna, Austria and using the reagent kits 7K7225 for estradiol, and 7K7725 for progesterone.

Adipokines and protein

A subset of adipokines (AFABP: BioVendor, RD191036200R; Leptin: BioVendor RD191001100, Modrice, Czech Republic; Irisin: Phoenix Ph. Inc., EK_067-52, Burlingame, CA USA; SFRP: Cloud Clone Corp., SEC842Hu, Katy, USA; Hepcidin: DRG Diagnostics, Hepcidin-25-HS EIA, Marburg, Germany) in serum and breast milk was determined by commercially available enzyme-linked immunosorbent assays. Adipokine concentration in breast milk was either expressed per ml of breast milk or was normalized to protein content. Measurement of the protein concentration in breast milk was performed according to the method described by Bradford M.M (93).

Amino acid profile

Amino acid profiles were determined from maternal serum and breast milk via ion exchange chromatography followed by post-column derivatization with ninhydrin. The measurement was done at the University of Salzburg (University Clinic for Pediatrics and Adolescent Medicine) with the Biochrom 30+ Amino Acid Analyzer (Physiological System) (Biochrom Ltd., UK), according to the manufacturer's recommendations.

2.4.3.2. Stool

Gut microbiota

Pea sized human stool samples were collected in stool sample containers (containing 1 ml RNAlater) and stored at -20°C. Deoxyribonucleic acid (DNA) was extracted using the Magnapure Bacterial DNA Kit following the manufacturers recommendations. Next generation sequencing (Ion Torrent 318) and phylogenetic as well as statistical analysis was done by the Laboratory of Diagnostic Genome Analysis at the Institute of Pathology, Medical University of Graz, Austria. In brief, next generation sequencing was performed with Ion Torrent 318 chips. Sequencing reactions were performed on Ion Torrent PGM using the Ion 400BP Sequencing Kit (all reagents from Thermo Fisher Scientific, MA, USA). Sequences were split by barcode and transferred to the Torrent suite server. Unmapped bam files were used as input for bioinformatics. All sequences were initially trimmed by a sliding window quality filter with a width of 20 nucleotides and a cutoff of Q20. Reads shorter than 100 nucleotides and reads mapping to the human genome were removed using deconseq (94). The resulting reads were subjected to error correction using the Acacia tool (95) leading to error correction of 10-20 % of reads. Subsequently PCR chimeras were removed by usearch algorithm in de-novo and reference-based settings (96) and the final sequence files were analysed by QIIME 1.8 workflow script (97). Operational taxonomic unit search was performed using the parallel_pick_open_reference_otus workflow script and the greengenes 13_8 reference database.

2.4.4. Behavioural variables

This section describes the health-related behavioural variables in detail.

2.4.4.1. Dietary Assessment

Maternal diet and eating behaviour during and after pregnancy were assessed via i) the valid and reliable Inventory for Eating Behaviour and Weight Problems (IEG)

(98) and ii) a recently developed online administrable food frequency questionnaire (HPL-FFQ) before the second and fourth center visit. The HPL- FFQ underwent pretests and expert validation and included frequency (per day, per week, per month, rarely or never) and what quantity of consumed food and beverage items were consumed during the last 3 months. For HPL-FFQ validity, further data were obtained using a 24-hour dietary recall at TP2 and TP4. The estimation of energy intake and nutritional composition of food items from the HPL-FFQ and 24-hour dietary recalls was calculated using the nut.s nutritional.software (dato Denkwerkzeuge, version: 1.32.30, 2015). All questionnaires were mailed three to four days prior to the women's appointments and were checked for completeness during center visits TP2 and TP4. Additionally, the same questionnaires are mailed in online version to the mothers in FU1. Furthermore, The German Nutrition Society (DGE) guidelines and their reference tables served as the basis for the comparison's nutritional selection. Using the 24-hour dietary records, they were compared with the nutrient consumption measured during the lactation phase (TP4) and the third trimester of pregnancy (TP2). For descriptive presentation of the nutritional calculations, unrealistic reported data were identified in the first step. According to Ramage et al., the assessment of outliers in the FFQ data was based on unrealistic energy intake estimates of 600 kcal or >3500 kcal per day (99). Because of unrealistic energy intake reported on the FFQ (TP2 n=2) and 24-Hour-Recall (TP2 n=1) outliers were excluded from the nutritional analysis.

2.4.1.1. Feeding practices

Data on breastfeeding practice and duration were recorded in detail after delivery, regarding the definitions of the World Health Organization (100). Furthermore, for evaluating the exclusivity of breastfeeding, questions were asked to determine the volume of breast milk compared to other fluid intakes. Questions regarding kind of feeding, duration, and frequency of the feeds and supplement intake like water, tea, or solid food, were asked in a 24-hours and 7-day recall at TP3 and TP4. Additionally, maternal feeding characteristics are assessed using the Infant Milk Feeding Questionnaire (IMFQ) (101) at TP3 and TP4.

2.4.1.2. Health behaviour, physical activity and stress perception.

Dlugosch and Krieger's German-language General Health Behaviour Questionnaire (FEG) (102) is used to measure behavioural factors of postpartum women regarding alcohol, smoking, sleep, and well-being/psychosocial stress as well as dealing with health and illness (102). Due to the modular structure of the of the FEG, the individual areas can be determined separately. In the area of alcohol, health behaviour is determined by the frequency of consumption alcoholic beverages (beer, wine/sparkling wine, spirits: cognac, whisky, schnapps etc., other alcoholic beverages) (4 items). In the area of "Well-being and burdens „two scales describe the extent to which different areas of life (work/occupation, marriage/partnership, family/children, friends/acquaintances, leisure time, financial situation, housing situation) lead to i) satisfaction and well-being (7 items) and ii) contribute to difficulties and problems (8 items). The area "Dealing with health and illness" contains three scales, describing the extent of i) traditional health behaviours (5 items, e.g., use of preventive checkups, doctor visits, use of medications), ii) recording of physical resilience (5 items) and iii) the extent of physical complaints (5 items) (49).

To determine physical activity behaviour during pregnancy, questions were asked about frequency (0 to 7 days), duration (1 to 7 hours or more), and intensity (getting out of breath and/or sweating; every day to never). Physical activity in mothers is assessed by means of the International Physical Activity Questionnaire (IPAQ), a reliable and validated questionnaire (103). For FU1, the short version was used online. The instrument assesses physical activity in the last 7 days with 7 items and records the activity of different intensity levels: 1) vigorous-intensity activities, 2) moderate-intensity activities, 3) walking, and 4) sitting. Frequency (days/week) and duration (time/day) is collected separately for each specific activity type.

2.4.1.3. Stress and coping assessment

The Stress and Coping Inventory (SCI) was designed to reliably measure the current stress, the physical and psychological consequences, and its coping. Considering the subjective stress experience postpartum, seven items are asked, each item covering an important area of life (finance, housing, workplace/training place, partnership, family and friends, disease, life goals) (104).

2.4.1.4. Semi-structured interviews

As part of the prospective longitudinal study, 24 pregnant women were selected from the study population with a variation strategy in terms of age, education, occupation, number of deliveries, and type of delivery. Inclusion criteria included the participants' willingness to participate in the study, informed consent and the ability to express experiences one year after delivery regarding lifestyle changes. None of the eligible participants declined to take part in the study after they were approached. They were hired in-person or over the phone through the author of this thesis. The interview guide was developed based on the research question posed in advance and including current literature on the topic. The interview guide was also pretested with an individual who met the study population criteria. The pretest of the interview guide was recorded with an audio recorder, and field notes were taken both during the pretest and afterwards. After the pretest, the guide was adjusted and finalized in terms of the wording of the questions. The final semistructured interview topics included (i) subjective concept of health, (ii) feelings about lifestyle and health behaviour changes, and (iii) stresses and resources that influence personal lifestyle/health behaviours. The topics covered in the semi-structured interview schedule explored the effects of pregnancy and childbirth on the health behaviours of mothers of one-year-old children. To be able to represent possible changes from pre-pregnancy to the current life situation, including the first year as a mother, the participants surveyed were asked to provide retrospective descriptions of their health behaviours and lifestyles, focusing on nutrition and exercise. The guideline-based interviews took place during the period from September 2015 to February 2016 and were conducted face-to-face at a convenient venue suggested by the participants. After informed consent was obtained, all interviews were recorded with the use of a voice recorder (Philips, Voice Tracer LFH0662). At the end of each interview, observation logs were prepared by the researcher to record subjective impressions of the interview, disturbances, and other general conditions. In addition, frequently mentioned key themes were continuously outlined by the researcher. After the interviews were recorded, they

were transcribed verbatim using the software f4transrkipt (v7.0.6) according to predetermined transcription rules. Afterwards, the transcripts were anonymized. It is not possible to draw conclusions about the interviewee, as the interview results were provided in aggregated form. Furthermore, the participants in the qualitative study did not get financial compensation or any incentive for giving an interview.
An overview of major components of the study such as time points, data, and instruments are presented in Table 2.

In order to enhance overall the quality of the text in English, AI-supported language models (e.g. DeepL (105), chatGPT) was used for the linguistic revision of the text. The content integrity and scientific validity of the text was always ensured by manual review, high quality literature and adaptation by the author.

Table 2: Major components and instruments of the study.

Timepoint (TP)	TP1[a]	TP2[b]	TP3[c]	TP4[d]	FU1[e]
Data: instruments					
Screening for eligibility criteria and obtaining informed consent	x	x	x	x	
Demographics: structured questionnaire	x				x
Maternal health status and smoking: self-reported	x	x	x	x	x
Maternal medical history: structured questionnaire	x				
Maternal weight and height: medical records, weight scale, stadiometer, self-reported	x	x	x	x	x
Paternal weight and height: reported by mother	x				
Pregnancy history: medical records, self-reported	x	x	x	x	
Medication treatment mother and child: reported by mother	x	x	x	x	x
Birth history: medical records			x		
Feeding practices: structured questionnaire, IMFQ, CFQ			x	x	x
Infant's 24-hour and 7-day dietary intake: food recall reported by mother			x	x	
Maternal nutritional behaviour: HPL-FFQ, IEG, PrefQuest®		x		x	x
Maternal 24-hour dietary intake: food recall		x		x	
Anthropometric data of child: medical records, caliper, reported by mother			x	x	x
Body fat composition of child: ADP			x	x	
Blood and stool of mother: laboratory analyses	x	x	x	x	
Breastmilk: laboratory analyses			x	x	
Blood and stool of child: laboratory analyses			x	x	x
Sensory taste perception of mother: threshold, preference, and sensitivity tests		x	x	x	
Sensory taste perception of child: threshold, preference, sensitivity tests and video recording			x	x	
Health behaviour and stress perception of mother: FEG, SCI					x
Maternal physical activity: IPAQ and structured questionnaire		x		x	x
Health behaviour and lifestyle changes: Semi-structured interview of mother					x

[a]TP1: first center visit between 24 and 28 weeks of gestation.

[b]TP2: second center visit in the third trimester of pregnancy, preferably between 32 and 34 weeks of gestation.

[c]TP3: first visit conducted with the same mother-infant pairs between 6 and 8 weeks.
[d]TP4: second visit conducted with the same mother-infant pairs 14 and 16 weeks after delivery.
[e]FU1: first follow-up involving an internet-based questionnaire survey

2.4.2. Data analysis

Quantitative data analyses were performed using SPSS Version 27 (IBM SPSS Statistics, Armonk, NY, USA). Descriptive statistics, means, standard deviations, frequencies and percentages were examined. Categorical variables are presented as absolute numbers and rates. Mean nutrition values were derived by participant-individual averaging. Not normally distributed parameters were either log transformed in the reviewed papers (2) or analysed using non-parametric methods. For group comparisons, the Kruskal-Wallis test, the Mann-Whitney U test and the $\chi 2$ test were used. Spearman correlation analyses investigated relationships between maternal nutritional intake, Δ maternal BMI and infant body composition. Non-parametric tests such as the Wilcoxon sign-rank test and the Friedman test were used to analyse temporal changes in nutritional and activity parameters. Box plots were generated using the ggplot2 package (106) within the R programming language (107). In the the peer reviewed publication related with this thesis, methods of correlation and regression analysis were used to investigate the association between various exposure variables of interest and the longitudinal outcomes (2). Furthermore, associations between the aforementioned parameters as well as the BMI of the child, the collected biomarkers, and other mother-infant parameters were investigated by means of explorative data analysis. Univariate models were performed initially to explore the association between the exposure variables and each outcome. Effects of potential confounders were adjusted in the multivariable models within the published papers (2,3). P values less than 0.05 were considered statistically significant.

Qualitative data were analysed using the software f4analyse for data coding, sorting, and categorizing. The author of this thesis used Braun & Clark's thematic analysis for the qualitative project (108). This is a common qualitative analytical technique for searching through a data set, such as interview transcripts, to find, examine, and report themes. Therefore, a thematic approach and triangulation with the quantitative data was performed to identify themes informed by the methods of

Braun & Clarke (108). There are two techniques to find themes and patterns in data using thematic analysis. Themes that are discovered throughout the study are closely related to the data when using the inductive technique, and researchers do not attempt to fit these themes into a pre-existing framework. This type of analysis is therefore data-driven. A "theoretical" thematic analysis that is motivated by the researchers' theoretical interests and looks for themes is described by the deductive approach (108). German was used for both the topic analysis and the interviews. The selected themes weren't predetermined before the study began; rather, they were deduced inductively from the data. The application of this method structured the qualitative data analysis in an efficient and systematic manner. In the first phase of the analysis, the author read through the transcripts several times to gain an in-depth understanding of the content. In the second phase, the author coded specific passages and segments of text to make the concepts and ideas contained. Then, in the third phase, similar codes were merged into sub-themes and overarching main themes (109). Due to the cyclical nature of thematic analysis, preliminary findings were frequently examined. Supporting quotations were translated into English. Figure 3 provides an illustration of the methodological procedure.

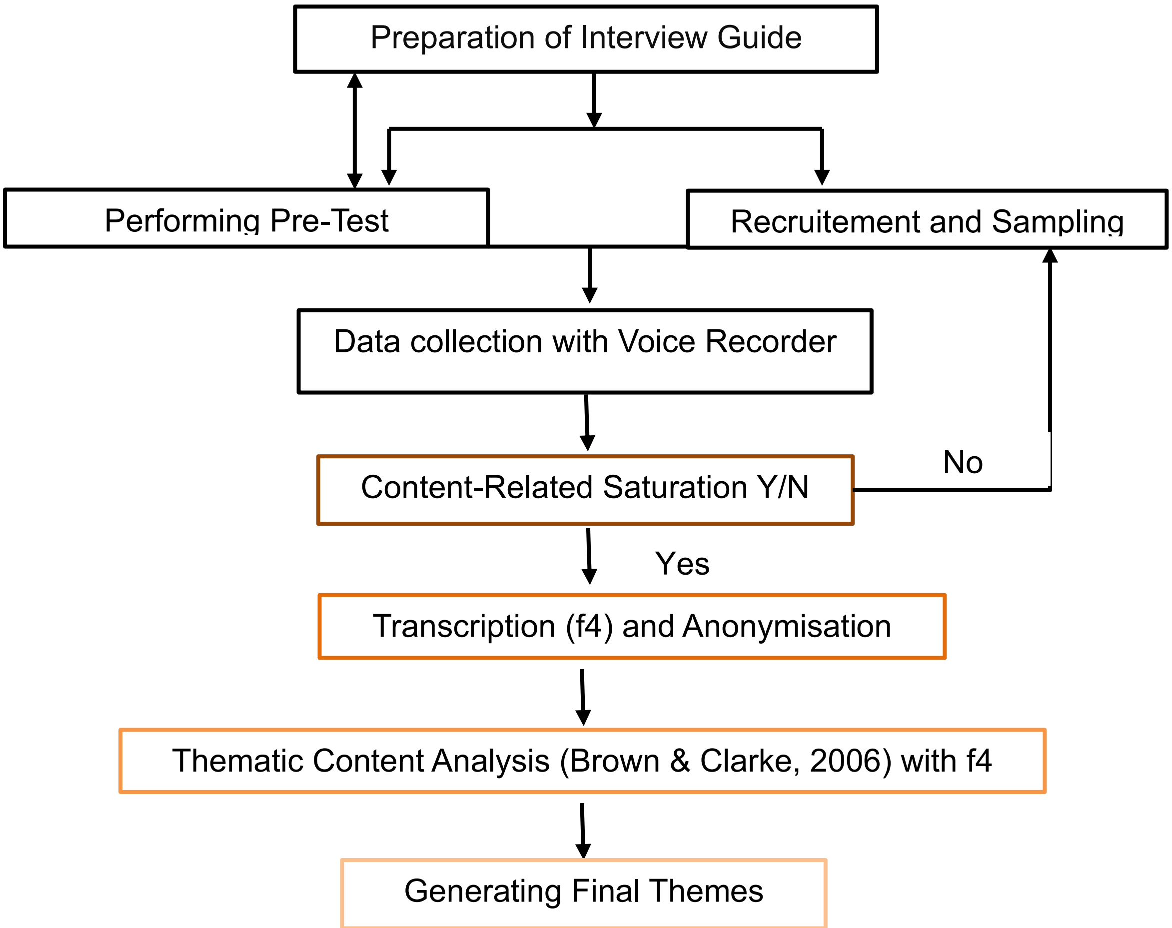

Figure 3: Steps for conducting the thematic content analysis.

3. RESULTS

This results section presents findings from both the quantitative and qualitative components of the study from pregnancy to one year postpartum. This study initially recruited 57 healthy women, of whom 54 were enrolled. Attrition occurred during the study period as follows: three participants dropped out during the prepartum period, two did not complete the first follow-up (FU1), and data were missing for two participants for the first and second postpartum visits (TP3 and TP4). However, these two women later participated in FU1.

In addition, the qualitative analysis includes data from 24 women, providing insights into their dietary and lifestyle behaviours, perceptions, and experiences during pregnancy and postpartum.

Explorative statistical analysis

The quantitative analysis is based on data collected from a total of 49 mother-child pairs, focusing on nutritional intake, weight development, physical activity, and body composition and other lifestyle-related factors to assess maternal and child health at different time points (TP2, TP4 and FU1). Thus, the following data might slightly differ from our previously published baseline data in Riederer et al., focusing on infant body composition (2).

Due to the exploratory nature of the study and limited sample size the results should be interpreted carefully and refer only to this sample. Studies with larger samples and longer observation periods are needed to validate relationships and influencing factors.

3.1. Maternal characteristics: pregnancy and postpartum

Table 3 outlines the maternal characteristics from pregnancy to 14-16 weeks postpartum (TP4) from 49 mothers. Most of the study participants (79.6 %, n = 39) were from Austria and had completed tertiary education (73.5 %, n = 36), which implies a homogeneous group. 71.4 % (n = 35). The mean maternal age at birth in the study population was 32.0 years (SD = 3.9 years). 63.3 % of the children were born by vaginal delivery, and 45 % (n = 22) of the born children were female (see Table 4).

The mean BMI of the mothers in the early stage of pregnancy is 22.5 kg/m² (SD = 2.9). 79.6 % of the mothers had a normal BMI, while 18 % were either overweight or obese. The mean GWG (total gestational weight gain) of 14.5 kg (SD = 4.1) and the mean weekly weight (incremental weight gain between the 2^{nd} and 3^{rd} trimester) of 0.5 kg/week (SD = 0.2) are both consistent with the recommendations of the Institute of Medicine (IOM). However, when GWG was analyzed in categories, 55.1 % of the women adhered to the IOM guidelines, while nearly a third (32.7%) exceeded the recommended weight gain, and 12.2 % fell below the recommendations (110). The mean early gestational weight gain in the second trimester was 8.1 kg (SD = 2.4), whereas the late gestational weight gain in the third trimester averaged 6.5 kg (SD = 3.3). Especially, regarding incremental weight gain between the 2^{nd} and 3^{rd} trimester, 51.0 % of the participants gained more weight than recommended, indicating that a substantial proportion exceeded the guidelines during later pregnancy stages.

Before pregnancy, 26.5 % (n = 13) of the women stated that they had smoked. Regarding breastfeeding practices at TP4, 67.3 % (n = 33) of the mothers reported fully breastfeeding their children, while 30.6 % (n = 15) were not fully breastfeeding. Physical activity was assessed at all time points with three questions (see Table 3) and in detail at FU1 with the IPAQ questionnaire (111) (see Table 4). At TP2, 51 % of mothers met the Austrian recommendations for physical activity (at least 150 minutes per week). After birth, a significant decrease in recommended physical activity was observed at TP4 (59.2 %), while the decrease continued at FU1 (see Table 3), with 69.4 % of mothers exercising less than recommended (see Table 4).

Table 3: Maternal characteristics from pregnancy to 14-16 weeks postpartum (TP4).

Maternal characteristics	***Total n = 49***	
	Mean (SD)	*Range*
Maternal age at delivery (years)	32.0 (3.9)	21.0-41.0
Early pregnancy BMI (kg/m²),	22.5 (2.9)	18.37-30.83
Total gestational weight gain (kg)	14.5 (4.1)	7.0-28.0
Early gestational weight gain (kg), n = 48	8.1 (2.4)	3.0-15.3
Late gestational weight gain (kg), n = 48	6.5 (3.3)	-.10-16.0
Incremental weight gain between 2nd & 3rd trimester (kg/week; IOM), n = 48	.5 (0.2)	-1.21
	% (n)	
BMI initial weight and height mother (WHO)		
Low weight (< 18,5 kg/m2)	2.0 (1)	
Normal (18,5 - 24,9 kg/m2)	79.6 (39)	
Overweight (25,0 - 29,9 kg/m2)	14.3 (7)	
Obesity (>= 30,0 kg/m2)	4.1 (2)	
Total gestational weight gain (IOM) in categories		
Less than recommended	12.2 (6)	
Recommended	55.1 (27)	
More than recommended	32.7 (16)	
Incremental weight gain between 2nd & 3rd trimester (IOM) in categories, n = 48		
Less than recommended	22.4 (11)	
Recommended	24.5 (12)	
More than recommended	51.0 (25)	
Parity		
Primipara	71.4 (35)	
Multipara	28.6 (14)	
Caesarean delivery (%)	36.7 (18)	
Sex (Female) (%)	44.9 (22)	
Smoking before pregnancy (yes, %), n=48	26.5 (13)	
Country of birth (Austria, %), n=46	79.6 (39)	
Education level (%)		
Not completed tertiary education	26.5 (13)	
Completed tertiary education	73.5 (36)	
Physical activity in pregnancy at TP2 (%)		
Less than recommended	49.0 (24)	
Recommended	51.0 (25)	
Physical activity postpartum at TP4 (%), n=44		
Less than recommended	59.2 (29)	
Recommended	30.6 (15)	
Breastfeeding practices at TP4 (%), n=48		
Fully breastfed	67.3 (33)	
Not fully breastfed	30.6 (15)	

Note: TP2 = 32-34 weeks of pregnancy, TP4 = 14-16 weeks post partum, SD = Standard Deviation, n = number of included participants, BMI = Body Mass Index, IOM = Classification of gestational weight gain from the Institute of Medicine

3.2. Maternal characteristics: one year follow-up

For 1 year after birth (FU1) Table 4 provides data on the maternal characteristics. The postpartum weight gain from TP4 to one year postpartum, the mothers showed an average weight loss with a mean value of -2.9 kg (SD = 3.4). Compared to the initial weight before pregnancy, the average weight difference one year after birth (total postpartum weight retention) is only 1.0 kg (SD = 3.8). 43 women (87.8 %) showed no substantial postpartum weight gain (postpartum weight 1y - pre-pregnancy weight) and kept less than 5kg or lost the extra weight after giving birth, while only 12.2 % of the women maintained a significant weight of ≥ 5 kg after one year. This is confirmed by Δ maternal BMI (BMI after 1 year – BMI pre-pregnancy) with an average of 0.4 kg/m² (SD = 1.4).

As mentioned above, 69.4 % of mothers exercised less than recommended at FU1. According to the IPAQ results, most of the physical activity consisted of walking, which was done about 5 days a week. Vigorous activity was rarely performed, while moderate activity was performed on average 2 to 3 days per week. The average amount of time spent sitting was about 4.5 hours per day, indicating a moderately sedentary lifestyle.

The consumption of tobacco products constitutes a marginal exception; alcohol consumption, in contrast, is practiced by more than half of the study population. Furthermore, one third of women are employed one year after giving birth.

Table 4: Descriptive results of maternal characteristics one year postpartum (FU1).

Maternal characteristics at FU1	***Total n = 49***	
	Mean (SD)	*Range*
Total postpartum weight retention (kg)	1.0 (3.8)	-4.5-14.0
Postpartum weight gain (FU1-TP4) (n=48)	-2.9 (3.3)	-9.5-5.3
BMI 1 year postpartum	22.9 (3.3)	18.71-31.8
Δ maternal BMI (kg/m^2)	.4 (1.4)	-1.74-4.88
Average hours of sleep per night	7.2 (0.9)	5-9
Physical activity (IPAQ) (n=45)		
Days of vigorous PA	1.1 (1.2)	0-4
Days of moderate PA	2.5 (2.5)	0-7
Days of walking	4.9 (2.2)	0-7
Total minutes of weekly PA	2540.4 (1876.1)	278-6777
Daily sitting time in minutes	273.4 (309.9)	30.0-2100.0
Minutes of vigorous PA (trunc 180 min.)	36.8 (41.8)	0.180.0
Minutes of moderate PA (trunc 180 min.)	53.0 (52.0)	0-180.0
Minutes of walking (trunc 180 min.)	65.1 (47.2)	0-180.0
	% (n)	
Physical activity at FU1 (%)		
Less than recommended	69.4 (34)	
Recommended	30.6 (15)	
Physical activity at FU1 in categories (IPAQ) (n=45)		
Low	15.6 (7)	
Moderate	53.3 (24)	
High	31.1 (14)	
Smoking (yes, %)	6.1 (3)	
Alcohol consumption (yes, %))	57.1 (28)	
Employment status (yes, %)	30.6 (15)	

Note: SD = Standard Deviation, n = number of included participants, FU1 = Follow Up 1 year postpartum, Total postpartum weight retention = postpartum weight (1y) - pre-pregnancy weight, Postpartum weight gain = postpartum weight (1y) - weight at TP4, Δ maternal BMI (kg/m2) = BMI at FU1 - pre-pregnancy BMI, PA = Physical Activity

3.2.1. Maternal stress and coping (SCI) at FU1

To determine the mothers' perception of stress, the Stress and Coping Inventory by Satow (2012) (104) was used at FU1. The scales stress due to uncertainty, stress due to excessive demands, and stress due to loss and negative events that occurred were added up to form an overall scale of subjectively perceived stress. The results of the Shapiro-Wilk tests for all three subscales as well as the total scale indicated a not normally distributed sample. Overall, mothers' stress-related burden appears to be low, with stress through loss or negative events being the lowest. The average overall stress score is also 1.8 (SD = 0.9) (see Table 5).

Table 5: Descriptive results of stress related burden of mothers one year postpartum.

Maternal stress-related burden (n=49)	*Mean (SD)*
Stress thorugh uncertainty	2.1 (0.9)
Stress trough excessive demand	2.2 (0.9)
Stress trough loss or negative events	1.3 (0.08)
Total stress-related burden	1.8 (0.9)
Note: SD = Standard Deviation, Mean values are based on a seven-point Likert scale (1 = not stressed, 7 = very stressed).	

3.2.2. Maternal general health behaviour (FEG) at FU1

The Health Behaviour Questionnaire (FEG) is a self-assessment procedure used to collect data on health-related behaviours (102). Regarding general health behaviour the data show that the mothers in this study are generally satisfied with their lives and rarely need to use health services. They also report a high contribution of various determinants of health (work/occupation, marriage/partnership, family/children, friends/acquaintances, leisure time, financial situation, housing situation) to well-being and a low contribution of the same to problems. The overall mean values for the scales are shown in Table 6.

Table 6: Descriptive results of general health behaviour of mothers one year postpartum.

Maternal general health behaviour (n=49)	*Mean (SD)*
Wellbeing and burdens	
General satisfaction with life*	2.0 (0.9)
Current wellbeing*	1.7 (0.9)
Factors contribute to well-being (e.g. (e.g. family, finances, housing)	4.3 (0.5)
Factors that contribute to problems (e.g. family, finances, housing)	1.8 (0.6)
Dealing with health and illness	
Utilization of health services	2.5 (0.7)
Physical resilience	3.7 (0.7)
Physical complaints	2.0 (0.6)
Note: SD = Standard Deviation, *Mean values are based on a seven-point Likert scale (-3 = very unsatisified, 3 = very satisfied), Mean values are based on a five-point Likert scale (1 = never, 5 = very often).	

3.3. Child characteristics

Table 7 provides an overview of child characteristics at birth, TP4 and FU1. The analysis is based on a total sample of 49 offsprings enrolled at birth. Body composition was measured at TP4 using the specially designed infant PEA POD® system (COSMED, Rome, Italy) and at FU1 using the BOD POD® system (COSMED, Rome, Italy), both validated air displacement plethysmography devices. Z-scores were calculated to allow comparison with international standards (WHO reference values). Z-scores are based on WHO growth standards and describe how a child's measurements (weight, length and BMI) compared to a reference population of healthy children of the same age and sex. A Z-score of 0 means that the measurement is exactly at the mean (112).

The children were born after an average gestational age of 277.2 days (SD = 7.8), which means that most of them were born on time. The mean birth weight was 3262.6 g (SD = 400). At birth, the Z-scores for weight, length and body mass index (BMI) tended to show lower values compared to the age-appropriate reference values. The mean Z-score for weight was -0.13 (SD = 0.83), for weight in relation to length -0.56 (SD = 0.95) and for BMI -0.46 (SD = 0.87).
At TP4, the children continued to have slightly negative Z-scores. The mean Z-score for weight was -0.41 (SD = 0.92), for weight-for-length -0.43 (SD = 1.17) and for BMI -0.43 (SD = 1.13). The body composition showed a mean fat-free mass of 4601.1 g (SD = 530.6) and a fat mass of 1560.8 g (SD = 522.9). The average fat-free mass index was 12.1 kg/m² (SD = 1.2). One year after birth (FU1), the mean Z-score for weight was -0.03 (SD = 0.83), which was almost equal to the reference data. The Z-score for weight-for-length was -0.45 (SD = 1.03), while the Z-score for BMI remained negative (-0.57, SD = 1.16).

Table 7: Descriptive results of child characteristics at birth, 14.-16. week and one year postpartum.

Child characteristics	***Total n = 49***	
	Mean (SD)	*Range*
Characteristics at birth		
Gestational age at delivery (days)	277.2 (7.8)	260-291
Birth weight (g)	3255.53 (398.8)	2530-4110
W/A-Z.Score	-.13 (0.83)	-1.66-1.46
W/L-Z-Score	-.56 (0.95)	-2.23-1.35
BMI/A-Z-Score	-.46 (0.87)	-1.82-1.09
Characteristics at TP4		
W/A-Z.Score (n = 48)	-.41 (0.92)	-2.57-1.92
W/L-Z-Score (n = 48)	-.43 (1.17)	-3.2-3.13
BMI/A-Z-Score (n = 48)	-.43 (1.13)	-2.98-3.11
Fat-free mass (g) (n=46)	4601.1 (530.6)	3576.6-5979.7
Fat mass (g) (n=46)	1560.8 (522.9)	
Fat-free mass index (kg/m²) (n=46)	12.1 (1.2)	9.39-14.67
Characteristics at FU1		
W/A-Z-Score (5th HPE)	-.03 (0.83)	-1.65-1.82
W/L-Z-Score (5th HPE) (n = 48)	-.45 (1.03)	-2.54-1.92
BMI/A-Z-Score (5th HPE)	-.57 (1.16)	-2.9-1.97

Note: TP4 = 14-16 weeks post partum, FU1 = Follow Up 1 year postpartum, SD = Standard Deviation, n = number of included participants, W/A-Z-Score = weight for age Z-Score, W/L-Z-Score = weight for length Z-Score, BMI/A-Z-Score = Body Mass Index for age Z-Score

3.4. Maternal nutritional intake

For descriptive presentation of the nutritional calculations, unrealistic reported data were identified in the first step. According to Ramage et al., the assessment of outliers in the FFQ data were based on unrealistic energy intake estimates of 600 kcal or >3500 kcal per day (99). Because of unrealistic energy intake reported on the FFQ and 24 hour-recall data from TP2 were excluded from the nutritional analysis.

3.4.1. Comparison with DGE recommendations

The analysis of the nutrient intake in the sample was compared with the recommendations of the German Nutrition Society (DGE) for pregnant women in the third trimester. Nutrient intake was assessed by 24-hour recalls using the third trimester of pregnancy (TP2, n = 46) and the breastfeeding period (TP4, n = 41).

The 24-hour recall (24HR) method allows for capturing short-term dietary patterns, including a broader range of foods and supplements, which may be underreported in other dietary assessment tools, such as FFQs (113). Due to mixed distribution structures of the data, a non-parametric test, the Wilcoxon test for a single sample was applied for all variables to ensure consistent and robust results. Descriptive analysis and significant results of nutrient intakes in both periods compared to DGE recommendations are shown in Table 8.

The results of the one-sample Wilcoxon signed rank test showed a significant deviation from the DGE recommendations in the third trimester (TP2) for most nutrients except vitamin A, vitamin B12, vitamin C and zinc. Similar results were found in the lactation period at TP4, except for protein (see Table 8).

Energy, macronutrients

The mean energy intake was 1811.8 kcal (SD = 530) during TP2 and 1834.5 kcal (SD = 523) during TP4, which is 765–888 kcal below the recommended 2600–2700 kcal. Protein intake was 73.4 g (SD = 26.1) in TP2 and 69.5 g (SD = 26.2) in TP4, and above the recommendations of 58 g and 63 g, respectively. Carbohydrate intake was 213.4 g (SD = 68.9) in TP2 and 209.9 g (SD = 65.8) in TP4, which is significantly below the recommended 317–329 g. Dietary fibre intake was 21.3 g (SD = 7.4) in TP2 and 21.5 g (SD = 7.1) in TP4, both below the recommendation of >30 g.

Fats, fatty acids

Fat intake was 71.1 g (SD = 29.2) in TP2 and 77.5 g (SD = 26.8) in TP4, slightly below the recommendations of 83.9–87 g. Linoleic acid intake was higher than the recommendations of 6.5–6.75 g, with 9.8 g (SD = 5.1) in TP2 and 11.6 g (SD = 6.9) in TP4, while linolenic acid intake in TP2 was 1.1 g (SD = 0.6) in TP2, slightly below the recommendations of 1.3–1.35 g, but reached the recommended range in TP4 with 1.4 g (SD = 1.6). The intake of DHA and EPA was well below the recommended 250 mg in both phases. DHA intake was 134.4 mg (SD = 239.3) in TP2 and 125.5 mg (SD = 209.4) in TP4, while EPA intake was 66.6 mg (SD = 124.9) in TP2 and 84.3 mg (SD = 196.7) in TP4.

Key micronutrients

Micronutrient intakes also varied. Vitamin D intake was 2.2 µg (SD = 3.9) in TP2 and 2.9 µg (SD = 3.8) in TP4, far below the recommended 20 µg. In contrast, vitamin K intake was above recommendations with 136.3 µg (SD = 88.5) in TP2 and 123.5 µg (SD = 115.7) in TP4 compared to 60 µg. Folate intake was 224.4 µg (SD = 90.0) in TP2 and 230.9 µg (SD = 100.9) in TP4, significantly below the recommended 550 µg and 450 µg, respectively. Iron intake was 11.4 mg (SD = 4.2) in TP2 and 11.5 mg (SD = 4.3) in TP4, both below the recommended 30 mg and 20 mg, respectively. Iodine intake was also insufficient, with 107.7 µg (SD = 71.1) in TP2 and 114.9 µg (SD = 68.6) in TP4 compared to the recommendations of 230 µg and 260 µg, respectively. Calcium intake was 907.6 mg (SD = 466.9) in TP2 and 933.5 mg (SD = 479.5) in TP4, slightly below the recommended 1000 mg. Zinc intake was 10.0 mg (SD = 3.8) in TP2 and 10.4 mg (SD = 4.0) in TP4, slightly below the recommended ranges of 9–13 mg and 11–14 mg. Copper intake was above the recommendations of 1.0–1.5 mg, with 1.7 mg (SD = 0.7) in TP2 and 1.6 mg (SD = 0.6) in TP4.

It is important to note that dietary supplements were not included in this analysis. This may have underestimated nutrient intakes, especially for critical micronutrients such as iron, iodine, and folate, which are commonly supplemented during pregnancy and lactation.

Table 8: Comparisons between DGE recommendations and nutritional intake of mothers in pregnancy and lactation period.

Nutrient	DGE values 3rd trimester Mean	Nutritional intake 24HR - TP2 (n = 46) Mean	SD	DGE values lactation period Mean	Nutritional intake 24HR- TP4 (n = 41) Mean	SD
Energy, macronutrients						
Energy (kcal)	2600-2700	1811.8**	530.0	2600-2700	1834.5**	523.0
Protein (g)	58	73.4**	26.1	63	69.5	26.2
Carbohydrate (g)	317 -329	213.4**	68.9	317 -329	209.9**	65.8
Fibre (g)	>30	21.3**	7.4	>30	21.5**	7.1
Fats, fatty acids						
Fat (g)	83.9-87	71.1**	29.2	83.9-87	77.5*	26.8
Linol acid (g) (2.5 % E)	6.5-6.75°	9.8**	5.1	6.5-6.75*	11.6**	6.9
Linolen acid (g) (0.5 % E)	1.3-1.35°°	1.1*	.6	1.3-1.35**	1.4*	1.6
DHA (mg)	250	134.4**	239.3	250	125.5**	209.4
EPA (mg)	250	66.6**	124.9	250	84.3**	196.7
Alcohol (g)	-	.5**	1.3	-	.4**	1
Key micronutrients						
Vitamin A (mg-RAE)	0.8	3.7	13.6	1.3	1.0*	.6
Vitamin D (µg)	20	2.2**	3.9	20	2.9**	3.8
Vitamin K (µg)	60	136.3**	88.5	60	123.5**	115.7
Vitamin B6 (mg)	1.8	1.5**	.6	1.6	1.2**	.5
Folate B9 (µg)	550	224.4**	90.0	450	230.9**	100.9
Vitamin B12 (µg)	4.5	4.0	2.4	5.5	3.9**	2.4
Vitamin C	105	111.0	57.8	125	83.3**	57.4
Calcium (mg)	1000	907.6*	466.9	1000	933.5*	479.5
Iron (mg)	30	11.4**	4.2	20	11.5**	4.3
Iodine (mg)	230	107.7**	71.1	260	114.9**	68.6
Zinc (mg)	9-13	10.0	3.8	11-14	10.4*	4.0
Copper (mg)	1.0-1.5	1.7**	.7	1.0-1.5	1.6**	.6

Note: TP2 = 32-34 weeks of pregnancy, TP4 = 14-16 weeks post partum, SD = Standard Deviation, 24HR = 24-hour recall, kcal = kilocalories, g = grams, mg = milligrams, µg = micrograms, EPA = eicosapentaenoic acid, DHA = docosahexaenoic acid, DGE = Deutsche Gesellschaft für Ernährung, °recommendations of an intake of 2.5 % of the total energy intake; °°recommended intake of 0.5 % of total energy intake. Guideline values for average energy intake in people with 1.6 PAL = physical activity level, **p-value* significant at p < 0.05 level and ** *p-value* significant at p < 0.01 level.

3.4.2. Nutritional changes in pregnancy, postpartum and follow-up

The Friedman test, a non-parametric method, was applied to analyze nutrient intakes from the FFQ (including energy, macronutrients, key micronutrients, and amino acids) across three time points - TP2, TP4, and FU1 (see Figure 4-6). Significant results were further analyzed using Dunn-Bonferroni tests. For exploratory purposes, additionally Wilcoxon signed-rank tests were applied to compare key nutrients between TP2 and FU1, without Bonferroni corrections due to the moderate sample size (n = 40) and the exploratory nature of the analysis (see Table 9).

Macronutrients

Dietary fibre intake showed a significant difference across the three time points ($\chi^2(2) = 8.450$, $p = 0.015$, n = 40). The mean rank was highest at TP2 (2.38) compared to TP4 (1.83) and FU1 (1.80), indicating a decline over time. Post-hoc test (Dunn-Bonferroni) was performed, which show that there is a significant difference between dietary fibre intake at TP2 and TP4 ($z = 0.55$, $p_{adj} = 0.042$) and TP2 and FU1 ($z = 0.57$, $p_{adj} = 0.030$), whereas TP2 show a higher dietary fibre intake as TP4 and FU1. This finding was supported by the Wilcoxon signed-rank test, which showed a significant decline in dietary fibre intake from TP2 (28.2 g, SD = 9.3) to FU1 (24.3 g, SD = 8.7) ($p = 0.004$).

Alcohol intake significantly increased across the three time points ($\chi^2(2) = 31.786$, $p < 0.001$, n = 40). The mean rank was highest at FU1 (2.59), followed by TP4 (2.08) and TP2 (1.34), indicating a steady increase in alcohol consumption over time. After Bonferroni adjustment a significant difference was observed between alcohol intake at TP2 and TP4 ($z = -0.738$, $p_{adj} = 0.003$), between TP4 and FU1 ($z = -0.513$, $p_{adj} = 0.066$) and between ($z = -1.250$, $p_{adj} < 0.001$), indicating a substantial increase in alcohol consumption from TP2 to FU1. These findings were further confirmed by the Wilcoxon signed-rank test ($p < 0.001$).

Micronutrients

Vitamin K intake showed significant differences across the three time points ($\chi^2(2) = 15.000$, $p = 0.001$, n = 40). The mean rank was higher at TP2 (2.25) compared to

TP4 (1.50). A significant difference was observed between Vitamin K intake at TP2 and TP4 ($z = 0.750$, $p_{adj} = 0.002$), indicating a higher intake at TP2 compared to TP4. A significant difference was found between TP4 and FU1 ($z = -0.750$, $p_{adj} = 0.002$), suggesting a lower intake at TP4 compared to FU1. No significant difference was observed between TP2 and FU1, which was also confirmed with the Wilcoxon signed-rank test ($p = 0.619$).

Vitamin B9 showed significant differences ($\chi^2(2) = 11.850$, $p = 0.003$, $n = 40$) with higher intake during pregnancy (rank = 2.43) compared to the later time points (TP4 = 1.69; FU1 = 1.90). For further analysis, Dunn-Bonferroni Test was performed and showed a significant difference in Vitamin B9 intake between TP2 and TP4 ($z = 0.75$, $p_{adj} = 0.002$). There were no significant differences in Vitamin B9 intake between TP2 and FU1 ($z = 0.53$, $p_{adj} = 0.057$) and TP4 and FU1 ($z = -0.23$, $p_{adj} = 0.943$). However, the Wilcoxon post-hoc test for the comparison between TP2 321.3 µg (SD = 102.0) and FU1 291.1 µg (SD = 105.4) confirmed a significant result ($p = 0.037$).

Vitamin C intake significantly differed across time points ($\chi^2(2) = 12.350$, $p = 0.002$, $n = 40$) with higher intake at baseline (rank = 2.35) compared to later time points (TP 4 = 1.58; FU1 = 2.08). A significant difference was observed between Vitamin C intake at TP4 and TP2 ($z = 0.775$, $p_{adj} = 0.002$), indicating a higher intake at TP4 compared to TP2. No significant difference was observed in Vitamin C intake between TP4 and FU1 ($z = -0.500$, $p_{adj} = 0.076$).and TP2 and FU1 ($z = 0.275$, $p_{adj} = 0.656$). Also, the Wilcoxon test showed no statistically significant change in the comparison between TP2 144.7 mg (SD = 60.8) and FU1 133.5 mg (SD = 56.4) ($p = 0.346$).

Iron intake also significantly decreased over time ($\chi^2(2) = 9.800$, $p = 0.007$, $n = 40$). The highest mean rank (2.40) showed that the intake during pregnancy was higher than at later times (TP 4 = 1.85; FU1 = 1.75). Post hoc testing showed a significant difference in iron intake between TP4 and TP2 ($z = 0.550$, $p_{adj} = 0.042$), indicating higher iron intake at TP2 compared to TP4. No significant observation was shown in iron intake between FU1 and TP4. But, a significant difference was observed in iron intake between TP2 and FU1 ($z = 0.650$, $p_{adj} = 0.011$), indicating higher iron intake at TP2 compared to FU1. These findings were supported by the Wilcoxon test, which showed a significant decline from TP2 (321.3 µg, SD = 102.0) to FU1 (291.1 µg, SD = 105.4) (p = 0.037).

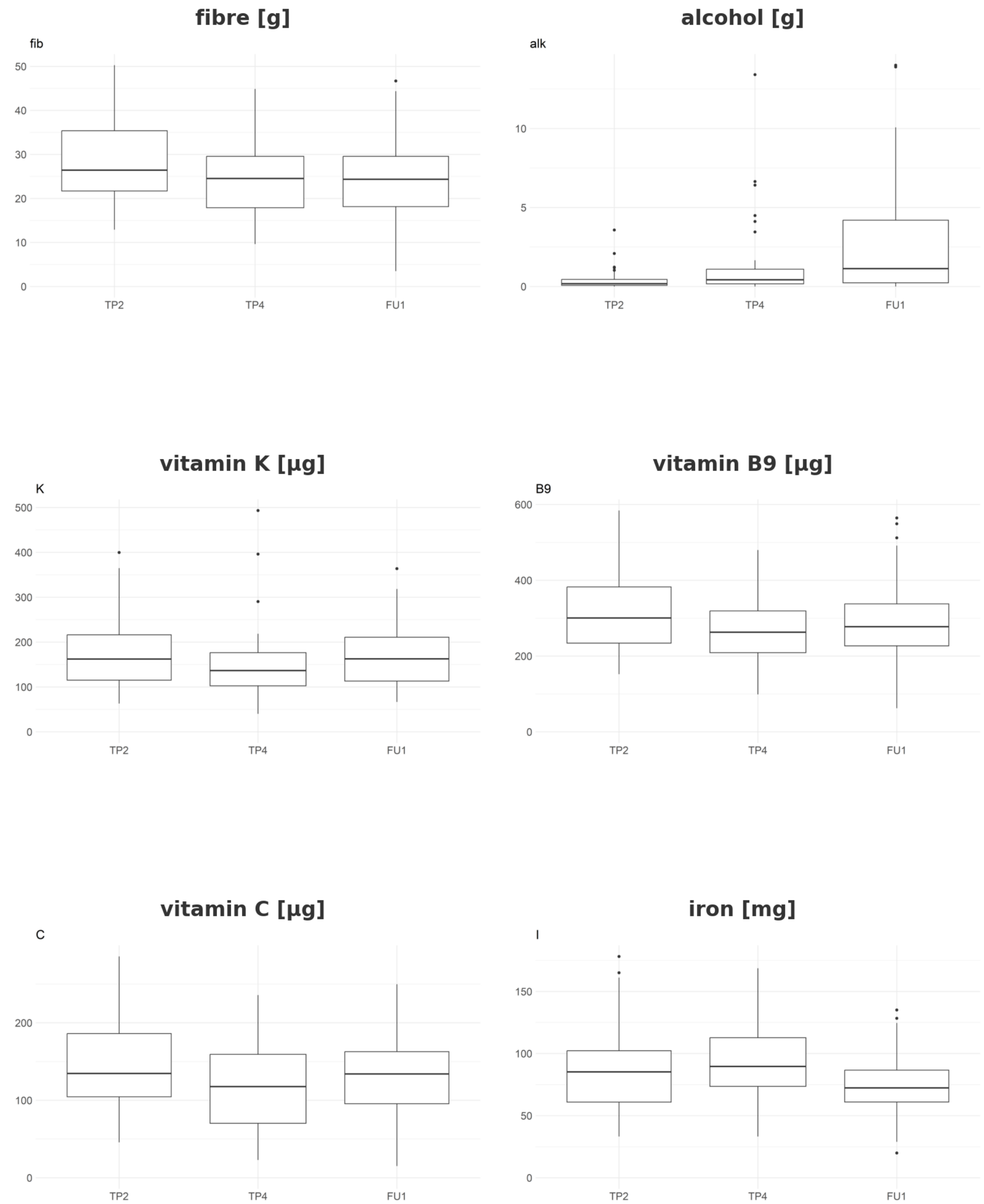

Figure 4: Boxplot matrix depicting the distribution of nutrient intake over time of TP2, TP4 and FU1 based on the results of the Friedman tests.

Supplementary exploratory analysis

Although the Friedman test showed no significant differences for carbohydrates, protein, iodine, zinc, and several amino acids across the three time points, Wilcoxon signed-rank tests showed trends. Carbohydrate (p = 0.018) and protein intake (p = 0.036) significantly decreased from TP2 to FU1. Iodine intake also declined significantly, as did zinc (p = 0.037) (see Table 9 and Figure 5).

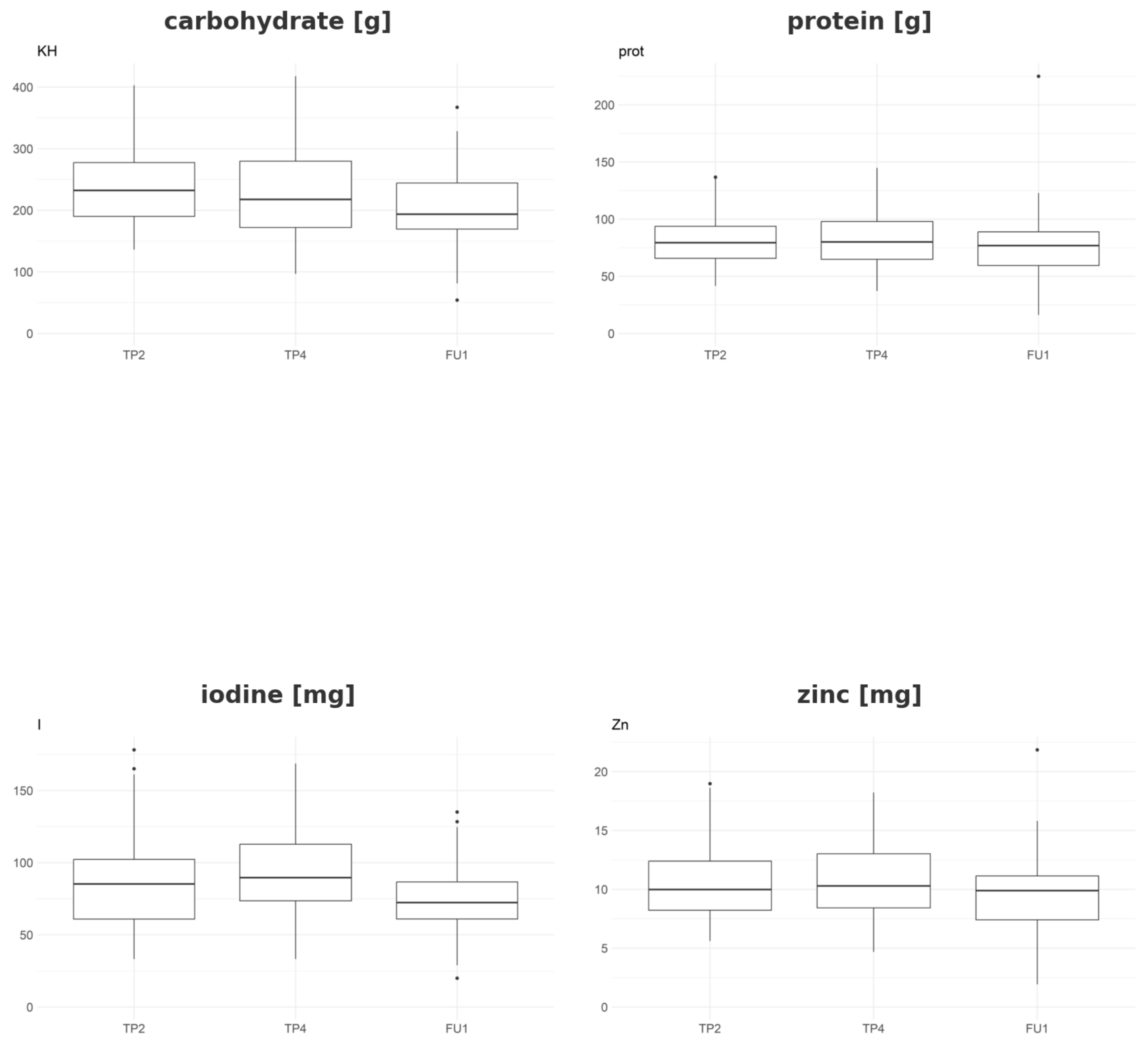

Figure 5: Boxplot matrix depicting the distribution of nutrient intake over time of TP2, TP4 and FU1 based on further results of the Wilcoxon signed-rank tests.

All amino acids showed significant decreases, except histidine (see Table 9 and Figure 6).

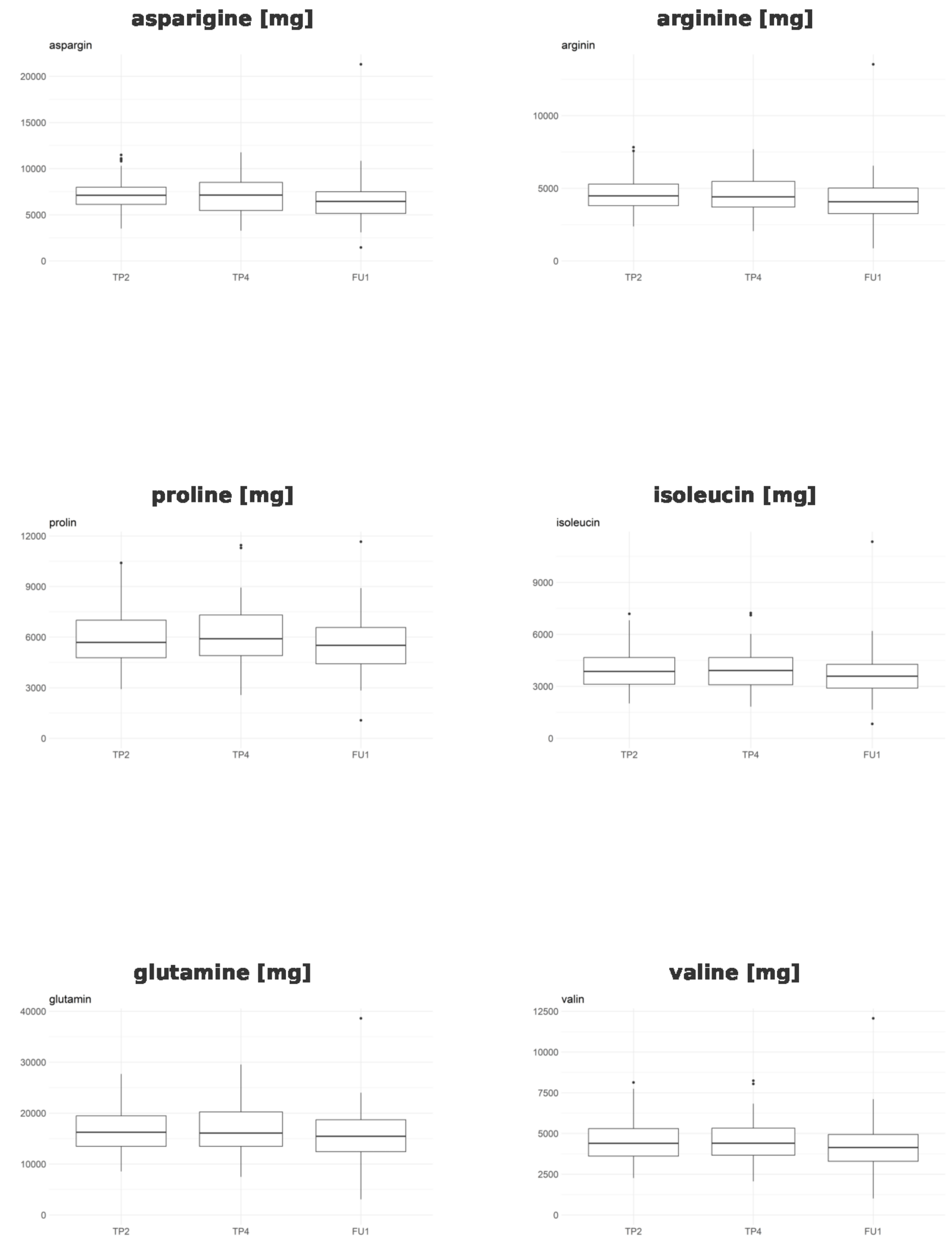

Figure 6: Boxplot matrix depicting the distribution of amino acids intake over time of TP2, TP4 and FU1 based on further results of the Wilcoxon signed-rank tests.

Table 9: Descritptive results of maternal nutritional intake at TP2, TP4 and FU1 and comparison of TP2 and FU1.

	TP2 (FFQ, n = 47)		TP4 (FFQ, n = 40)		FU1 (FFQ, n = 47)		TP2 - FU1
Nutrient	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p*-value Wilcoxon
Energy, macronutrients							
Energy (kcal)	1986.4	491.4	1980.7	591.3	1881.9	545.4	.115
Protein (g)	82.1	23.7	82.8	24.8	77.4	31.1	.036*
Carbohydrate (g)	237.4	62.4	222.1	71.9	206.2	69.1	.018*
Fibre (g)	28.2	9.3	24.7	8.7	24.3	8.7	**.004***
Fats, fatty acids							
Fat (g)	76.1	25.1	81.5	29.3	79.1	27.9	.532
Saturated Fat (g)	31.0	11.2	34.8	13.7	32.3	12.6	.641
MUFA (g)	28.6	9.9	30.4	11.3	30.2	11.0	.305
PUFA (g)	12.1	4.8	11.7	4.3	12.2	4.3	.966
Linol acid (g)	9.4	3.8	9.0	3.3	9.3	3.5	.857
Linolen acid (g)	2.2	1.2	2.2	1.1	2.4	1.0	.295
Laurin acid (mg)	1272.5	514.2	1388.9	618.0	1331.4	577.3	.800
Palmitin acid (mg)	14795.2	5204.6	16642.8	6285.5	15399.4	5897.5	.568
DHA (mg)	191.1	123.8	214.3	161.7	201.8	170.1	.966
EPA (mg)	81.6	64.7	94.7	92.6	85.2	96.7	.841
Omega3-fatty acids (mg)	2526.7	1230.3	2526.4	1166.8	2695.9	1084.2	.325
Omega-6 fatty acids (mg)	9550.1	3830.5	9158.5	3351.7	9486.6	3543.8	.874
Cholesterol (mg)	309.3	147.6	323.1	114.3	327.6	178.2	.346
Starch (mg)	133475.4	37720.4	131483.9	50863.9	120649.3	45277.2	.120
Alcohol (g)	0.4	0.6	1.4	2.6	2.9	3.6	**<.001****
Key micronutrients							
Vitamin A (mg-RAE)	1.6	0.7	1.5	0.7	1.7	0.7	.492
Vitamin D (µg)	3.3	1.8	3.6	1.6	3.9	1.7	**.047***
Vitamin K (µg)	178.4	79.8	151.0	87.4	174.4	71.1	.619
Vitamin B6 (mg)	1.7	0.5	1.5	0.5	1.6	0.6	**.048***
Folate B9 (µg)	321.3	102.0	274.2	97.6	291.1	105.4	**.037***
Vitamin B12 (µg)	4.8	1.9	5.1	1.8	4.7	2.2	.546
Vitamin C (µg)	144.7	60.8	116.6	55.8	133.5	56.4	.346
Calcium (mg)	978.0	460.1	1015.9	495.1	892.8	362.1	.081
Iron (mg)	11.6	3.6	10.4	3.3	10.1	3.5	**.016***
Iodine (mg)	87.5	34.4	91.3	31.1	75.6	24.3	.027*
Zinc (mg)	10.6	3.3	10.7	3.3	9.8	3.5	.037*
Copper (mg)	1.8	0.5	1.7	0.5	1.6	0.5	.128
Key amino acids							
Asparagine (mg)	7144,050	2019,6633	7136.7	2028.5	6656.2	2868.9	.011*
Histidin (mg)	2188.2	690.2	2258.1	720.9	2093.8	957.0	.063
Arginin (mg)	4620.2	1356.1	4585.4	1326.9	4279.1	1815.3	.011*
Prolin (mg)	6000.7	1828.8	6069.2	2026.9	5619.3	1893.7	**.049***
Isoleucin (mg)	4001.8	1247.8	4045.0	1237.2	3775.4	1577.0	.049*
Glutamin (mg)	16706.1	4563.8	16794.2	5149.3	15671.5	5574.5	.032*
Valin (mg)	4570.1	1404.2	4623.8	1413.8	4307.5	1707.8	.047*

Note: TP2 = 32-34 weeks of pregnancy, TP4 = 14-16 weeks post partum, FU1 = Follow Up 1 year postpartum, SD = Standard Deviation, FFQ = food frequency questionnaire, kcal = kilocalories, g = grams, mg = milligrams, µg = micrograms, MUFA = monounsaturated fat, PUFA = polyunsaturated fat, EPA = eicosapentaenoic acid, DHA = Docosahexaenoic acid, Wilcoxon Signed-Rank Test *p-value significant at $p < 0.05$ level and ** p-value significant at $p < 0.01$ level.

3.4.3. Analysis of Δ maternal BMI and nutritional intake

The variable Δ maternal BMI shows an average of 0.4 kg/m² (SD = 1.4) (see Table 4) and does not follow a normal distribution. Spearman's correlations of maternal nutritional intakes and Δ maternal BMI were analyzed over the three time points TP2, TP4 and FU1, collected by FFQ (see Table 10).

At TP2, significant positive correlations were observed for energy intake (r_s = 0.34, p = 0.018, CI: 0.053 to 0.579), protein intake (r_s = 0.29, p = 0.045, CI: -.002 to 0.542) and fat intake (r_s = 0.34, p = 0.018, CI: 0.055 to 0.580). These results suggest that higher intakes of energy, protein and fat may be associated with an increase in BMI. Similarly, saturated fat (r_s = 0.31, p = 0.036, CI: 0.013 to 0.552), monounsaturated fat (MUFA) (r_s = 0.32, p = 0.029, CI: 0.026 to 0.561) and palmitic acid (r_s = 0.33, p = 0.024, CI: 0.037 to 0.568) were positively correlated with changes in BMI, suggesting that higher intakes of these fatty acids may contribute to increases in BMI. In addition, omega-6 fatty acids (r_s = 0.29, p = 0.047, CI: -.005 to 0.540) and valine (r_s = 0.29, p = 0.049, CI: -.007 to .538) also showed significant positive correlations, suggesting a potential effect of these nutrients on BMI increase.

At TP4, the results showed several significant negative correlations. Dietary fibre intake (r_s = -0.41, p = 0.008, CI: -.649 to -.109) was inversely related to changes in BMI, suggesting that higher dietary fibre intake may protect against increases in BMI. Similarly, DHA (r_s = -0.33, p = 0.040, CI: -.586 to -.008) and omega-3 fatty acids (r_s = -0.33, p = 0.038, CI: -.588 to -.011) showed negative associations with BMI, suggesting a protective effect of these fatty acids. Micronutrients such as vitamin A (r_s = -0.42, p = 0.007, CI: -.653 to -.117), vitamin K (r_s = -0.34, p = 0.033, CI: -.593 to -.019), folate B9 (r = -0.32, p = 0.044, CI: -.581 to -.001), vitamin B12 (r_s= -0.43, p = 0.006, CI: -.658 to -.125) and vitamin C (r_s = -0.40, p = 0.010, CI: -.640 to -.094) also showed significant negative correlations, suggesting that higher intakes of these vitamins may reduce the increase in BMI.

In contrast, at FU1, no significant associations were found between nutrient intake and BMI changes, suggesting that the associations observed at earlier time points may not persist one year postpartum.

Table 10: Associations of change in BMI (Δ) and nutrition intakes measured at TP2, TP4 and FU1.

	TP2 (ΔBMI, n = 47)		TP4 (ΔBMI, n = 40)		FU1 (ΔBMI, n = 47)	
Nutrient	r_s	*p*-value	r_s	*p*-value	r_s	*p*-value
Energy, macronutrients						
Energy (kcal)	.34	**.018***	-.10	.523	.13	.393
Protein (g)	.29	**.045***	-.19	.250	.03	.825
Carbohydrate (g)	.21	.168	-.11	.506	.06	.695
Fibre (g)	.09	.534	-.41	**.008***	-.06	.691
Fat (g)	.34	**.018***	-.09	.601	.21	.165
Fats, fatty acids						
Saturated Fat (g)	.31	**.036***	-.02	.898	.12	.412
MUFA (g)	.32	**.029***	-.10	.531	.21	.167
PUFA (g)	.23	.115	-.28	.076	.21	.161
Linol acid (g)	.28	.055	-.20	.216	.28	.054
Linolen acid (g)	.02	.908	-.33	**.040**	.15	.325
Laurin acid (mg)	.25	.086	.05	.775*	.16	.272
Palmitin acid (mg)	.33	**.024***	-.02	.912	.12	.416
DHA (mg)	.13	.378	-.33	**.040***	-.03	.817
EPA (mg)	.09	.56	.05	.774	-.08	.601
Omega3-fatty acids (mg)	.09	.536	-.33	**.038***	.12	.403
Omega-6 fatty acids (mg)	.29	**.047***	-.19	.247	.28	.058
Cholesterol (mg)	.28	.054	-.07	.686	.0	.98
Starch (mg)	.09	.551	-.14	.408	.07	.618
Alcohol (g)	.20	.173	.10	.553	.14	.362
Key micronutrients						
Vitamin A (mg-RAE)	.04	.811	-.42	**.007***	-.07	.653
Vitamin D (µg)	.27	.068	-.09	.598	.0	.993
Vitamin K (µg)	.20	.187	-.34	**.033***	.03	.852
Vitamin B6 (mg)	.20	.182	-.13	.413	.06	.664
Folate B9 (µg)	.14	.353	-.32	**.044***	.01	.969
Vitamin B12 (µg)	.27	.065	-.43	**.006***	.03	.85
Vitamin C	.12	.441	-.40	**.010***	-.13	.373
Calcium (mg)	.26	.077	.07	.653	.14	.332
Iron (mg)	.21	.167	-.26	.099	.06	.675
Iodine (mg)	.21	.167	-.01	.956	-.01	.964
Zinc (mg)	.23	.128	-.18	.279	.05	.742
Copper (mg)	.20	.176	-.22	.181	-.02	.905
Key amino acids						
Asparagine (mg)	.26	.081	-.26	.111	.01	.972
Histidin (mg)	.26	.076	-.18	.258	.05	.749
Arginin (mg)	.25	.089	-.28	.086	.02	.885
Prolin (mg)	.27	.062	-.12	.461	.1	.491
Isoleucin (mg)	.28	.054	-.19	.237	.05	.752
Glutamin (mg)	.28	.058	-.18	.272	.05	.73
Valin (mg)	.29	**.049***	-.19	.246	.04	.779

Note: TP2 = 32-34 weeks of pregnancy, TP4 = 14-16 weeks post partum, FU1 = Follow Up 1 year postpartum, SD = Standard Deviation. FFQ = food frequency questionnaire. g = grams. mg = milligrams. µg = micrograms. MUFA = monounsaturated fat. PUFA = polyunsaturated fat. EPA = eicosapentaenoic acid. DHA = Docosahexaenoic acid. Spearman's rho *p-value significant at $p < 0.05$ level and ** p-value significant at $p < 0.01$ level.

3.4.4. Further explorative analysis of maternal nutritional intake

Association of maternal nutritional intake and infant anthropometry

The results of the Spearman correlations indicate significant associations between maternal nutrient intake and the infant's body composition, particularly the Fat Mass Index (FMI), at TP4. Specifically, nutrient intake at TP2, measured using the FFQ, showed significant negative correlations with EPA ($r_s = -0.302$, $p = 0.049$, CI = -0.558 to 0.008) and DHA ($r_s = -0.342$, $p = 0.025$, CI = -0.589 to -0.038).

For exploratory reasons, these findings were further supported by data collected through the 24HR method at TP2, which also show significant negative correlations with EPA ($r_s = -0.375$, $p = 0.013$, CI = -0.613 to -0.075) and DHA ($r_s = -0.310$, $p = 0.043$, CI = -0.565 to -0.002). These results suggest that higher prenatal intake of EPA and DHA may be associated with lower fat mass in infants at TP4.

Association of maternal nutritional intake and breastfeeding practice

A Mann-Whitney U test was conducted to examine differences in maternal nutrient intake, collected using the FFQ, based on the variable “Type of nutrition of the child” at TP4 (fully breastfed vs. not fully breastfed). No significant differences were found between nutrient intake at TP2 or FU1 and breastfeeding status. However, at TP4, a significant difference emerged between alcohol intake and breastfeeding style ($U = 101.5$, $p = 0.05$).

For exploratory reasons, nutrient intake collected via the 24HR method was also analyzed in relation to breastfeeding behaviour using the Mann-Whitney U test. A significant difference was identified in vitamin A intake (mg-RAE) at TP2, measured by the 24-hour recall method, and breastfeeding behaviour at TP4 ($U = 131$, $p = 0.035$).

3.5. Maternal physical activity

As mentioned before at TP2, 51 % of mothers met the Austrian recommendations for physical activity (at least 150 minutes per week). After birth, a decrease in recommended physical activity was observed at TP4 (59.2 %), while the decrease continued at FU1, with 69.4 % of mothers exercising less than recommended (see Table 4).

3.5.1. Physical activity changes in pregnancy, postpartum and follow-up

A Friedman test confirmed these findings across three time points (TP2, TP4 and FU1, n = 45). The analysis included responses to the following three ordinal ranked questions: (i) “How often have you been physically active for 60 minutes in the last 7 days?”, (ii) “How often have you been physically active to the point of sweating?”, and (iii) “How many hours per week are you physically active to the point of sweating?”. A significant difference was found for the question “How often have you been physically active for 60 minutes in the last 7 days?” ($\chi^2(2) = 10.43$, $p = 0.005$). The mean rank was highest at TP2 (2.28) and decreased at TP4 (2.03) and FU1 (1.69), indicating a decrease in activity frequency over time. Post-hoc test (Dunn-Bonferroni) was performed, which show that there is a significant difference between TP2 and TP4 ($z = 0.589$, $p_{adj} = 0.016$).
The question “How often were you so physically active that you broke out in a sweat?” also showed a significant difference ($\chi^2(2) = 8.66$, $p = 0.013$). The mean rank increased from 1.71 for TP2 to 2.12 for TP4 and reached 2.17 for FU1. This indicates a slight increase in activity up to sweating. Post-hoc test showed no significant results between the time points anymore.
A highly significant difference was found for the question “How many hours per week were you physically active to the point of sweating?” ($\chi^2(2) = 13.40$, $p = 0.001$). The mean rank was highest for TP2 (2.36) and decreased significantly for TP4 (1.87) and FU1 (1.78), indicating a reduction in the total duration of intense physical activity over time. Post-hoc test was performed, which show that there is a significant difference between TP2 and TP4 ($z = 0.578$, $p_{adj} = 0.018$).

3.5.2. Analysis of Δ maternal BMI and physical activity

Spearman's correlation analyses were also performed for the 3 physical activity questions at TP2, TP4 and FU1. It shows that there is a significant negative correlation between Δ maternal BMI and "How often did you do 60 minutes of physical activity in the last 7 days? ($p = 0.032$, $r_s = -0.307$, CI= -.547 to -.019). No other significant associations with physical activity were found. No significant associations were found between Δ maternal BMI and physical activity variables collected with IPAQ at FU1.

Further, for comparison between Δ maternal BMI and the groups that met the Austrian exercise recommendations and those that did not, a Mann-Whitney U test was applied. The analysis was performed for three time points: TP2, TP4 and FU1. At time point TP2, the mean rank of Δ maternal BMI was 26.42 for participants who did not meet the exercise recommendations and 23.64 for participants who met the recommendations ($U = 266.0$, $Z = -0.680$ $p = 0.496$). This indicates that there was no significant difference in BMI change between groups at TP2.

At TP4, there was a mean rank of 25.17 for participants who did not meet the exercise recommendations and a mean rank of 17.33 for participants who did meet the recommendations ($U = 140.0$, $Z = -1.920$, $p = 0.055$). Although this difference just missed the significance threshold, it may indicate a tendency for participants who met the exercise recommendations to have smaller changes in BMI.

At the one-year follow-up (FU1), the participants who did not meet the recommendations had a mean rank of 26.21, while the participants who met the recommendations had a mean rank of 22.27 ($U = 214.0$, $Z = -0.890$, $p = 0.374$). This indicates that the groups were not significantly different in terms of Δ maternal BMI at this time point either.

3.6. Further explorative analysis of maternal and infant characteristics

In this section, the mothers‘ weight-related variables are further analysed and also linked to the infants’ data.

3.6.1. Maternal weight related variables

Regarding Δ maternal BMI, maternal weight-related variables, general health behaviour or sociodemographic factors, no significant results were found. However, associations were found with variables of infant anthropometry.

Associations of Δ maternal BMI and child characteristics
Thus, Spearman's correlation analyses show that there is a significant negative correlation between Δ maternal BMI and both infants’ birth weight ($p = 0.011$, $r_s = -0.362$, CI=-0.589 to -0.082) and the weight for age z-score at birth ($p = 0.036$, $r_s = -0.300$, CI=-0.542 to -0.012). No other significant results were observed between Δ maternal BMI and anthropometry at birth, in TP4 and FU1, or in body composition (fat mass, fat-free mass, and fat mass index) in TP4. These results may indicate a potential trend suggesting that a greater increase in maternal BMI during pregnancy could be related to lower birth weight and lower infant weight-for-age z-scores.

Group comparison of initial maternal BMI above and below 25' BMI and maternal anthropometry
The Mann-Whitney U test showed a significant difference in BMI one year after birth between the two groups (U=6.0, $p<0.001$), highlighting that pre-pregnancy BMI may influence maternal postpartum BMI outcomes. No significant results were shown with *Δ maternal BMI.*

Group comparison of Incremental Weight Gain Mean in kg/week (IOM) and maternal anthropometry
A Kruskal-Wallis test showed significant differences in IWG between the ‘less than recommended’, ‘recommended’ and ‘more than recommended’ groups in relation to

BMI one year after birth (BMI1y) ($\chi^2(2) = 12.836$, $p = 0.002$). To further analyse these differences, pairwise comparisons with Bonferroni correction were performed: There is a significant difference in BMI1y between the ‘less than recommended’ and ‘more than recommended’ groups. The ‘more than recommended’ group has a significantly higher BMI one year postpartum compared to the ‘less than recommended’ group ($z = -16.695$, $p_{adj} = 0.003$). There is a trend towards a difference in BMI one year postpartum between the ‘recommended’ and ‘more than recommended’ groups. After Bonferroni correction, however, the result is no longer significant ($z = -11.657$, $p_{adj} = 0.053$). There is no significant difference in BMI1y between the ‘less than recommended’ and ‘recommended’ groups ($p_{adj} = 1.0$).
No significant results were shown with *Δ maternal BMI.*

Group comparison of Incremental Weight Gain Mean in kg/week (IOM) and infant anthropometry

A Kruskal-Wallis test was performed to analyse differences in the fat mass (kg) of children at TP4 between the IWG groups ‘less than recommended’, ‘recommended’ and ‘more than recommended’. The test showed a significant difference between the groups ($\chi^2(2) = 8.475$, $p = 0.014$). For further analysis, pairwise comparisons with Bonferroni correction were performed. There is a tendency towards a difference in fat mass at TP4 between the ‘less than recommended’ and ‘more than recommended’ groups. After Bonferroni correction, however, the result is no longer significant ($z = -11.625$, $p_{adj} = 0.054$). There is a significant difference in fat mass between the ‘less than recommended’ and ‘recommended’ groups. Children from the ‘recommended’ group show a significantly higher fat mass at TP4 compared to the ‘less than recommended’ group ($z = -15.530$, $p_{adj} = 0.017$). There is no significant difference in fat mass between the ‘more than recommended’ and ‘recommended’ groups ($p_{adj} = 1.0$).

Also, differences are shown in fat mass index (FMI) at TP4 between the 'less than recommended', 'recommended' and 'more than recommended' groups. The K-S test showed a significant difference between the groups ($\chi^2(2) = 8.619$, $p = 0.013$). Subsequent pairwise comparisons showed that there was a significant difference in FMI between the 'less than recommended' and 'recommended' groups ($z = -16.015$, $p_{adj} = 0.013$), with children in the 'recommended' group having a higher FMI. A trend towards a difference was observed between the 'less than recommended' and 'more than recommended' groups ($z = -11.008$, $p_{adj} = 0.076$), but the result was no longer significant after Bonferroni correction. No significant difference was found between the 'more than recommended' and 'recommended' groups ($z = 5.007$, $p_{adj} = 0.885$). The results indicate that children in the 'recommended' group have a higher FMI than those in the 'less than recommended' group, while no significant differences were found between the other groups.

3.6.2. Maternal breastfeeding practice

Using Mann-Whitney U test, significant differences were observed between breastfeeding practice at TP4 (fully breastfed vs. not fully breastfed) and infants' birth weight ($U = 156.5$, $p = 0.043$), as well as weight ($U = 139.0$, $p = 0.016$) and length ($U = 137.5$, $p = 0.013$) of the child measured between the 7th and 9th month based on HPE examination data. This indicates a possible influence of breastfeeding behaviour on weight development in early infancy. In addition, significant differences were found in the z-score for weight at 1 year of age (FU1) ($U = 153$, $p = 0.047$), suggesting that breastfeeding behaviour may have a long-term influence on weight development. The z-score for weight in relation to length at 1 year of age (FU1) also showed significant differences between the groups ($U = 157.5$, $p = 0.045$), indicating a possible relationship between breastfeeding behaviour and the children's body proportions. No significant results were shown with Δ maternal BMI or other maternal weight related variables.

.

Qualitative analysis

24 semi-structured interviews were conducted of women one year after childbirth. The characteristics of the interviewees are illustrated in Table 11.

Table 11: Descriptive results of 24 interviewed mothers one year postpartum.

Maternal characteristics	***Total n = 24***	
	Mean (SD)	*Range*
Maternal age at FU1	33.6 (4.8)	22.0-42.0
Early pregnancy BMI (kg/m²),	23.0 (3.1)	19.36-30.83
Total gestational weight gain (kg)	14.5 (4.1)	7.0-28.0
	n	
BMI at FU1		
Normal (18,5 - 24,9 kg/m2)	18	
Overweight (25,0 - 29,9 kg/m2)	5	
Obesity (>= 30,0 kg/m2)	1	
Total gestational weight gain (IOM) in categories		
Less than recommended	6	
Recommended	27	
More than recommended	16	
Parity		
Primipara	17	
Multipara	7	
Caesarean delivery	8	
Sex (Female)	5	
Smoking (yes)	2	
Education level		
Not completed tertiary education	8	
Completed tertiary education	16	
Physical activity level		
low	3	
moderate	15	
high	5	
Family status		
Living with partner	23	
Marital status		
Married	8	

Note: FU1 = Follow Up one year postpartum, SD = Standard Deviation, n = number of included participants, BMI = Body Mass Index, IOM = Classification of gestational weight gain from the Institute of Medicine

3.7. Maternal perceptions of health and influencing factors

Nearly all participants recognized that health is subjective and influenced by individual perspectives and experiences. A holistic perspective of health, including physical, mental, and emotional wellbeing emerged as essential for women and are often stated. Many of them mentioned therefor the importance of a balanced and healthy lifestyle with exercise, and healthy eating habits in maintaining long-term health: "*If you can live balanced. So stress-free. I think that is quite an important point for health. Exercise and nutrition, those are the three basic pillars for me, that you are healthy and feel good"* (P03).

However, while all the interviewees initially provided holistic descriptions of the concept of health, some of them seemed to focus during the interview primarily on physical health. This created sometimes contradictory statements regarding the influence of health conditions. They emphasized the close association between health and the absence of illness, as stated by the following quote: *" In general, health is something that is difficult with two children (...) to take care of oneself/ so to take care of one's health. I associate health with illness and illness is something you can't afford, with two, alone"* (P18). Additionally, one woman expressed that being healthy comes naturally to her and is currently not a top priority in her life: *"I don't know what health means to me. So, under health is with me already rather a very physical thought. And just yes health is for me, it is not the top priority in my life"* (P11).

Others emphasized mental health or emotional health, such as balance, joy, and satisfaction with one's activities, like: *"For me, health is when I feel good in my skin, i.e. when my body fits and plays along and I have a zest for life, so to speak, and I enjoy life"* (P24). Also, some mothers believed that health is not entirely controllable, which highlights the different approaches of womens' health beliefs: "*But to some extent I don't have full control over my health, yes, so to some extent it's fate or whatever you want to call it, I think"* (P11).

3.7.1. Factors influencing maternal health

Stress is a common factor, consistently cited as detrimental to health: "*I think stress makes me sick, so I notice that more and more, I think I'm no longer as stress resistant as I once was. Maybe also because you always have to think for two"* (P12). Participants associated stress with negative physical and mental drawbacks like fatigue, gastrointestinal problems, insomnia, and overall reduced well-being. Negative emotions including worry, anxiety, or feeling overwhelmed are cited as factors that can negatively impact their mental health. Specifically, work-related stress is mentioned by some participants as a factor influencing their health negatively: *“And now for me personally, I'm most afraid that this could make me sick, the stress from work, the negative. Whereas I like my job”* (P03). Stressful work environments, long hours, and work-related obligations are perceived as detrimental to their well-being. Therefore, participants mention the importance of self-care. They see stress management, relaxation and balance in life as crucial for maintaining their health. Participants cite during the interview strategies to reduce stress, such as relaxation techniques, time off, hobbies, or participation in social activities. In this context, they also emphasize the influence of sleep and the importance of sufficient and restful sleep for their general well-being: *“Must not go beyond the limits. Just listen to your body”* (P09).

Regular exercise and physical activity are also highlighted as important factors in maintaining health. Participants mention various activities such as sports, walking, yoga, running or nordic walking. Some participants also mention the positive influence of exercise on general well-being and susceptibility to infections or colds, while other who lead a sedentary lifestyle or do not exercise regularly say it has a negative impact on their health and aware that this can lead to lower fitness levels, weight gain and various health problems.

It is emphasized that exercise together with a healthy diet avoiding processed or fried foods is an important part of a healthy lifestyle: “…*that we cook good food, and most of the time we even cook organic and with lots of vegetables and whole grains”* (P36). However, one respondent said: *“In the meantime, I don't like to talk about food anymore, but I got really annoyed by the constant use of the word "healthy". And (...) I've come to the conclusion that I can't call food healthy or unhealthy, but only a way of life or a way of eating”* (P08).
Participants also specifically pointed out the importance of a healthy diet for their family and children. They feel a responsibility to ensure that their family members eat healthy. They emphasize the role of nutrition in promoting their children's health and the importance of fresh, nutritious meals prepared at home, like this quote describe: *“I also grew up with the fact that you/ We cooked something fresh every day, I do that now because I think to myself, I've eaten that and I think that's good and I think that's just as good for my kids”* (P42). Thus, diet is considered an

important factor in promoting good health and serving as a role model for the family. They are aware of their responsibility for their own health and that of their families. While most participants emphasize the importance of healthy eating habits, its relation to body image and self-esteem are also acknowledged.
Further, some participants mention the significance of family relationships, attributing a positive influence on their health to their partners or family members, as they lead an active and health-conscious lifestyle. One participant stated: "*People who influence my health are certainly my husband, who lives a very - how shall I put it - very sports-conscious life, I'll say now, and is very attentive to nutrition. He has also always been a bit of a driver for me"* (P16).

Additionally, participants also mention the influence of external factors on their health, like genetics and environmental conditions. They mention the importance of a supportive social environment, leisure time and participation in social activities as well as living and financial conditions. Participants emphasize the need for social interaction and the positive influence it has on their well-being. They also recognize the role of partnership and the importance of a healthy and fulfilling relationship in contributing to their overall health, like one mother said: *"A good social environment. Free time. I also realize that I don't really feel good if I don't go out more often, and I realize that I need to go out regularly to meet other people. Be it that I am out with the child, but also alone. That's also very important for me"* (P21).

Overall, participants recognize the role of diet, exercise, stress management, social activities as well as the importance of taking care of themselves, listening to their own bodies, and being aware of external factors that affect their health. The interviews demonstrate that health is a multifaceted concept that is not entirely under one's control but can be influenced by individual choices and lifestyle habits.

3.8. Postpartum lifestyle changes

Five overarching themes from the thematic analysis were identified to understand women's lifestyle and its changes one year postpartum (see Figure 7 and Table 12). These categories include:

(i) Social relations, work and partnership,
(ii) Responsibilities, stressors, and time,
(iii) Diet, exercise, and addictive substances,
(iv) Mental and emotional health, and
(v) Family and external support.

The thematic analysis shows that the birth of a child brings about a variety of changes in women's lifestyles. There are both commonalities and individual differences in the experiences and adjustments women make in different areas of their lives.

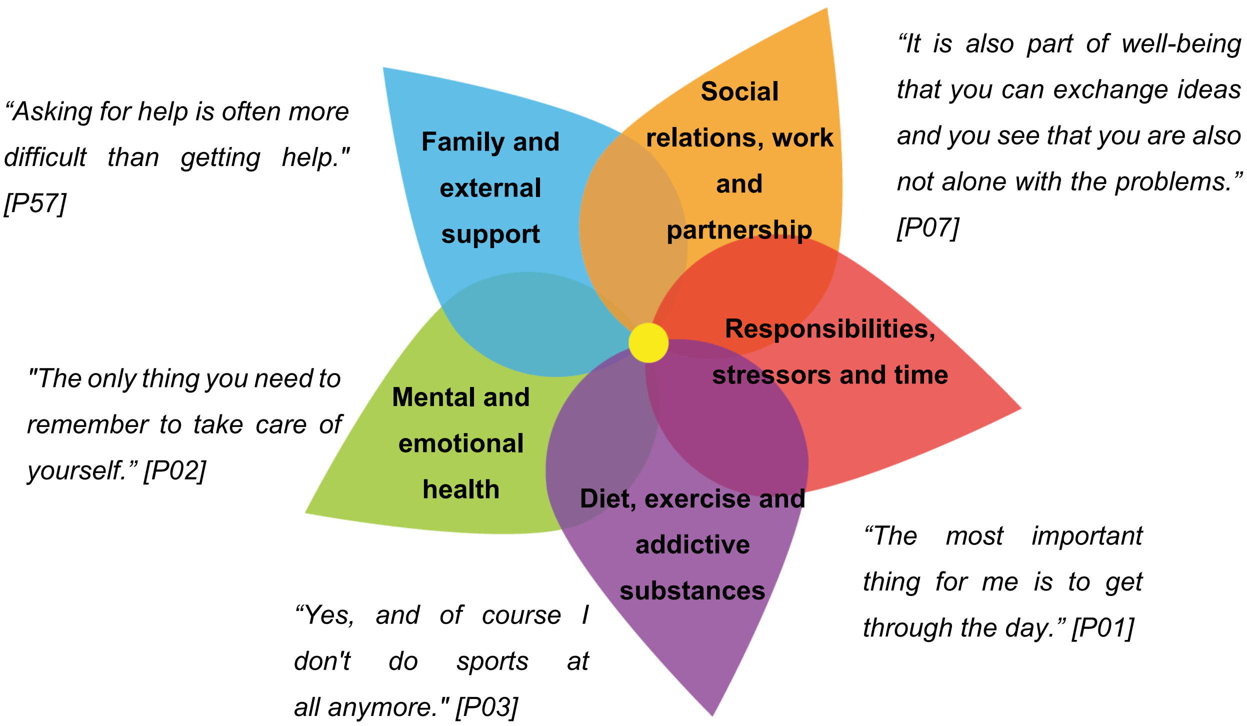

Figure 7: Five key themes regarding women's health and lifestyle one year after childbirth.

3.8.1. Changes in diet, exercise, and addictive substances

Most of the interviewee's state that their eating habits have changed after the birth of the child. Many women report being more aware of their dietary choices and eating more consciously after pregnancy, including choosing healthy foods, cooking at home, and eating fresh meals. There is also a tendency to reduce meat and sausage products and an increased interest in organic foods. Like one mother said: *"It used to be more important that it had fewer calories and less fat, and now the focus is more on what's healthy, because those are two different things. That has certainly changed for the better, I'd say, because in the past I didn't care if it was unhealthy"* (P02). Nevertheless, the reason for this is often that attention is paid primarily to the child's healthy diet. The same interview participant indicates that she pays less attention to her own diet and focuses instead on her child's diet: *"But the year after the child, so I absolutely did not look at my diet […] So I looked at her diet top then, I didn't look at mine at all (laughs)"* (P02). Further, women reported more intense enjoyment when eating. They consciously take time to enjoy meals and focus on the taste and quality of the food, like a participant mentioned: *"Food is important to me, but when I have something else to do, I don't care as much, and food has to be a treat" (P18).*

Most women state that their exercise behaviour has also changed after giving birth. However, they emphasize the importance of active everyday exercise, this includes, for example, carrying the child, walking around, or playing with the child, and spend more time outdoors due to the child: ***"****In the beginning, I went for a lot of walks to get back into shape" (P24).* However, also often women experience limitations due to physical complaints, these can be, for example, back or pelvic floor problems, lack of time for sports activities or mentions changes in priorities: *"I think you generally become more careless. So, I wouldn't say now that I lack the time. So, when he's sleeping, I could do something or if it's just strengthening exercises or something. It's kind of like -out of sight, out of mind-"* (P24).

Additionally, alcohol, tobacco and medication use were not often raised as a topic by the interviewees, but nearly all mothers reduced their alcohol consumption. Regarding smoking the women report, that they have an increased sensitivity to smoking, particularly in relation to child safety and health. Also, caffeine consumption is reduced by the interviewees during pregnancy and lactation period so as not to affect the child.

3.8.2. Changes in social relations, work, and partnership

Changes in the social environment is a common theme stated from the interviewees. Women are increasingly looking for contact with other mothers to exchange experiences and find like-minded people. At the same time, contact with people without children can decrease because their interests and life situations differ. Organizing meetings can become more difficult as the needs of the child need to be considered. Women emphasize the importance of engaging in adult conversations as they dedicate substantial time to their child. Nevertheless, they also express the necessity for moments of solitude and personal space: *"What you naturally miss as a woman is the time for yourself"* (P56).

Further, the interviews show that motherhood changes attitudes towards work. Women now view their work from a different perspective and may prioritize it differently. They mentioned that motherhood is leading to a shift in priorities, with seeing their work in the context of family life. Many women say, that fears and insecurities about returning to work can arise, especially regarding the compatibility of work and family. Some women reflect on their professional goals and priorities while worrying about maintaining their professional position during the maternity leave.

The interviews make it clear that motherhood also has an impact on the partnership. Some women report that the experience of parenthood has brought them and their partners closer together. However, it is reported that the time women spend with their partners is reduced by the new tasks of mothering. Further, the interviewees experienced that the partnership requires increased organization and alignment to balance the needs of the child and the relationship. Planning activities can become a challenge as the needs of the child need to be considered. The women emphasize the importance of conscious time together to maintain the connection to the partnership. Some women also mention the changes in their sexual life, like one mother said: *"Definitely the sex life, that's, what are we going to joke about, you wouldn't believe it beforehand. It rarely happens and then you are tired, actually we are both, but the child is there and yes, other satisfactions in life are in the foreground at the moment. But we are aware that we must not forget that. That there is that too and intimacy. So that's a very big change"* (P01).

3.8.3. Changes in mental and emotional health

Most of the women interviewed report having trouble sleeping because of concerns and fears about their child's well-being. So, many women say they suffer from sleep deprivation, which has an impact on women's mood and mental health. Many women report increased irritability, decreased focus, and impaired cognitive performance due to the lack of sleep: "*If you never sleep through the night, I've thought to myself that I'll get complete dementia because I have to write everything down because otherwise, I'll forget everything"* (P36). However, some women report that their sleep patterns have improved over time. With the establishment of the child's sleep and routines and the adaptation to the mother role, they experience a gradual improvement in the quality of sleep.

Some women experienced a change in their attitude towards their own body image. Weight issues are often mentioned in connection with lifestyle behaviour such as nutrition, physical activity and stress management. Some women interviewed face difficulties and stresses that push them to their limits and lead to a change in their body image. While some women are satisfied with the physical changes during and after pregnancy, others find them challenging and experience stress about losing weight. For example, one woman shared her problems with losing weight: *"So I can't get a kilo down right. Well, that's quite bad for me (laughs), I have to say honestly. […] It's a bit difficult for me and yes, I'm always a bit stressed at the moment, because I am trying things out and it doesn't work"* (P25). Another woman expressed concern about not being able to lose the pregnancy pounds*, "I thought maybe I'm one of those who will never get these pregnancy pounds down, and really panicked a bit about it"* (P16). Some women also mentioned their ongoing efforts to reduce their weight. They acknowledged that they needed to give their bodies time, but also expressed frustration with their progress, as one woman explained, *"So I'm* *already aware that you have to give the body time […] with the weight, but just I have not reached it with the first year"* (P11). In relation to that, some statements also occur regarding changes in women's external appearance. One mother mentioned how certain outward appearances, such as wearing earrings or necklaces, had changed. They mentioned that the demands of motherhood often result in less time for beauty rituals, as women prioritize caring for their child, like one mother stated. For instance, a mother mentioned not wearing perfume during the initial period of motherhood and questioned if she is still a „real woman" and contemplated the essence of womanhood, concluding that true womanhood lies in mothering for her: "*Sometimes you sit down and think "Am I still a real woman?" but then of course the other question is "What makes the woman stand out?". Because those are the minor things, those are the external appearances, that you dress nicely, put on make-up"* (P56).

Some women report changes in terms of becoming calmer, more balanced and more understanding, like a mother reflected: *"And I think I've also opened up a little bit and calmed myself down. So, you're not so selfish anymore"* (P01). In this context, setting priorities was also mentioned by many mothers one year after childbirth: *"Even now, I couldn't imagine not having my son, I know what the meaning of life is. The whole career attitude I had is no longer important"* (P56). Emotional changes are also frequently mentioned, like intensive mother love but also fear: *"I think the feeling that has changed the most is (…) that you have never loved like that before. That has changed drastically. And fear in your life becomes an issue because you are simply afraid for your child that something could be the case, I didn't know that before"* (P12).

Table 12: Summary of specific changes/trends in lifestyle-related factors expressed by interviewed mothers (↑ = Increase; ↓ = Decrease; ◆ = Observation, no trend).

Level	Theme	Subtheme	Content
Individual	Diet, exercise and addictive substances	Dietary behaviour	↑ Healthy eating ↑ Consciousness of food choices ↑ Cooking at home / fresh meals ↑ Plant-based or alternative protein sources ↑ Interest in organic foods ↓ Meat and sausage intake
Individual	Diet, exercise and addictive substances	Exercise	↑ Everyday exercise ↓ Time for sports ↓ Physical wellbeing/comfort
Individual	Diet, exercise and addictive substances	Alcohol, smoking and caffeine	↑ Awareness of smoking (active and passive) ↓ Alcohol consumption ↓ Caffeine consumption
Interpersonal	Social relations, work and partnership	Social environment	◆ Shift in friends' groups ↑ Connection with other mothers ↓ Interaction with those who are childless ↓ Organizing social activities
Interpersonal	Social relations, work and partnership	Partnership	↑ Importance of conscious couple time ↑ Organisation and arrangements ↑ Awareness of relationship maintenance ↓ Spontaneous planning ↓ Physical intimacy / sexual intercourse
Interpersonal	Social relations, work and partnership	Professional work	↑ Appreciation of one's own professional position ↑ Attitude toward work / new priorities ↑ Fears and insecurities about returning to work
Individual	Mental and emotional health	Sleep	◆ Sleep deprivation vs. Sleep improvement over time within a year ↑ Effect on mental health
Individual	Mental and emotional health	Weight and body image	◆ Pressure losing weight within a year vs. body acceptance
Individual and Interpersonal	Mental and emotional health	Feeling perception	↑ Reflection and definition of one's own role as a mother, the own identity and self-care issues ↑ Ambivalent feelings (love and fear)

3.9. Stressors related to lifestyle and health behaviour

Regarding stresses different pressures that mothers experience daily were found. According to the findings, time pressure and a shortage of time are among the most prevalent stresses. Due to the numerous responsibilities and chores in their everyday life, several of the women who were interviewed said they felt stressed out and rushed for time, like one statement shows*: "You try to somehow stay awake and fit all day and wait until finally half past five [...] then I'm soon the wife, the partner, the lover and ME. And that's very stressful when the child is not yet asleep at eight and you get pissed off and don't stay much of the day, so the most important thing for me is that I manage the day with it"* (P01).

Emotional stress was another substantial stress that was observable in the interviewee's statements. Motherhood presents for them emotional difficulties like self-doubt, tension, anxiety, and concerns for the welfare of the kids: *"Then what also often stresses me a little bit is, when I look at the long time, that if you do something the whole day, but you have the feeling that you have done nothing"* (P12). Additionally, the interviewees sometimes feel pressured to justify their choices, like one mother said: *"How can I say that you do not lose self-esteem, self-confidence, because as a mother you often feel like a sack in the corner, not necessarily recognized by society"* (P01).

The difficulties of partnerships were frequently mentioned. Due to disagreements, lack of time spent together, and various parenting philosophies, the connection with the partner can become strained. The demands of parenting have an impact on the relationship and cause conflict, like one statement show: *"How do I deal with my partner, how do I make sure that we have enough time for each other, or how do I say that if I don't like what he's doing or if I have different views without having a fight or something. These are challenges now"* (P14).

Mothers were also found to be burdened by logistical and organizational. Mothers face an added burden in managing their daily commitments, such as childcare, housework, and employment, however, its often difficult for them to ask for help: *"So I would never ask anyone for help or show in any way that I can't. Because I've always managed to do it alone and I'm used to always having to do it alone"* (P48).

3.9.1. Resources and support

Support from their partner is a valuable resource for many women. To successfully raise children and navigate the rigors of daily living, moms often need the understanding and support of their partners. Stress can be decreased, and wellbeing can be improved with shared tasks and support, which reflect following quote: *"I'm very happy about my partnership, which also takes a lot of pressure off me, because I know that I can call him at any time. Even when he is at work. If it's really and it's a hard day then I can call him and at least I can tell him, can say a little bit, can whine a little bit (laughs) and in the best case he can come home a little bit earlier. I know at least he will try"* (P21).

Other important resources include family and social support: *"It's the regularity and it's my relatives, friends, family, where I just a lot if I don't know what I'm doing now with the little one, then I pack her up and we go once to grandma's and then we go once there and there, everyone's happy to see us"* (P03). Mothers can benefit from the counsel, assistance, and emotional support of friends, family, and neighbors through trying times, like one statement illustrates: *"I need that, that every day a little bit someone comes with whom I can talk, something simple, but simply there is someone there […] a little bit with the neighbors, that is something that relieves me. And a little bit of other mothers who are on my wavelength"* (P14). Overall, for them stress can be lessened by a supportive social setting.

Mothers view the chance to find time for themselves as a significant resource. They experience that they can handle obstacles better when they have time for their personal interests and relaxation. In this context, mothers say that self-care as an important resource: *"The only thing you need to remember to take care of yourself"* (P02). Those that carve out time for leisure activities such as hobbies, sports, or relaxation benefit from this and become more resilient. Also, several moms expressed the need for greater knowledge and recognition of their roles as partners and mothers.

Further, external care is often desired support so that the mothers can have time for their own needs and relationships. Moms view domestic assistance as a desired form of support to ease daily life *“It's just so much less complicated when someone does it”* (P36) as well as childcare, like one mother stated: *“That would certainly be childcare on call. I think that would be what every mother wants but doesn't get, at least not for free […] if I could really say at any time: "Now I'll do this or that for an hour." So that would change something. It's not tragic that it doesn't exist, but if I could wish for something, exactly that is it”* (P31).

However, positive interactions with kids are both relieving and energetic for mothers as well. Interacting in peace and delight with the kids can be a source of happiness and reassurance, as one interviewee said: *“It often gives me a lot of strength and energy and, seen in this way, also relief when I am alone with the children for half a day or an evening or something and notice that it is such a well-rehearsed thing”* (P08).

Additionally, financial stability is often mentioned by the mothers and crucial for them. Living with the assurance that one is financially secure makes daily tasks simpler and lessens concerns about the future.

3.9.1.1. Subjective needs for change

The mothers indicate desires for change, individual needs, and challenging aspects they face after motherhood (see Table 13). The need for support, balancing personal needs and family responsibilities, and the importance of time management as well as health and psychological well-being are key themes expressed in mothers individual experiences one year after childbirth.

A common trend is a <u>desire for lifestyle and health changes</u> one year postpartum. Mothers express a desire for holistic improvements in their health. On the physical level, they strive for increased fitness, healthier eating e.g. fewer snacks between meals, drinking more water or eating more fruits, and overcoming smoking habits. They also address specific health issues such as back pain, post-pregnancy weight gain or anti-aging treatments. In addition to physical health, mothers place a high priority on their psychological well-being. Stress management is a focus, and they crave more energy for themselves, as they invest much of their energy in caring for their children. A specific desire one mother mentioned is "*I would like someone to cook for me, that I do not have to do anything. A little more energy I would like to have for myself, because you often spend the energy for the child*" (P01).

Another key concern is finding a <u>balance between personal self-care and obligations</u> to family and work. Mothers want time for sports activities, mental stimulation like learning new skills, hobbies and rest periods, like one mother stated: *"Surely, it's the social contacts. (...) Time for myself. So, a quiet time where you can maybe read a newspaper from the beginning"* (P56).

Thus, the importance of <u>social networks and intact relationships</u> becomes clear. Mothers crave extended support networks, whether from their partner, family or new acquaintances in social groups such as baby clubs. The quality of their partnerships also matters, and some mothers express a desire for more time together with their partners: *"So I would like us to go somewhere on our own for a night or two. So that you really look more at that again"* (P02).

Some mothers show a positive perception of their current lifestyle and express no specific need for change. They are satisfied with what they have already achieved. Recognition is given to progress, whether in overcoming cravings or preparing fresh meals on a regular basis.

Table 13: Summary of subjective needs for change mentioned by mothers at FU1.

Level	Theme	Subtheme	Content
Individual	Diet, exercise and addictive substances	Physical health	Fitness, healthy food, bad habits
Individual	Mental and emotional health	Psychological well-being	Stress management, balance
Individual	Responsibilities, stressors and time	Self-care	Hobbies, rest, flexibility in work hours
Individual	Responsibilities, stressors and time	Family and childcare	Organization, balancing childcare and work
Interpersonal	Family and external support	Support networks	Partner, family members, social groups like toddler groups
Interpersonal	Social relations, work and partnership	Relationship quality	Time together, improving partnership
Individual	Mental and emotional health	Skills	Mental stimulation, new skills
Individual	Mental and emotional health	Recognition of individuality and progress	Achievements, acceptance

3.9.1.2. Personal advice from mothers

Mothers' advice for mothers or their own reflections largely reflects their needs for change as well. In terms of partnership, teamwork, and communication, mothers emphasize the importance of nurturing the partnership and talking openly about feelings and challenges. They encourage being a strong team with their partner, making joint decisions, and maintaining communication in parenting. They also emphasize that it is normal to admit negative feelings and to be honest about the difficulties of motherhood, like one mother said: *"It's important to know there is no such thing as the perfect mother, so we are not machines. And there is not the perfect mother, the perfect children, the perfect family, as many women want to show. You are allowed to complain, and you are allowed to say that you can't do it anymore"* (P57).

In this context, the division of tasks and work-life-balance within the partnership is also seen as essential. Thus, paternity leave is experienced as a very positive development to distribute responsibilities fairly, illustrated with the statement of a mother: “Paternity leave! Absolutely, absolutely!” (P08). Further, clear agreements on responsibilities and the creation of free spaces for both partners are pointed out, as one mother state: *“So really a checklist of who has how much free time, who's done what chores. That kind of stays the same, I think”* (P01).

Seeking support is recommended as an early step. An important issue is building a strong supportive social network. The mothers emphasize the importance of exchanges with other women and mothers to strengthen each other. These exchanges are described as supportive and encouraging, helping to understand similar challenges and share experiences. As well, mothers emphasize that help from experienced people such as midwives can clarify uncertainties. Thus, the importance of evidence-based guides to preparing for pregnancy as well as support and advice regarding returning to work after childbirth becomes clear: *“Women are already at a disadvantage, and the male parental leave simply doesn't work”* (P03).

The topics of postpartum lifestyle flexibility, adaptability and resilience are also in focus. Mothers are encouraged to think positively and prepare for the long-term commitment of motherhood. In addition, the importance of self-care is emphasized - whether in terms of a balanced diet, exercise or maintaining an individual lifestyle. They emphasize the importance of "time for yourself" and encourages activities with partners and friends: *“And also dare to demand it and to say when I need help or when I say I need time for myself, to really demand it”* (P16). Further, expectant mothers should be prepared for social influences and empowered to break free from negative pressures. Interviewees talked about how interests and priorities can change, and encouraged mothers-to-be to consciously enjoy and find their own way without letting rigid ideas affect them. Also, returning to work play a role here, requiring careful planning: “*I would advise her, generally mothers, the (...) generally, young mothers, not to forget themselves, so do not live only for the children. You have your own life too*” (P18).

Finally, patience, trust in intuition and empowerment are emphasized as essential aspects of motherhood. Mothers are encouraged to remain patient, avoid unnecessary stress, and be prepared to limit your time resources. The mothers encourage future mothers to listen to their own gut feeling and not to be too influenced by external opinions. They advise being selective about advice and trusting your own beliefs. It is pointed out that individual changes and developments should be accepted, whether in relation to one's own lifestyle before the birth or to the needs of the child. Thus, raising awareness of the different stages of children's development is considered helpful. Further, the <u>diversity of maternity experiences</u> should be emphasized and recognized. *"You have to do what you think is right for yourself. And as stupid as it sounds, you make it all up yourself. And those thousands of pieces of advice that everyone gives you, they can fit, but they can also not fit"* (P24).

> *When you have people around who really help. It was so easy, and I was like, "This is how you can have kids"* [P57]

4. Discussion

The main focus of this thesis was to assess the impact of pregnancy and childbirth on maternal BMI and lifestyle-related risk factors. This study investigated changes in physical activity, dietary intake, and smoking habits from the third trimester to one year postpartum, as well as the influence of gestational weight gain on maternal and infant health. Further, associations between maternal nutritional intake, BMI changes, and infant anthropometric outcomes were explored. A qualitative approach explored lifestyle changes due to pregnancy and childbirth.

The study population consisted predominantly of Austrian women with tertiary education, representing a homogeneous group. 32.7 % of participants exceeded the recommendations for total gestational weight gain (TGWG), and 51 % exceeded incremental weight gain (IWG) recommendations between the 2nd and 3rd trimesters. IWG groups significantly influenced BMI one year postpartum. Mothers in the "more than recommended" IWG group had a higher BMI compared to those in the "less than recommended" group. IWG was also associated with infant body composition. Children in the "recommended" IWG group showed higher fat mass (FM) and fat mass index (FMI) at TP4 compared to the children of women in the "less than recommended" group.

Δ maternal BMI, which averaged 0.4 kg/m² (SD = 1.4), was negatively correlated with both infant birth weight and weight-for-age z-score at birth. Further, women having a BMI ≥25 prior to pregnancy retaining a significantly higher BMI one year postpartum compared to women with a BMI <25. However, the average postpartum weight retention across the sample was low, at only 1.0 kg, indicating most mothers successfully returned to their pre-pregnancy weight.

Lifestyle-related risk factors showed changes over time. Physical activity declined postpartum, with only 30.6 % of mothers meeting recommended guidelines one year after birth compared to 51 % during pregnancy. Physical activity at TP4 was associated with lower BMI changes. Smoking habits improved substantially, with marked reductions from pre-pregnancy to one year postpartum.

Energy intake during pregnancy and postpartum was consistently below recommendations, while intakes of key nutrients, such as dietary fiber, folate, and iron, declined significantly postpartum. But, alcohol consumption increased. Associations between nutrient intake and Δ maternal BMI varied over time. Higher energy, macronutrient, and amino acid intakes during pregnancy correlated positively with Δ maternal BMI, while higher dietary fiber, omega-3 fatty acids, and micronutrient intakes postpartum were associated with reduced BMI changes. At FU1, these associations were no longer significant.

Additionally, there was an association between maternal nutrition and infant outcomes. Higher prenatal EPA and DHA intakes correlated with lower infant FM at TP4. Breastfeeding practices also showed an impact on infant growth. Fully breastfed infants showing higher weight and length z-scores at FU1 compared to partially breastfed infants.

The qualitative results show an increased maternal awareness of healthy eating, motivated by their children needs. However, stress, lack of time, and insufficient support are barriers for adapting healthy lifestyle. Thus, mothers stated the need for flexible, individualized support addressing nutrition, mental health, and physical changes.

4.1. Addressing the hypothesis of the study

The results of this study, both quantitative and qualitative, support the overarching hypotheses that pregnancy and childbirth significantly impact lifestyle factors, which change substantially in the postpartum period.

Main Hypothesis:

Pregnancy and childbirth significantly influenced maternal BMI, with additional associations to infant factors. The data showed a change in maternal BMI, including an average postpartum weight retention of 1.0 kg (SD = 3.8) and a slight BMI increase (Δ BMI = 0.4, SD = 1.4) one year postpartum. Furthermore, 87.8% of mothers gained less than 5 kg or completely lost the weight gained during pregnancy, while 12.2% retained ≥ 5 kg one year after delivery.

A significant difference in BMI one year postpartum was observed between mothers with a prenatal BMI <25 and those with BMI ≥25 ($U = 6.0$, $p < 0.001$), highlighting the influence of pre-pregnancy weight status. Additionally, significant negative correlations were found between Δ maternal BMI and infant birth weight ($p = 0.011$, $r_s = -0.362$) as well as weight-for-age Z-score at birth ($p = 0.036$, $r_s = -0.300$), suggesting that greater maternal BMI changes may be associated with lower birth weight and growth outcomes in infants.

Secondary Hypothesis 1 + 2

The results show that lifestyle risk factors, including diet, physical activity and smoking behaviour, undergo significant changes from the third trimester of pregnancy to one year postpartum. These changes are supported by maternal physical activity, dietary habits, smoking rates and their relationship with BMI.

During pregnancy (TP2), 51.0 % of mothers met the Austrian recommendations for physical activity. By 14-16 weeks postpartum (TP4), this proportion had decreased significantly, with 59.2 % of mothers being less active than recommended. At one year postpartum (FU1), only 30.6 % of women met the recommendations, while 69.4 % remained below the recommended levels. Significant differences were observed between the three time points in the frequency of physical activity (p =

0.005) and the duration of vigorous physical activity ($p < 0.001$). Walking emerged as the predominant form of physical activity postpartum, while moderate and vigorous activities decreased.

Smoking behaviour improved significantly, with rates declining from 26.5 % pre-pregnancy to just 6.1 % at FU1.

For nutrition, the intake of macro- and micronutrients (e.g. fibre, folate, iron, alcohol) show that the dietary habits of mothers change significantly from pregnancy (TP2) to the postpartum period (FU1) (see Figure 5). Further, the results show that eating habits and their relationship to BMI change significantly between pregnancy and the postpartum period (see Table 10).

BMI changes were significantly associated with incremental weight gain (IWG) during pregnancy. Women who exceeded the recommended IWG had a higher BMI one year postpartum ($\chi^2(2) = 12.836$, $p = 0.002$). Additionally, differences in fat mass index (FMI) at TP4 between the IWG groups ($\chi^2(2) = 8.619$, $p = 0.013$) also suggest that maternal weight gain influences infant growth and body composition.

Answering qualitative research questions

1. *What are the subjective health beliefs of mothers one year after the birth of their child?*

The mothers in the study expressed a broadly holistic view of health, encompassing physical, mental and emotional well-being. However, there are differences: some focused primarily on physical health, associating it closely with the absence of disease, while others emphasized mental or emotional health. Some also believed that health is not entirely in their control, attributing it to fate or other uncontrollable factors. Often mothers mentioned to generally prioritize their child's health and nutrition over their own. This suggests that subjective health beliefs are more focused on child-centered health practices than on their own health. Mothers also showed increased awareness of healthy eating habits and food choices, although these changes are more likely due to the child's needs than their own.

2. *What are women's subjective experiences of lifestyle changes in nutrition, physical activity, mental health, and social health in the first year postpartum?*

The results suggests that mothers recognized the importance of a balanced lifestyle that includes exercise, healthy eating habits, and stress management. The women mentioned activities such as sports, walking, and yoga for physical health. Regarding diet, they considered a healthy diet important not only for themselves but also for their families. However, some were critical of the classification of foods as strictly "healthy" or "unhealthy." Mental health appeared to be influenced by stress, negative emotions, and the work environment. Social activities and relationships were also seen as important for overall well-being.

Focusing on changes in nutritional behaviour, most mothers reported being more conscious of their food choices and consuming less processed meat. Some aim for fewer snacks and more water and fruits. However, many mothers also reported that they do not pay as much attention to their own diet as they do to their child's.

Regarding changes in physical activity behaviour mothers emphasized the importance of "everyday exercise" such as walking and babywearing, although formal exercise routines have decreased. More time and physical fitness are desired.

Mothers place a high value on their psychological well-being and focus on stress management and balancing personal self-care with family/work responsibilities. They mentioned often sleep deprivation and its negative effects on their mental health, including increased irritability and the subjective perception of decreased cognitive functioning.

Regarding social health, mothers reported a shift in social circles, favoring interactions with other mothers and reducing interactions with childless friends. The stress and time commitments associated with motherhood also appear to affect romantic relationships and professional work. Overall, the importance of social networks is emphasized.

3. *How are resources and stresses related to the mother's lifestyle/health behaviour one year after birth?*

Stress is consistently cited as having a negative impact on physical and mental health, including symptoms such as fatigue and gastrointestinal problems. Stressors include work-related obligations and the responsibility of caring for two or more people, as well as time pressure, emotional stress, disagreements between partners, and logistical challenges are important stressors that influence maternal health behaviours. Stress management techniques such as relaxation, hobbies and social activities were cited as ways to combat stress. The mothers also noted in this context the importance of a supportive social environment. For example, social networks such as contact with other mothers are an important resource for young mothers. Family and external support also play an important role. Lack of sleep and body image were mentioned as significant stressors. Many mothers reported anxiety and uncertainty about returning to work and balancing family and career. Some women also stated that demands of motherhood, such as caring for and feeding the child, take precedence over personal hygiene, exercise, and sometimes even work, leading to additional stress. Thus, time for self-care and financial stability are cited as valuable resources that have a positive impact on their health behaviours.

4. *What advice are given from mothers to address these?*

The mothers suggested various strategies for maintaining health and managing stress, such as using relaxation techniques and taking time off. Regular exercise and a balanced, nutritious diet were also recommended. Listening to one's body and not exceeding one's limits are considered essential. Further, they encouraged to be adaptable and resilient and to prepare for the long-term commitment of motherhood. Mothers also emphasized the importance of having a supportive social environment and participating in social activities to maintain health. Attention should be paid not only to the child's diet, but also to the mother's diet. Incorporating time-saving strategies for healthy eating may help. Further, emphasizing the importance of "everyday" activities that engage the child may be beneficial. Brief, purposeful physical activity sessions can also be incorporated into the child's bedtimes. Additionally, strategies for sleep deprivation and stress management should be discussed, possibly with outside support. And it is important to promote social contact between new mothers and provide resources for maintaining relationships and professional development. Thus, mothers recommend nurturing the partnership and maintaining open communication as well building a strong social network and getting advice from experienced people such as midwives. Additionally, mothers emphasized the significance of allocating time for themselves and preserving their individual lifestyles. It is recommended that mothers exercise patience and intuition and trust their instincts rather than being unduly influenced by external opinions.

4.2. Critical reflection of the results with the current state of the literature

Pregnancy is often seen as a key period for adopting healthier lifestyles, driven by the dual motivation of improving maternal well-being and promoting positive health outcomes for the unborn child. These changes are further facilitated by increased interactions with healthcare providers and access to information during pregnancy (114). However, as the results of the shows, these health-seeking behaviours often decline after birth, reflecting findings in the wider literature.

Smoking

The results of this dissertation indicate that 26.5% of mothers smoked before pregnancy, but this dropped to 6.1% one year postpartum. This significant reduction aligns with the literature, which highlights pregnancy as a motivational period for lifestyle changes, including smoking cessation (115). Research indicates that at individual level, smoking as a stress-reduction strategy, self-efficacy, and the perception of risk to the unborn child are important themes (116). The qualitative interviews further support this finding, revealing that mothers often cited the health of their child as the primary reason for quitting. These results confirm that pregnancy and childbirth can serve as effective catalysts for reducing smoking behaviour, consistent with existing evidence (115).

Physical activity

Because pregnancy is linked to greater incentive to start or maintain a healthy lifestyle and more frequent medical consultations, which make it simpler to track physical activity, it is a good time to start exercising (115). While pregnancy provides an incentive to adopt healthier behaviours, including physical activity, the results show that 49–59% of mothers were less active than recommended during pregnancy, despite the well-documented benefits of exercise in reducing gestational diabetes, excessive weight gain, and prenatal depression (117). In this study postpartum, physical activity levels declined further, with 69.4% of mothers being less active than recommended one year after delivery. This aligns with the qualitative findings in this study. The interviews indicate that barriers such as

fatigue, lack of time, and competing responsibilities play a major role in this decline. Mothers also reported a need for better guidance and support systems, which aligns with literature suggesting that insufficient advice and worries about exercise risks are common barriers during this period (118).
Further, the desire for a more complete condition of physical and mental wellness is a recurring subject in the qualitative statements. A lot of women expressed the desire to become more physically fit, adopt healthier eating practices, and give up vices like smoking. Back discomfort and postpartum weight gain are two issues that frequently come to the fore. Those qualitative findings of the thesis is supported by the results of the Makama et al., where postpartum women prefer flexible, low-intensity lifestyle interventions delivered by health professionals through online and in-person formats (85). Further qualitative findings suggest the development of a patient-centered behavioural weight management intervention for pregnant and postpartum women and point out that women's preexisting knowledge and experiences related to pregnancy and postpartum care influence their health behaviours (119).

Thus, the findings highlight that, despite the acknowledged benefits of exercise, a significant proportion of mothers do not meet activity guidelines even during this "motivational" phase. Further, it underscores the need for targeted interventions to sustain physical activity postpartum, tailored to the unique challenges faced by mothers.

Maternal weight

Regarding weight gain, the Institute of Medicine provides guidelines for gestational weight gain based on pre-pregnancy BMI (120). Exceeding these guidelines, often referred to as excessive gestational weight gain (GWG), is a common challenge, with nearly 50 % of mothers surpassing recommended targets (121). The findings of this study align with these observations, that many mothers in the study reported weight retention postpartum, which was significantly associated with physical inactivity and insufficient nutritional intake. The mean gestational weight gain (GWG) was 14.5 kg (SD = 4.1), with 32.7 % of mothers exceeding the Institute of Medicine (IOM) guidelines. Furthermore, significant negative correlations were found between Δ maternal BMI and infant birth weight ($p = 0.011$, $r_s = -0.362$) as well as birth weight-for-age z-score ($p = 0.036$, $r_s = -0.\ 300$), suggesting that larger changes in maternal BMI may be associated with lower birth weight and infant growth outcomes, which is supported by the literature that a higher likelihood of low birth weight was associated with both obesity (OR = 1.9124, SE = 0.526) and lower than normal weight gain (OR = 2.3614, SE = 0.388) (122).

The qualitative statements show that a source of stress is the societal pressures by unattainable beauty standards, particularly when it comes to postpartum body image. The findings indicate that motherhood frequently causes women to engage in significant self-reflection, which makes it difficult for them to develop and maintain a healthier connection with their bodies. Those results are consistent with other study findings, that women experience strong societal pressures on their bodies during pregnancy and the postpartum phase. These external factors—such as the media, friends, family, and partners—all contribute to body dissatisfaction and the objectification of one's own body (123,124). These findings according to the results of this study underscore the need for interventions to enhance women's positive body image throughout the pregnancy and postpartum period by highlighting the complicated link between parenthood, body image, and sociocultural influences (124). In addition to the importance of weight management during pregnancy, the quality of nutrition during and after pregnancy is another important factor in the health of both mother and child.

Maternal nutritional intake

The study results about nutritional intake across several time points show similar patterns of change between pregnancy and the postpartum period as those reported by Aparicio et al. (2020). For energy intake, values of 1986.4 kcal/day (SD = 491.4) in the third trimester (TP2) and 1980.7 kcal/day (SD = 591.3) during breastfeeding (TP4) were observed, both well below the recommendations of the German Nutrition Society (DGE) of 2200–2500 kcal for pregnant and breastfeeding women. Also, Aparicio et al. (2020) reported an average energy intake of 1779.1 kcal/day (SD = 356.0) during pregnancy and 1744.8 kcal/day (SD = 382.8) postpartum (83). In this study and in Aparicio et al. (2020), no significant increase in energy intake were found in line with the recommendations.

Dietary fibre intake decreased significantly in this study from 28.2 g (SD = 9.3) in TP2 to 24.3 g (SD = 8.7) in FU1 (p=0.004). This finding aligns with Aparicio et al. (2020), who reported a significant decrease from 12.5 g (SD = 3.8) during pregnancy to 11.9 g (SD = 3.9) postpartum (p=0.015) (83). Both studies highlight the insufficient intake of dietary fibre postpartum.

Alcohol consumption increased significantly in this study, from 0.4 g/day (SD = 0.6) in TP2 to 2.9 g/day (SD = 3.6) in FU1 (p<0.001). Aparicio et al. (2020) documented a similar trend, emphasizing the importance of prevention programs to raise awareness of the risks of alcohol consumption postpartum (83).

For micronutrients, no significant difference in vitamin K intake was observed between TP2 (M=178.4 µg) and FU1 (M=174.4 µg), while a decrease was recorded in TP4 (M=151.0 µg). Aparicio et al. (2020) also reported decreased postpartum values for vitamin K, although their values were generally lower. Vitamin B9 intake (folic acid) in this study showed a significant decrease from 321.3 µg (SD = 102.0) in TP2 to 291.1 µg (SD = 105.4) in FU1 (p=0.037), consistent with the findings of Aparicio et al. (2020), where only 33.8 % of the recommended daily intake was achieved during pregnancy. Likewise, iron intake decreased significantly from 11.6 mg (SD = 3.6) in TP2 to 10.1 mg (SD = 3.5) in FU1 (p=0.016), a trend also observed by Aparicio et al. (2020), with values declining from 7.7 mg during pregnancy to 6.6 mg postpartum (83). A systematic review of observational studies confirms that most studies observed significant decreases in fruit and vegetable consumption and diet quality during the transition from pregnancy to the postpartum period. Further, women with lower levels of education, lower income, and/or full-time employment tended to have poorer dietary patterns after pregnancy (48). Pregnant women often do not raise their energy and nutrient consumption to a sufficient level, despite the increased nutritional requirements during gestation. (83,125,126). These findings are consistent with the outcomes of this study results and underscore the importance of targeted nutritional interventions during the first 1000 days (7).

Focusing on qualitative statements mothers expressed on nutritional behaviour, they mentioned that they eat more consciously and prioritize the nutritional needs of their children. However, they often neglect their own diet in favor of that of their children, which has both positive and negative effects. The qualitative interviews in this study further show that mothers struggled to balance health goals with the demands of new motherhood, identifying social support and structured programs as critical for managing weight and dietary habits effectively, which align with other study findings (46).

Δ maternal BMI

The results show that that higher energy and nutrient intake during the third trimester contributes to an increase in maternal BMI. Significant positive correlations with Δ maternal BMI were found for energy intake, protein intake, and fat intake as well as for saturated fat, monounsaturated fat (MUFA) and palmitic acid, omega-6 fatty acids and, suggesting a potential effect of these nutrients on BMI increase. The positive correlation between energy and fat intake and BMI in TP2 is consistent with studies showing that excessive calorie and fat intake leads to excessive GWG (120).

In the lactation period at TP4, there were significant negative associations with vitamin A, B9 (folate), B12, K and C levels and Δ maternal BMI. Lu & Sun (2023) showed in their study that higher intakes of vitamins A, C and D are associated with a reduced risk of obesity and obesity-related indicators by suppressing the inflammatory response (127). Dietary fibre intake, omega-3 fatty acid and DHA were also negatively associated with Δ maternal BMI. Although a systematic review examines factors related to maternal DHA and omega-3 fatty acid status during pregnancy, it does not specifically address associations with BMI postpartum (128). However, the literature does confirm that higher intakes of dietary fiber are associated with lower body weight (129,130).

The loss of significant associations between nutrient intake at FU1 and Δ maternal BMI suggests that the influence of diet on weight decreases over time postpartum in this study population.

In addition, explorative analysis on maternal dietary intake showed that intake of EPA and DHA during the third trimester was significantly associated with a lower infant fat mass index (FMI). The results of this work could suggest that EPA and DHA can influence the body composition of infants. Studies support the role of omega-3 fatty acids in fetal development, including their beneficial effects on fat distribution and metabolism (131,132). For example a meta-analysis has reported associations between high maternal DHA and/or EPA levels and higher offspring birth weight and weight during childhood, the observed reduction in FMI in this study suggests that these fatty acids may support a healthier body composition rather than excessive fat accumulation (131).

Regarding alcohol consumption a significant difference at TP4 in relation to breastfeeding status was found. Mothers who are fully breastfeeding may consume less alcohol, which is consistent with existing recommendations to avoid or reduce alcohol while breastfeeding (133).

Qualitative findings: Mental Health, Sleep, and Work-Life Balance

The qualitative results confirm the evidence, that the fundamental changes in lifestyle brought about by pregnancy and childbirth affect a variety of areas, such as eating habits, exercise routines, sleep patterns, interpersonal connections, self-care routines, and a change in the focus of women's lives to their child (121).

Results from the qualitative interviews show that sleep deprivation has a negative impact on the mental health of mothers after the birth of a child, confirming the hypothesis that pregnancy and childbirth significantly affect sleep patterns. These findings are also consistent with the literature. There is evidence that the sleep structure of the primigravid does not return to pre-pregnancy levels after delivery, and evidence suggests that changes in sleep architecture begin as early as the first trimester(134).

Mothers emphasized the critical role of mental health, as the experience of internalized struggle is a common phenomenon. In the interviews, many mothers expressed a desire to achieve emotional balance and harmony while managing their stress levels. These emotional experiences can be intense, as love and concern for the child's welfare must be carefully balanced with worries and anxieties about the child's health and safety. While caring for another person can be deeply fulfilling, it can also significantly increase stress. The findings highlight the importance of psychosocial support, whether from partners, relatives, friends, or professional counselors. This is supported by evidence indicating that sleep deprivation, mental exhaustion, and difficulty with planning impede mothers' ability to engage in health-promoting behaviours (135). Mothers in this study also sought guidance and assistance from a variety of sources, including medical professionals, relatives, acquaintances, and online materials. However, they emphasized the need for more in-person support from healthcare providers and peer networks to navigate the postpartum period effectively (136). In addition, many women expressed fear and anxiety about returning to work and juggling family and work responsibilities. This is consistent with other studies that have identified lack of social support at work as a modifiable risk factor for postpartum anxiety and the need to assess overall workload and resources to promote the mental health of new mothers returning to work (137,138).

Another issue that is addressed by mothers is the need for better time management in the work-life balance. For the interviewed mothers, juggling their work and childcare responsibilities is challenging. More flexible work schedules and quality time with their partner are desired. To facilitate the completion of daily tasks and obligations, mothers seek assistance from familial and social support networks, including those within infant clubs. Results from Strange et al. support the qualitative findings that for mothers of children aged 0 to 5, involvement in local mothers' groups is linked to increased levels of social capital, social support, and mental health (139). Also, the results of the thesis confirm, that mothers, who are juggling job and childcare obligations often find it easier to work with flexible work arrangements. Literature confirm, that mothers who work longer hours and are happier in their jobs are more likely to live in nations with more flexible work schedules (140). However, because of a lack of support and care following childbirth, lifestyle modifications frequently return to pre-pregnancy behaviours

(114). This emphasizes the necessity of continuing treatments catered to the requirements of postpartum women.

Personal growth and self-development are also mentioned topics by interviewed mothers. Mothers in this study want to develop new skills and engage in activities that stimulate their minds, while some express satisfaction with their current lifestyle and point to positive changes they have already made. This result is confirmed by a study from Lindqvist et al., where many of the pregnant women expressed satisfaction with their lifestyle habits, despite expressing a desire to implement changes. In addition, pregnant women generally felt that their ability to change their habits was proportionate to their motivation to do so. The study also highlights that women with higher BMIs and higher levels of education reported greater motivation to change their lifestyle (141).

Tailored interventions and support systems for postpartum health

Based on the findings of a review, the most effective interventions were delivered by dietitians and nutritionists and were highly tailored. Thus, tailored tools that respond to inequalities are needed to support all women in obtaining or maintaining a healthy diet during pregnancy (142). Other study findings suggest that a comprehensive education package, a mobile health platform to lower barriers and provide personalized feedback/goal-setting, and regular health nudges are recommended to cultivate sustained lifestyle habits (143). Further it is that treatments concentrate on improving capability through behaviour control and sleep support, creating opportunities by involving partners and bolstering peer support, and motivating women by emphasizing the mental health advantages of these strategies (135).

The findings of this thesis suggest that mothers face a multifaceted system of psychological, physical and social challenges. The availability of social support, personal time and social networks are essential for effective coping mechanisms. Mothers express a desire for external support and greater recognition of their role. A comprehensive understanding of the range of concerns and support needs is essential for the development of targeted health programs and services that can reduce stress and improve the quality of life and healthy lifestyles of mothers.

4.3. Strengths and limitations

This explorative study combines long term quantitative and qualitative data collection of nutritional, sensory, anthropometric, and biochemical parameters of mother-infant pairs and is characterized by several strengths. First, the mixed methods approach, using both quantitative and qualitative data, has enabled the study to provide a comprehensive perspective of mothers' lifestyle during pregnancy and postpartum period that is often absent in studies. Second, study population is small but selected by strictly defined and comprehensive inclusion and exclusion criteria, homogenous and tightly documented with a follow-up period. However, it is important to note that the results must be interpreted with caution. The high level of education among mothers limits the generalizability of findings to more diverse populations. But its homogeneity and detailed description are sufficient for exploratory analyses and method development. In addition, BC could be measured accurately with ADP. Further, nutrient intake is assessed pre- and postnatal via a recently validated but not yet published HPL-FFQ. The two 24-hour recalls were performed as an in-depth face-to-face interview by a trained nutrition expert. The objective of this approach was to ensure an adequate comparison of DGE recommendations in this thesis. Moreover, nutritional and physical activity data were self-reported, creating potential recall bias. Further, dietary supplements, commonly used during pregnancy, were not collected, potentially underestimating nutrient intake. Another limitation is the fact that the data categories retrieved from the medical records may be not exhaustive and may show heterogeneous data quality due to different data collection procedures. Information such as pre-pregnancy body weight and body weight during the first trimester could not be objectively measured because the first visit was set between 24 to 28 weeks of gestation. Furthermore, postponements of visits must be expected and may influence the week of pregnancy in the defined visit period. Furthermore, it must be mentioned, that dietary supplements were not considered in this study. These nutrients are often taken as dietary supplements, especially by pregnant women. Nevertheless, the results could play an important role in further research on predictors for maternal and child obesity but raise questions about the accuracy and reliability of the various measurement methods too.

The qualitative method via face-to-face used in this study proved to be effective, as it enabled the women and the author to go into depth when necessary and to address ambiguities directly. In this way, misunderstandings on both sides were largely avoided or eliminated. The atmosphere of the interviews was found to be very pleasant, and the conversations went smoothly. Further, the participants gave very personal and self-reflective answers. Some interviewees made a stressed and strained impression, as some took part in the interview with a child or were under time pressure. Some, on the other hand, enjoyed the interview to talk about their experiences and concerns. Nevertheless, all showed great interest in the topic and were aware of its relevance. The interviews were generally perceived as highly stimulating and positive. Furthermore, the use of a recording device and transcription software (f4) facilitated the administration and subsequent transcription of the interviews, ensuring the accuracy and reliability of the data. In addition, the thesis addresses the often overlooked stresses and needs of mothers in the first year after giving birth and highlights the importance of individual support.

4.4. Conclusions and future prospects

This study shows that lifestyle-related risk factors change from pregnancy to one year postpartum. An important finding, which is also consistent with other literature sources, is that women do not achieve the nutritional recommendations during pregnancy and after childbirth. Pregnant women in this study population did not increase their energy and nutrient intake during pregnancy and postpartum, however this increase is recommended. However, as pregnancy represents a potential window of opportunity to strengthen health-promoting behaviour, even greater emphasis should be placed on education and awareness-raising measures as well as targeted interventions for mothers. The postnatal period in particular is a time of change for women and a time of finding their roles. Taking care of their own health and the well-being of their newborn child is a major challenge for mothers. More framework conditions and resources should be provided for mothers after the birth to protect women from excessive demands. Excessive demands on women after childbirth should not be accepted as a standard fact, but this thesis draws attention to the fact that women need targeted support to maintain healthy behaviour for themselves personally, such as a healthy diet, physical activity and a good body image of themselves, including the issue of weight development. This can only be achieved if women do not have to research offers themselves, which in turn is time-consuming, but if measures are delivered to the women in an outreach programme, uncomplicated and precisely in the phase one year after the birth, when women are unfortunately difficult to reach. The diversity of women's perceptions of lifestyle changes, as stated in this thesis with the 24 women, reflects the complexity of individuality. Despite positive intentions, translating these into sustained postpartum behaviours is nevertheless challenging. Thus, importance of flexible, individualized health support, such as telehealth solutions, to address nutrition, psychological and physiological changes, stress, and the perceived lack of support, is needed. Tailored interventions should also account for cultural and socioeconomic factors and promoting practical strategies, such as dietary supplementation, physical activity, and stress management. Thus, healthcare programs should integrate nutritional education, personalized counseling, and initiatives to foster moderate to vigorous physical activity into daily routines of the mothers. Accessible solutions, such as postpartum yoga, walking groups, and community-based initiatives, could help new mothers maintain a balanced lifestyle. Moreover, psychological support addressing stress, sleep deprivation, and body image concerns should be prioritized. Mindfulness workshops, peer support networks, and evidence-based interventions can empower mothers to navigate early motherhood more confidently.

The quantitative parameters identified in this exploratory study suggest potential avenues for better understanding the interactions between maternal nutritional and metabolic status and infant development. Future research should further investigate the associations between maternal diet and infant taste preferences, biomarkers (e.g. from breast milk or blood), infant body composition and gut microbiota, particularly during the critical first year of life and with a cohort that has a good distribution of sociodemographic variables, which in turn may also be reflected in the distribution of health status and BMI/weight development This was covered in this study, but sample sizes should be larger and in addition, the integration of genetic analyses could provide deeper insights into how maternal and infant genetic profiles influence dietary needs and health outcomes. Thus, future studies should include larger sample sizes and longer follow-up periods to validate and strengthen the findings, explore additional influencing factors and to enhance generalizability.

So, the study shows the importance of the first 1,000 days as a pivotal window for health interventions. By addressing nutrition, physical activity, and emotional well-being holistically, healthcare providers and policymakers can significantly improve maternal and child health outcomes. Empowering mothers through evidence-based support, tailored interventions, and societal acknowledgment of their diverse roles can help establish the foundation for improved long-term outcomes for both mothers and children.

Investigating the long-term health trajectories of mother and child and the role of nutrition, such as body composition and taste preferences, could be a larger research field. Combining genetic analyses with nutritional studies including taste could provide new insights into individualised healthcare approaches. Moreover, the developing and evaluating of tailored interventions addressing the unique challenges faced by postpartum women should be addressed.

5. Bibliography

1. Fuchs-Neuhold B, Staubmann W, Peterseil M, Rath A, Schweighofer N, Kronberger A, et al. Investigating New Sensory Methods Related to Taste Sensitivity, Preferences, and Diet of Mother-Infant Pairs and Their Relationship With Body Composition and Biomarkers: Protocol for an Explorative Study. JMIR Res Protoc. 2022 Apr 27;11(4):e37279.

2. Riederer M, Wallner M, Schweighofer N, Fuchs-Neuhold B, Rath A, Berghold A, et al. Distinct maternal amino acids and oxylipins predict infant fat mass and fat-free mass indices. Arch Physiol Biochem. 2023 May 4;129(3):563–74.

3. Riederer M, Schweighofer N, Trajanoski S, Stelzer C, Zehentner M, Fuchs-Neuhold B, et al. Free threonine in human breast milk is related to infant intestinal microbiota composition. Amino Acids. 2022 Mar;54(3):365–83.

4. Peterseil M, Gunzer W, Fuchs-Neuhold B. Einflussfaktoren auf die Geschmacksentwicklung von Säuglingen. Pädiatr Pädologie. 2016 Sep 1;51(4):156–61.

5. Fuchs-Neuhold B, Holasek S. Mothers' perceptions of barriers and opportunities for health-promoting lifestyle one year postpartum. Eur J Public Health. 2023 Oct 24;33(Suppl 2):ckad160.1509.

6. Gunzer W, Peterseil, M, Pilz R, Pail E, Fuchs-Neuhold, B. Assessment of maternal nutrition during pregnancy and early lactation period in Austria: Comparison of a Food-Frequency Questionnaire with a 24-hour Recall. 25th European Congress on Obesity, Vienna, Austria, May 23-26, 2018: Abstracts. Obes Facts. 2018 May;11(Suppl 1):1–364.

7. Beluska-Turkan K, Korczak R, Hartell B, Moskal K, Maukonen J, Alexander DE, et al. Nutritional Gaps and Supplementation in the First 1000 Days. Nutrients. 2019 Nov 27;11(12):2891.

8. Heslehurst N, Vieira R, Akhter Z, Bailey H, Slack E, Ngongalah L, et al. The association between maternal body mass index and child obesity: A systematic review and meta-analysis. PLoS Med. 2019 Jun;16(6):e1002817.

9. Liu B, Xu G, Sun Y, Qiu X, Ryckman KK, Yu Y, et al. Maternal cigarette smoking before and during pregnancy and the risk of preterm birth: A dose–response analysis of 25 million mother–infant pairs. PLOS Med. 2020 Aug 18;17(8):e1003158.

10. Kibret KT, Chojenta C, Gresham E, Tegegne TK, Loxton D. Maternal dietary patterns and risk of adverse pregnancy (hypertensive disorders of pregnancy and gestational diabetes mellitus) and birth (preterm birth and low birth weight) outcomes: a systematic review and meta-analysis. Public Health Nutr. 2019 Mar;22(3):506–20.

11. Daly M, Kipping RR, Tinner LE, Sanders J, White JW. Preconception exposures and adverse pregnancy, birth and postpartum outcomes: Umbrella

review of systematic reviews. Paediatr Perinat Epidemiol. 2022;36(2):288–99.

12. Mamluk L, Edwards HB, Savović J, Leach V, Jones T, Moore THM, et al. Low alcohol consumption and pregnancy and childhood outcomes: time to change guidelines indicating apparently 'safe' levels of alcohol during pregnancy? A systematic review and meta-analyses. BMJ Open. 2017 Jul 1;7(7):e015410.

13. Cooper R, Pereira SMP. Maternal weight status before pregnancy is strongly associated with offspring weight status in childhood. Evid Based Nurs. 2020 Jul 1;23(3):91–91.

14. Hayes L, McParlin C, Azevedo LB, Jones D, Newham J, Olajide J, et al. The Effectiveness of Smoking Cessation, Alcohol Reduction, Diet and Physical Activity Interventions in Improving Maternal and Infant Health Outcomes: A Systematic Review of Meta-Analyses. Nutrients. 2021 Mar;13(3):1036.

15. Barker DJP, Osmond C. INFANT MORTALITY, CHILDHOOD NUTRITION, AND ISCHAEMIC HEART DISEASE IN ENGLAND AND WALES. The Lancet. 1986 May 10;327(8489):1077–81.

16. Barker DJP. Developmental origins of chronic disease. Public Health. 2012 Mar 1;126(3):185–9.

17. Hales CN, Barker DJP. The thrifty phenotype hypothesis: Type 2 diabetes. Br Med Bull. 2001 Nov 1;60(1):5–20.

18. Hales C, Barker D. Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis. Int J Epidemiol. 2013 Oct 1;42(5):1215–22.

19. Perrone S, Santacroce A, Picardi A, Buonocore G. Fetal programming and early identification of newborns at high risk of free radical-mediated diseases. World J Clin Pediatr. 2016 May 8;5(2):172–81.

20. Rauschert S, Kirchberg FF, Marchioro L, Koletzko B, Hellmuth C, Uhl O. Early Programming of Obesity Throughout the Life Course: A Metabolomics Perspective. Ann Nutr Metab. 2017 Mar 17;70(3):201–9.

21. Young MF, Nguyen PH, Addo OY, Pham H, Nguyen S, Martorell R, et al. Timing of Gestational Weight Gain on Fetal Growth and Infant Size at Birth in Vietnam. PLOS ONE. 2017 Jan 23;12(1):e0170192.

22. Andres A, Shankar K, Badger TM. Body Fat Mass of Exclusively Breastfed Infants Born to Overweight Mothers. J Acad Nutr Diet. 2012 Jul 1;112(7):991–5.

23. Czarnobay SA, Kroll C, Corrêa CB, Mastroeni SSBS, Mastroeni MF. Predictors of excess body weight concurrently affecting mother-child pairs: a 6 year follow-up. J Public Health Oxf Engl. 2023 Mar 14;45(1):e10–21.

24. Endres LK, Straub H, McKinney C, Plunkett B, Minkovitz CS, Schetter CD, et al. Postpartum Weight Retention Risk Factors and Relationship to Obesity at 1 Year: Obstet Gynecol. 2015 Jan;125(1):144–52.

25. Scheurer JM, Zhang L, Gray HL, Weir K, Demerath EW, Ramel SE. Body Composition Trajectories From Infancy to Preschool in Children Born Premature Versus Full-term. J Pediatr Gastroenterol Nutr. 2017 Jun;64(6):e147–53.

26. Bijlholt M, Ameye L, van Uytsel H, Devlieger R, Bogaerts A. Evolution of Postpartum Weight and Body Composition after Excessive Gestational Weight Gain: The Role of Lifestyle Behaviors—Data from the INTER-ACT Control Group. Int J Environ Res Public Health. 2021 Jun 11;18(12):6344.

27. Maynard LM, Wisemandle W, Roche AF, Chumlea WC, Guo SS, Siervogel RM. Childhood body composition in relation to body mass index. Pediatrics. 2001 Feb;107(2):344–50.

28. Weber DR, Moore RH, Leonard MB, Zemel BS. Fat and lean BMI reference curves in children and adolescents and their utility in identifying excess adiposity compared with BMI and percentage body fat. Am J Clin Nutr. 2013 Jul;98(1):49–56.

29. Bell KA, Wagner CL, Perng W, Feldman HA, Shypailo RJ, Belfort MB. Validity of Body Mass Index as a Measure of Adiposity in Infancy. J Pediatr. 2018 May;196:168-174.e1.

30. van Beijsterveldt IALP, de Fluiter KS, Breij LM, van der Steen M, Hokken-Koelega ACS. Fat mass and fat-free mass track from infancy to childhood: New insights in body composition programming in early life. Obes Silver Spring Md. 2021 Nov;29(11):1899–906.

31. Butte NF, Wong WW, Hopkinson JM, Smith EO, Ellis KJ. Infant Feeding Mode Affects Early Growth and Body Composition. Pediatrics. 2000 Dec 1;106(6):1355–66.

32. Breij LM, Kerkhof GF, De Lucia Rolfe E, Ong KK, Abrahamse-Berkeveld M, Acton D, et al. Longitudinal fat mass and visceral fat during the first 6 months after birth in healthy infants: support for a critical window for adiposity in early life. Pediatr Obes. 2017 Aug;12(4):286–94.

33. Gale C, Logan KM, Santhakumaran S, Parkinson JR, Hyde MJ, Modi N. Effect of breastfeeding compared with formula feeding on infant body composition: a systematic review and meta-analysis. Am J Clin Nutr. 2012 Mar;95(3):656–69.

34. Abraham EC, Godwin J, Sherriff A, Armstrong J. Infant feeding in relation to eating patterns in the second year of life and weight status in the fourth year. Public Health Nutr. 2012 Sep;15(9):1705–14.

35. Maier-Nöth A, Schaal B, Leathwood P, Issanchou S. The Lasting Influences of Early Food-Related Variety Experience: A Longitudinal Study of Vegetable Acceptance from 5 Months to 6 Years in Two Populations. PLOS ONE. 2016 Mar 11;11(3):e0151356.

36. Arenz S, Rückerl R, Koletzko B, von Kries R. Breast-feeding and childhood obesity—a systematic review. Int J Obes. 2004 Oct;28(10):1247–56.

37. Horta BL, Loret de Mola C, Victora CG. Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: a systematic review and meta-analysis. Acta Paediatr. 2015;104(S467):30–7.

38. Kadakia R, Nodzenski M, Talbot O, Kuang A, Bain JR, Muehlbauer MJ, et al. Maternal metabolites during pregnancy are associated with newborn outcomes and hyperinsulinaemia across ancestries. Diabetologia. 2019 Mar;62(3):473–84.

39. Alexandre-Gouabau MC, Moyon T, Cariou V, Antignac JP, Qannari EM, Croyal M, et al. Breast Milk Lipidome Is Associated with Early Growth Trajectory in Preterm Infants. Nutrients. 2018 Jan 31;10(2):164.

40. Baldeón ME, Zertuche F, Flores N, Fornasini M. Free Amino Acid Content in Human Milk Is Associated with Infant Gender and Weight Gain during the First Four Months of Lactation. Nutrients. 2019 Sep;11(9):2239.

41. Maher SE, O'Brien EC, Moore RL, Byrne DF, Geraghty AA, Saldova R, et al. The association between the maternal diet and the maternal and infant gut microbiome: a systematic review. Br J Nutr. 2023 May 14;129(9):1491–9.

42. Borge TC, Aase H, Brantsæter AL, Biele G. The importance of maternal diet quality during pregnancy on cognitive and behavioural outcomes in children: a systematic review and meta-analysis. BMJ Open. 2017 Sep;7(9):e016777.

43. Abdollahi S, Soltani S, De Souza RJ, Forbes SC, Toupchian O, Salehi-Abargouei A. Associations between Maternal Dietary Patterns and Perinatal Outcomes: A Systematic Review and Meta-Analysis of Cohort Studies. Adv Nutr. 2021 Jul;12(4):1332–52.

44. Venter C, Palumbo MP, Glueck DH, Sauder KA, O'Mahony L, Fleischer DM, et al. The maternal diet index in pregnancy is associated with offspring allergic diseases: the Healthy Start study. Allergy. 2022 Jan;77(1):162–72.

45. Fernández-Barrés S, Vrijheid M, Manzano-Salgado CB, Valvi D, Martínez D, Iñiguez C, et al. The Association of Mediterranean Diet during Pregnancy with Longitudinal Body Mass Index Trajectories and Cardiometabolic Risk in Early Childhood. J Pediatr. 2019 Mar;206:119-127.e6.

46. Martin JC, Joham AE, Mishra GD, Hodge AM, Moran LJ, Harrison CL. Postpartum Diet Quality: A Cross-Sectional Analysis from the Australian Longitudinal Study on Women's Health. J Clin Med. 2020 Feb 6;9(2):446.

47. Martin J, Joham A, Mishra G, Hodge A, Moran L, Harrison C. 352Postpartum diet quality: A cross-sectional analysis from the Australian longitudinal study on women's health. Int J Epidemiol. 2021 Sep 1;50(Supplement_1):dyab168.454.

48. Lee YQ, Loh J, Ang RSE, Chong MFF. Tracking of Maternal Diet from Pregnancy to Postpregnancy: A Systematic Review of Observational Studies. Curr Dev Nutr. 2020 Aug;4(8):nzaa118.

49. Ventura AK, Mennella JA. Innate and learned preferences for sweet taste during childhood. Curr Opin Clin Nutr Metab Care. 2011 Jul;14(4):379.

50. Mennella JA, Bobowski NK. The sweetness and bitterness of childhood: Insights from basic research on taste preferences. Physiol Behav. 2015 Dec 1;152(Pt B):502–7.

51. Liem DG. Infants' and Children's Salt Taste Perception and Liking: A Review. Nutrients [Internet]. 2017 Sep 13 [cited 2018 Jan 4];9(9). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5622771/

52. Drewnowski A. Taste Preferences and Food Intake. Annu Rev Nutr. 1997;17(1):237–53.

53. Bayol SA, Farrington SJ, Stickland NC. A maternal 'junk food' diet in pregnancy and lactation promotes an exacerbated taste for 'junk food' and a greater propensity for obesity in rat offspring. Br J Nutr. 2007 Oct;98(4):843–51.

54. Li M, Sloboda DM, Vickers MH. Maternal Obesity and Developmental Programming of Metabolic Disorders in Offspring: Evidence from Animal Models. J Diabetes Res. 2011 Sep 28;2011:e592408.

55. Mennella JA, Griffin CE, Beauchamp GK. Flavor Programming During Infancy. Pediatrics. 2004 Apr;113(4):840–5.

56. Forestell C, Mennella J. The Ontogeny of Taste Perception and Preference Throughout Childhood. In: Handbook of Olfaction and Gustation: Third Edition. 2015. p. 795–828.

57. Mennella JA, Jagnow CP, Beauchamp GK. Prenatal and postnatal flavor learning by human infants. Pediatrics. 2001 Jun 1;107(6):E88.

58. Mennella JA, Johnson A, Beauchamp GK. Garlic Ingestion by Pregnant Women Alters the Odor of Amniotic Fluid. Chem Senses. 1995 Apr 1;20(2):207–9.

59. Schaal B, Marlier L, Soussignan R. Human Foetuses Learn Odours from their Pregnant Mother's Diet. Chem Senses. 2000 Dec 1;25(6):729–37.

60. Hausner H, Bredie WLP, Mølgaard C, Petersen MA, Møller P. Differential transfer of dietary flavour compounds into human breast milk. Physiol Behav. 2008 Sep 3;95(1):118–24.

61. Hausner H, Nicklaus S, Issanchou S, Mølgaard C, Møller P. Breastfeeding facilitates acceptance of a novel dietary flavour compound. Clin Nutr. 2010 Feb 1;29(1):141–8.

62. Mennella JA. Ontogeny of taste preferences: basic biology and implications for health. Am J Clin Nutr. 2014 Mar 1;99(3):704S-11S.

63. Sartor F, Donaldson LF, Markland DA, Loveday H, Jackson MJ, Kubis HP. Taste perception and implicit attitude toward sweet related to body mass index

and soft drink supplementation. Appetite. 2011 Aug 1;57(1):237–46.

64. Cox DN, Hendrie GA, Carty D. Sensitivity, hedonics and preferences for basic tastes and fat amongst adults and children of differing weight status: A comprehensive review. Food Qual Prefer. 2016 Mar 1;48:359–67.

65. Lanfer A, Knof K, Barba G, Veidebaum T, Papoutsou S, de Henauw S, et al. Taste preferences in association with dietary habits and weight status in European children: results from the IDEFICS study. Int J Obes. 2012 Jan;36(1):27–34.

66. Lanfer A, Bammann K, Knof K, Buchecker K, Russo P, Veidebaum T, et al. Predictors and correlates of taste preferences in European children: The IDEFICS study. Food Qual Prefer. 2013 Mar 1;27(2):128–36.

67. Ahrens W. Sensory taste preferences and taste sensitivity and the association of unhealthy food patterns with overweight and obesity in primary school children in Europe—a synthesis of data from the IDEFICS study. Flavour. 2015;4(1):8.

68. Koletzko B, von Kries R, Monasterolo RC, Subías JE, Scaglioni S, Giovannini M, et al. Can infant feeding choices modulate later obesity risk?234. Am J Clin Nutr. 2009 May 1;89(5):1502S-1508S.

69. Ventura AK, Worobey J. Early Influences on the Development of Food Preferences. Curr Biol. 2013 May 6;23(9):R401–8.

70. Babili MG, Amerikanou C, Papada E, Christopoulos G, Tzavara C, Kaliora AC. The effect of prenatal maternal physical activity and lifestyle in perinatal outcome: results from a Greek study. Eur J Public Health. 2020 Apr 1;30(2):328–32.

71. Silva-Jose C, Sánchez-Polán M, Barakat R, Gil-Ares J, Refoyo I. Level of Physical Activity in Pregnant Populations from Different Geographic Regions: A Systematic Review. J Clin Med. 2022 Aug 8;11(15):4638.

72. Ferrari N, Joisten C. Impact of physical activity on course and outcome of pregnancy from pre- to postnatal. Eur J Clin Nutr. 2021;75(12):1698–709.

73. Hamann V, Deruelle P, Enaux C, Deguen S, Kihal-Talantikite W. Physical activity and gestational weight gain: a systematic review of observational studies. BMC Public Health. 2022 Oct 21;22(1):1951.

74. Modak A, Ronghe V, Gomase KP, Mahakalkar MG, Taksande V. A Comprehensive Review of Motherhood and Mental Health: Postpartum Mood Disorders in Focus. Cureus. 15(9):e46209.

75. Nagel EM, Howland MA, Pando C, Stang J, Mason SM, Fields DA, et al. Maternal psychological distress and lactation and breastfeeding outcomes: A narrative review. Clin Ther. 2022 Feb;44(2):215.

76. Waqas A, Zafar SW, Meraj H, Tariq M, Naveed S, Fatima B, et al. Prevention

of common mental disorders among women in the perinatal period: a critical mixed-methods review and meta-analysis. Glob Ment Health. 9:157–72.

77. Hoffman DJ, Reynolds RM, Hardy DB. Developmental origins of health and disease: current knowledge and potential mechanisms. Nutr Rev. 2017 Dec 1;75(12):951–70.

78. Koletzko B, Brands B, Poston L, Godfrey K, Demmelmair H. Early nutrition programming of long-term health. Proc Nutr Soc. 2012 Aug;71(03):371–8.

79. Hui AL, Back L, Ludwig S, Gardiner P, Sevenhuysen G, Dean HJ, et al. Effects of lifestyle intervention on dietary intake, physical activity level, and gestational weight gain in pregnant women with different pre-pregnancy Body Mass Index in a randomized control trial. BMC Pregnancy Childbirth. 2014 Sep 24;14(1):331.

80. Tang L, Pan XF, Lee AH, Binns CW, Yang CX, Sun X. Maternal lifestyle and nutritional status in relation to pregnancy and infant health outcomes in Western China: protocol for a prospective cohort study. BMJ Open. 2017 Jun 1;7(6):e014874.

81. Ahrens W, Bammann K, Siani A, Buchecker K, De Henauw S, Iacoviello L, et al. The IDEFICS cohort: design, characteristics and participation in the baseline survey. Int J Obes. 2011 Apr;35(S1):S3–15.

82. Nehring I, Kostka T, von Kries R, Rehfuess EA. Impacts of In Utero and Early Infant Taste Experiences on Later Taste Acceptance: A Systematic Review1, 2, 3. J Nutr. 2015 Jun 1;145(6):1271–9.

83. Aparicio E, Jardí C, Bedmar C, Pallejà M, Basora J, Arija V, et al. Nutrient Intake during Pregnancy and Post-Partum: ECLIPSES Study. Nutrients. 2020 May;12(5):1325.

84. Kinshella MLW, Moore SE, Elango R. The missing focus on women's health in the First 1,000 days approach to nutrition. Public Health Nutr. 2021 Apr;24(6):1526–30.

85. Makama M, Awoke MA, Skouteris H, Moran LJ, Lim S. Barriers and facilitators to a healthy lifestyle in postpartum women: A systematic review of qualitative and quantitative studies in postpartum women and healthcare providers. Obes Rev Off J Int Assoc Study Obes. 2021 Apr;22(4):e13167.

86. Ryan RA, Lappen H, Bihuniak JD. Barriers and Facilitators to Healthy Eating and Physical Activity Postpartum: A Qualitative Systematic Review. J Acad Nutr Diet. 2022 Mar;122(3):602-613.e2.

87. Hoedjes M, Berks D, Vogel I, Franx A, Duvekot JJ, Oenema A, et al. Motivators and barriers to a healthy postpartum lifestyle in women at increased cardiovascular and metabolic risk: a focus-group study. Hypertens Pregnancy. 2012;31(1):147–55.

88. Carter-Edwards L, Østbye T, Bastian LA, Yarnall KS, Krause KM, Simmons TJ.

Barriers to adopting a healthy lifestyle: insight from postpartum women. BMC Res Notes. 2009 Aug 17;2(1):161.

89. Rosenstein D, Oster H. Differential Facial Responses to Four Basic Tastes in Newborns. Child Dev. 1988;59(6):1555–68.

90. Knof K, Lanfer A, Bildstein MO, Buchecker K, Hilz H. Development of a method to measure sensory perception in children at the European level. Int J Obes. 2011 Apr;35(S1):S131–6.

91. Deglaire A, Méjean C, Castetbon K, Kesse-Guyot E, Urbano C, Hercberg S, et al. Development of a questionnaire to assay recalled liking for salt, sweet and fat. Food Qual Prefer. 2012 Mar 1;23(2):110–24.

92. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the Concentration of Low-Density Lipoprotein Cholesterol in Plasma, Without Use of the Preparative Ultracentrifuge. Clin Chem. 1972 Jun 1;18(6):499–502.

93. Bradford MM. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal Biochem. 1976 May 7;72(1):248–54.

94. Schmieder R, Edwards R. Fast Identification and Removal of Sequence Contamination from Genomic and Metagenomic Datasets. PLOS ONE. 2011 Mar 9;6(3):e17288.

95. Bragg L, Stone G, Imelfort M, Hugenholtz P, Tyson GW. Fast, accurate error-correction of amplicon pyrosequences using Acacia. Nat Methods. 2012 May;9(5):425–6.

96. Edgar RC. Search and clustering orders of magnitude faster than BLAST. Bioinformatics. 2010 Oct 1;26(19):2460–1.

97. Caporaso JG, Kuczynski J, Stombaugh J, Bittinger K, Bushman FD, Costello EK, et al. QIIME allows analysis of high-throughput community sequencing data. Nat Methods. 2010 May;7(5):335–6.

98. Diehl JM. Fragebögen zur Erfassung ernährungs-und gewichtsbezogener Einstellungen und Verhaltensweisen. In: Unpublizierte Zusammenstellung, nur für den internen Gebrauch Department of Psychologie: Universität Gie\s sen [Internet]. 2006 [cited 2015 Mar 1]. Available from: http://www.ernaehrungsdenkwerkstatt.de/fileadmin/user_upload/EDWText/TextElemente/Ernaehrungspsychologie/Diehl_2006_nutrition-attitudes.pdf

99. Ramage SM, McCargar LJ, Berglund C, Harber V, Bell RC. Assessment of Pre-Pregnancy Dietary Intake with a Food Frequency Questionnaire in Alberta Women. Nutrients. 2015 Jul 27;7(8):6155–66.

100. Global strategy for infant and young child feeding [Internet]. [cited 2023 Aug 23]. Available from: https://www.who.int/publications-detail-redirect/9241562218

101. Brown A, Lee M. Breastfeeding Is Associated with a Maternal Feeding Style Low in Control from Birth. PLOS ONE. 2013 Jan 30;8(1):e54229.

102. Dlugosch GE, Krieger W. Fragebogen zur Erfassung des Gesundheitsverhaltens: FEG; Handanweisung. Frankfurt: Swets Test Services; 1995. Test (Manual 108, [40] S.).

103. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. Med Sci Sports Exerc. 2003 Aug;35(8):1381.

104. Satow DL. Test- und Skalendokumentation. 2012;

105. DeepL Write: Ihr KI-Schreibassistent [Internet]. [cited 2024 Jul 15]. Available from: https://www.deepl.com/de/write

106. Wickham H. Data Analysis. In: Wickham H, editor. ggplot2: Elegant Graphics for Data Analysis [Internet]. Cham: Springer International Publishing; 2016 [cited 2025 Feb 4]. p. 189–201. Available from: https://doi.org/10.1007/978-3-319-24277-4_9

107. R: The R Project for Statistical Computing [Internet]. [cited 2025 Feb 4]. Available from: https://www.r-project.org/

108. Braun V, Clarke V. What can “thematic analysis” offer health and wellbeing researchers? Int J Qual Stud Health Well-Being [Internet]. 2014 Oct 16 [cited 2016 Aug 4];9. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4201665/

109. Saunders CH, Sierpe A, von Plessen C, Kennedy AM, Leviton LC, Bernstein SL, et al. Practical thematic analysis: a guide for multidisciplinary health services research teams engaging in qualitative analysis. BMJ. 2023 Jun 8;e074256.

110. Gilmore LA, Redman LM. Weight gain in pregnancy and application of the 2009 IOM guidelines: toward a uniform approach. Obes Silver Spring Md. 2015 Mar;23(3):507–11.

111. [International Physical Activity Questionnaire (IPAQ)] LZG.NRW [Internet]. 2015 [cited 2015 Jul 10]. Available from: https://www.lzg.nrw.de/themen/Gesundheit_schuetzen/praevention/qualitaetsinitiative/evaluationstools/methodenkoffer/instrumente-im-setting/sekundarschule/international-physical-activity-questionnaire-ipaq/index.html

112. World Health Organization. WHO child growth standards : growth velocity based on weight, length and head circumference : methods and development. 2009;242.

113. Bailey RL. Overview of Dietary Assessment Methods for Measuring Intakes of Foods, Beverages, and Dietary Supplements in Research Studies. Curr Opin Biotechnol. 2021 Aug;70:91–6.

114. Bagherzadeh R, Gharibi T, Safavi B, Mohammadi SZ, Karami F, Keshavarz S. Pregnancy; an opportunity to return to a healthy lifestyle: a qualitative study. BMC Pregnancy Childbirth. 2021 Nov 5;21(1):751.

115. Nawaz H, Adams ML, Katz DL. Physician—Patient Interactions Regarding Diet, Exercise, and Smoking. Prev Med. 2000 Dec 1;31(6):652–7.

116. Bauld L, Graham H, Sinclair L, Flemming K, Naughton F, Ford A, et al. Barriers to and facilitators of smoking cessation in pregnancy and following childbirth: literature review and qualitative study. Health Technol Assess. 2017 Jun;21(36):1–158.

117. Ribeiro MM, Andrade A, Nunes I. Physical exercise in pregnancy: benefits, risks and prescription. J Perinat Med. 2022 Jan 27;50(1):4–17.

118. Coll CVN, Domingues MR, Gonçalves H, Bertoldi AD. Perceived barriers to leisure-time physical activity during pregnancy: A literature review of quantitative and qualitative evidence. J Sci Med Sport. 2017 Jan 1;20(1):17–25.

119. Ayyala MS, Coughlin JW, Martin L, Henderson J, Ezekwe N, Clark JM, et al. Perspectives of pregnant and postpartum women and obstetric providers to promote healthy lifestyle in pregnancy and after delivery: a qualitative in-depth interview study. BMC Womens Health. 2020 Mar 4;20(1):44.

120. Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines. Weight Gain During Pregnancy: Reexamining the Guidelines [Internet]. Rasmussen KM, Yaktine AL, editors. Washington (DC): National Academies Press (US); 2009 [cited 2025 Jan 20]. (The National Academies Collection: Reports funded by National Institutes of Health). Available from: http://www.ncbi.nlm.nih.gov/books/NBK32813/

121. Coutinho E de C, Silva CB da, Chaves CMB, Nelas PAB, Parreira VBC, Amaral MO, et al. Pregnancy and childbirth: What changes in the lifestyle of women who become mothers? Rev Esc Enferm USP. 2014 Dec;48(SPE2):17–24.

122. Nucci D, Chiavarini M, Duca E. Pre-pregnancy body mass index, gestational weight gain and adverse birth outcomes: some evidence from Italy. Ann Ig Med Prev E Comunnità. 2018 Apr 30;(2):140–52.

123. Lovering ME, Rodgers RF, George JE, Franko DL. Exploring the Tripartite Influence Model of body dissatisfaction in postpartum women. Body Image. 2018 Mar;24:44–54.

124. Rodgers RF, Campagna J, Hayes G, Sharma A, Runquist E, Fiuza A, et al. Sociocultural pressures and body related experiences during pregnancy and the postpartum period: A qualitative study. Body Image. 2024 Mar;48:101643.

125. Savard C, Lemieux S, Weisnagel SJ, Fontaine-Bisson B, Gagnon C, Robitaille J, et al. Trimester-Specific Dietary Intakes in a Sample of French-Canadian Pregnant Women in Comparison with National Nutritional Guidelines.

Nutrients. 2018 Jun 14;10(6):768.

126. Dubois L, Diasparra M, Bédard B, Colapinto CK, Fontaine-Bisson B, Morisset AS, et al. Adequacy of nutritional intake from food and supplements in a cohort of pregnant women in Québec, Canada: the 3D Cohort Study (Design, Develop, Discover). Am J Clin Nutr. 2017 Aug;106(2):541–8.

127. Lu X, Sun Z. Association between vitamin levels and obesity in the national health and nutrition examination surveys 2017 to 2018. J Dev Orig Health Dis. 2023 Dec;14(6):773–80.

128. Wilson NA, Mantzioris E, Middleton PF, Muhlhausler BS. Influence of clinical characteristics on maternal DHA and other polyunsaturated fatty acid status in pregnancy: A systematic review. Prostaglandins Leukot Essent Fatty Acids. 2020 Mar;154:102063.

129. Dahl WJ, Stewart ML. Position of the Academy of Nutrition and Dietetics: Health Implications of Dietary Fiber. J Acad Nutr Diet. 2015 Nov;115(11):1861–70.

130. Awoke MA, Wycherley TP, Earnest A, Skouteris H, Moran LJ. The Profiling of Diet and Physical Activity in Reproductive Age Women and Their Association with Body Mass Index. Nutrients. 2022 Jun 23;14(13):2607.

131. Ren X, Vilhjálmsdóttir BL, Rohde JF, Walker KC, Runstedt SE, Lauritzen L, et al. Systematic Literature Review and Meta-Analysis of the Relationship Between Polyunsaturated and Trans Fatty Acids During Pregnancy and Offspring Weight Development. Front Nutr. 2021 Mar 25;8:625596.

132. Imhoff-Kunsch B, Briggs V, Goldenberg T, Ramakrishnan U. Effect of n-3 long-chain polyunsaturated fatty acid intake during pregnancy on maternal, infant, and child health outcomes: a systematic review. Paediatr Perinat Epidemiol. 2012 Jul;26 Suppl 1:91–107.

133. Harris M, Schiff DM, Saia K, Muftu S, Standish KR, Wachman EM. Academy of Breastfeeding Medicine Clinical Protocol #21: Breastfeeding in the Setting of Substance Use and Substance Use Disorder (Revised 2023). Breastfeed Med. 2023 Oct 1;18(10):715–33.

134. Sweet L, Arjyal S, Kuller JA, Dotters-Katz S. A Review of Sleep Architecture and Sleep Changes During Pregnancy. Obstet Gynecol Surv. 2020 Apr;75(4):253–62.

135. Lim S, Lang S, Savaglio M, Skouteris H, Moran LJ. Intervention Strategies to Address Barriers and Facilitators to a Healthy Lifestyle Using the Behaviour Change Wheel: A Qualitative Analysis of the Perspectives of Postpartum Women. Nutrients. 2024 Apr 3;16(7):1046.

136. Aston M, Price S, Monaghan J, Sim M, Hunter A, Little V. Navigating and negotiating information and support: Experiences of first-time mothers. J Clin Nurs. 2018 Feb;27(3–4):640–9.

137. Schwab-Reese LM, Ramirez M, Ashida S, Peek-Asa C. Psychosocial employment characteristics and postpartum maternal mental health symptoms. Am J Ind Med. 2017 Jan;60(1):109–20.

138. Radauceanu A, Grzebyk M, Demange V, Dziurla M, Lafon D, Goujon E, et al. Returning to work after childbirth and women's mental health: the place of work-family conflict and of social supports in a population of working mothers in Paris area. J Occup Environ Med [Internet]. 2024 Nov 11 [cited 2025 Jan 21]; Available from: https://journals.lww.com/10.1097/JOM.0000000000003260

139. Strange C, Bremner A, Fisher C, Howat P, Wood L. Mothers' group participation: associations with social capital, social support and mental well-being. J Adv Nurs. 2016 Jan;72(1):85–98.

140. Ruppanner L, Lee R, Huffman M. Do Mothers Benefit from Flexible Work? Cross-National Evidence for Work Time, Job Quality, and Satisfaction. Int J Sociol. 2018 Feb 27;48(2):170–87.

141. Lindqvist M, Lindkvist M, Eurenius E, Persson M, Mogren I. Change of lifestyle habits – Motivation and ability reported by pregnant women in northern Sweden. Sex Reprod Healthc. 2017 Oct;13:83–90.

142. Beulen YH, Super S, De Vries JHM, Koelen MA, Feskens EJM, Wagemakers A. Dietary Interventions for Healthy Pregnant Women: A Systematic Review of Tools to Promote a Healthy Antenatal Dietary Intake. Nutrients. 2020 Jul 3;12(7):1981.

143. Ku CW, Leow SH, Ong LS, Erwin C, Ong I, Ng XW, et al. Development of a Lifestyle Intervention Program for Overweight or Obese Preconception, Pregnant and Postnatal Women: a Qualitative Study. In 2021 [cited 2024 Jul 15]. Available from: https://www.researchsquare.com/article/rs-877807/v1