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Effect of a lifestyle intervention alongside antenatal routine care on maternal health behaviors and development and validation of a screening tool to identify women at risk for excessive gestational weight gain

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KNOWING IS NOT ENOUGH, WE MUST APPLY.

WILLING IS NOT ENOUGH, WE MUST DO.

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Abstract

Overweight and obesity are global health concerns that also affect women of childbearing age. Maternal health behaviors during pregnancy and postpartum can impact both maternal and child health. The cluster-randomized “Gesund leben in der Schwangerschaft”/“healthy living in pregnancy” (GeliS) study was performed in the German antenatal routine care setting with the aim of improving maternal health behaviors and reduce excessive gestational weight gain (EGWG). Between 2013 and 2015, 2,286 pregnant women were recruited for the GeliS lifestyle intervention study. The intervention group (IG) received three antenatal and one early postpartum counseling sessions alongside routine care by trained healthcare professionals, while the control group (CG) received routine antenatal care. Maternal weight and health behavior data were collected from maternity records and paper-based questionnaires. This thesis aimed to evaluate the effectiveness of the GeliS counseling on (1) maternal antenatal physical activity (PA) behavior, (2) maternal health behaviors beyond the intervention phase in the first year postpartum, (3) dietary supplement intake during and after pregnancy, and the supplementation behavior in the comprehensive GeliS dataset. Furthermore, (4) a screening tool was developed and validated using the GeliS cohort, which can be used to assess the risk of EGWG at the beginning of pregnancy.

The GeliS lifestyle counseling improved antenatal PA behavior, in particular PA of higher intensities. Moreover, a significantly larger proportion of women in the IG met PA recommendations in late pregnancy (64% vs. 49%, $p<0.001$). There was no evidence for a major difference in PA between the groups in the first year postpartum. However, the GeliS lifestyle counseling showed sustained effects on maternal postpartum dietary behavior. Diet quality, measured by a healthy eating index, was slightly higher in the IG at 6–8 weeks (T1pp) ($p=0.093$) and one year (T2pp) ($p=0.043$) postpartum. The IG showed lower consumption of fast food (T1pp: $p=0.016$; T2pp: $p<0.001$) and soft drinks (T1pp: $p<0.001$), increased vegetable intake (T2pp: $p=0.015$), and a higher likelihood of using healthy oils for cooking. The proportion of smokers was significantly lower in the IG throughout the first year postpartum. There were no statistically significant group differences in dietary supplement intake behavior either before study inclusion or during the intervention. Before conception, 31.3% of women in the IG and 31.4% in the CG supplemented folic acid. During pregnancy about half of the women took folic acid (IG: 54.1%; CG: 52.0%) and iodine (IG: 50.2%; CG: 48.2%). In the GeliS cohort, 23.0% of all women supplemented docosahexaenoic acid, while 21.8% and 49.4% took additional iron and vitamin D, respectively. The risk score model revealed that a high pre-pregnancy body mass index, intermediate educational level, foreign

country of birth, primiparity, current or former smoking, and signs of depressive disorder are significant risk factors for EGWG. Based on the cross-validation and external validation, the risk score model was rated as moderate (receiver operating characteristic curve: 0.709; 0.738, respectively). The factors were integrated into a practical screening questionnaire.

In conclusion, the GeliS lifestyle intervention successfully improved maternal antenatal PA behavior and had sustained effects on maternal dietary and smoking behaviors in the first year postpartum. The intervention had no effect on adequate use of dietary supplement. The supplementation of micronutrients before, during, and after pregnancy did not align with the current recommendations. Tailoring lifestyle interventions based on a woman's risk for EGWG early on may enhance effectiveness. Additionally, providing lifestyle counseling spanning both the pre-conception and postpartum phases, along with using smartphone applications, might improve maternal health outcomes.

Zusammenfassung

Übergewicht und Adipositas sind ein globales Gesundheitsproblem, das auch Frauen im gebärfähigen Alter betrifft. Der mütterliche Lebensstil während und nach der Schwangerschaft beeinflusst die Gesundheit von Mutter und Kind. Die cluster-randomisierte „Gesund leben in der Schwangerschaft“ (GeliS)-Studie wurde innerhalb der deutschen Routineversorgung für Schwangere durchgeführt, mit dem Ziel, das Gesundheitsverhalten schwangerer Frauen zu verbessern und eine exzessive Gewichtszunahme in der Schwangerschaft zu vermeiden. Zwischen 2013 und 2015 wurden 2.286 schwangere Frauen für die GeliS Lebensstilinterventionsstudie rekrutiert. Die Interventionsgruppe (IG) erhielt ein umfassendes Lebensstilprogramm, das aus drei pränatalen und einer frühen postpartalen Lebensstilberatung bestand, die parallel zu den routinemäßigen Vorsorgeuntersuchungen von speziell geschulten Gesundheitsfachkräften durchgeführt wurden. Die Kontrollgruppe (KG) durchlief das gewöhnliche Vorsorgeprogramm für Schwangere. Die Datenerhebung erfolgte mithilfe des Mutterpasses und papierbasierten Fragebögen. In der vorliegenden Arbeit wurde der Effekt des GeliS-Lebensstilinterventionsprogramms auf (1) das Bewegungsverhalten der werdenden Mütter während der Schwangerschaft, (2) das Gesundheitsverhalten über die Interventionsphase hinaus im ersten Jahr nach der Geburt, (3) die Einnahme von Nahrungsergänzungsmitteln während und nach der Schwangerschaft, sowie die Einnahme innerhalb der gesamten Kohorte untersucht. Darüber hinaus wurde (4) anhand der GeliS Kohorte ein Screening-Tool entwickelt und validiert, mit dessen Hilfe das Risiko für eine exzessive Gewichtszunahme bereits zu Beginn der Schwangerschaft bestimmt werden kann. Die GeliS-Lebensstilberatung verbesserte das pränatale Bewegungsverhalten, insbesondere Aktivitäten höherer Intensitäten. Ein signifikant größerer Anteil der Frauen in der IG erreichte die offiziellen Bewegungsempfehlungen (64% vs. 49%, $p<0{,}001$). Das Bewegungsverhalten im ersten Jahr nach der Geburt unterschied sich nicht mehr zwischen den Gruppen, jedoch erzielte die GeliS Lebensstilberatung nachhaltige Effekte auf das mütterliche Ernährungsverhalten. Frauen der IG hatten eine etwas höhere Ernährungsqualität 6–8 Wochen (T1pp) ($p=0{,}093$) und ein Jahr (T2pp) ($p=0{,}043$) nach der Geburt. Frauen der IG verzehrten weniger Fast Food (T1pp: $p=0{,}016$; T2pp: $p<0{,}001$) und Softdrinks (T1pp: $p<0{,}001$), konsumierten mehr Gemüse (T2pp: $p=0{,}015$) und verwendeten eher gesunde Öle zur Nahrungszubereitung. Der Anteil der Raucherinnen war in der IG im ersten Jahr postpartal signifikant geringer als in der KG. Es gab keinen wesentlichen Unterschied bei der Einnahme von Nahrungsergänzungsmitteln, weder vor Studieneinschluss noch während der Intervention. 31,3% der IG und 31,4% der KG supplementierten Folsäure vor der

Schwangerschaft. Etwa die Hälfte der Frauen nahm Folsäure (IG: 54,1%; KG: 52,0%) und Jod (IG: 50,2%; KG: 48,2%) während der Schwangerschaft zusätzlich ein. In der gesamten GeliS-Kohorte supplementierten 23,0% der Frauen Docosahexaensäure, 21,8% Eisen, und 49,4% Vitamin D während der Schwangerschaft. Das Risikoscore-Modell identifizierte einen hohen Body-Mass-Index, ein geringeres Bildungsniveau, ein anderes Geburtsland als Deutschland, Primiparität, aktuelles oder früheres Rauchen und Anzeichen für eine depressive Störung als Risikofaktoren für eine exzessive Gewichtszunahme, die in einen praktischen Screening-Fragebogen integriert wurden. Anhand einer Kreuzvalidierung und externen Validierung wurde der Risikoscore als moderat eingestuft (Receiver-Operating-Characteristics-Kurve: 0,709 bzw. 0,738).

Es lässt sich zusammenfassen, dass die GeliS-Lebensstilintervention das pränatale Bewegungsverhalten verbesserte und nachhaltige Effekte auf das Ernährungs- und Rauchverhalten der Mütter im ersten Jahr nach der Geburt zeigte. Jedoch hatte die Intervention keinen Einfluss auf die adäquate Einnahme von Nahrungsergänzungsmitteln. Die Supplementierung von Mikronährstoffen vor, während und nach der Schwangerschaft entsprach nicht den aktuellen Empfehlungen. Zukünftige Lebensstilinterventionen, die speziell auf das Risiko für eine exzessive Gewichtszunahme abgestimmt sind, könnten die Wirksamkeit von Interventionen erhöhen. Darüber hinaus könnten Lebensstilinterventionen, die den Zeitraum vor der Schwangerschaft und nach der Geburt einbeziehen und moderne App-Ansätze nutzen, die Erfolgsaussichten erhöhen, die Gesundheit der Mütter nachhaltig positiv zu beeinflussen.

List of abbreviations

Adj: Adjusted

App: Smartphone application

AUROC: Area under the receiver operating characteristic (curve)

BCT: Behavioral change technique

BMI: Body mass index

CG: Control group

CI: Confidence interval

DEGS: German health interview and examination survey for adults

DGE: German nutrition society

DHA: Docosahexaenoic acid

DOHaD: Developmental origins of health and disease

EBCOG: European board and college of obstetrics and gynaecology

EGWG: Excessive gestational weight gain

FeLIPO: Feasibility of a lifestyle-intervention in pregnancy to optimize maternal weight development

FFQ: Food frequency questionnaire

GDM: Gestational diabetes mellitus

GEE: Generalized estimating equations

GeliS: Gesund leben in der Schwangerschaft/healthy living in pregnancy

GWG: Gestational weight gain

HbA_{1c}: Glycosylated hemoglobin A_{1c}

HEI: Healthy eating index

HiPPP: Health in pre-conception, pregnancy and postpartum

IG: Intervention group

IPD: Individual participant data

i-WIP: The international weight management in pregnancy collaborative group

JITAI: Just-in-time adaptive intervention

LC: Lifestyle counseling session

LGA: Large for gestational age

MET: Metabolic equivalent of task

NAM: National academy of medicine

NCD: Non-communicable disease

NTD: Neural tube defect

OGTT: Oral glucose tolerance test

PA: Physical activity

PHQ: Patient health questionnaire

PP: Postpartum

PPAQ: Pregnancy physical activity questionnaire

PPWR: Postpartum weight retention

Pre-preg: Pre-pregnancy

Q: Questionnaire set

RCT: Randomized controlled trial

SQ: Screening questionnaire

T0: ≤12th week of gestation, early pregnancy

T1: >29th week of gestation, late pregnancy

T1pp: 6–8 weeks postpartum

T2pp: one year postpartum

TALIA: Total activity of light-intensity and above

TEL: Telephone interview

WBCB: Well-baby check-up booklet

Wk gest: Weeks of gestation

Wk pp: Weeks postpartum

WHO: World health organization

1 General introduction

1.1 Overweight and obesity – a global public health concern

Overweight and obesity is a global public health concern affecting both sexes and all age groups. The World Health Organization (WHO) reported in 2016 that global rates of overweight and obesity among adults were 39% and 13%, respectively (WHO 09.06.2021). In Europe, almost 60% of adults and one in three school-aged children are currently living with overweight or obesity, which reflects epidemic proportions (Kluge 2022). Similar rates are seen in Germany, where currently 34.5% of adults are affected by overweight and 19.0% are affected by obesity (Schienkiewitz et al. 2022b). The prevalence has increased over the past decades and is predicted to rise further (NCD Risk Factor Collaboration 2016, 2017). There is no country on track for achieving the WHO Global Non-Communicable Disease (NCD) targets to halt the rise in obesity by 2025 (World Obesity Federation 2022). The recent coronavirus pandemic has exacerbated the situation, as people with obesity were more likely to report weight gain during the pandemic period than people without obesity (Schienkiewitz et al. 2022a). Having overweight and obesity is a leading risk factor for many NCDs including cardiovascular or chronic kidney disease, diabetes mellitus, certain types of cancer and chronic respiratory diseases (G.B.D. Obesity Collaborators et al. 2017; Lauby-Secretan et al. 2016; Brock et al. 2020).

Overweight and obesity result from weight gain due to an imbalance, in which the energy intake is greater than the energy expenditure over a period of time (Swinburn et al. 2009). This imbalance is partly caused by unhealthy lifestyle habits related to diet and physical activity (PA), which are influenced by a changing living environment because of increased urbanization and industrialization (Swinburn et al. 2011). Initially, genetic makeup adapted to an environment where food was scarce, and PA was part of daily life (Kluge 2022). However, transitions in the food environment have introduced affordable, energy-dense, and processed foods that are not only easily accessible, but also heavily promoted. Technological advancements and environmental changes have resulted in a decline in both work-related and everyday activities so that many forms of work become increasingly sedentary and transportation methods have altered. This modern environment conducive to weight gain, termed an obesogenic environment, fosters less PA and heightened availability of unhealthy and energy-dense food choices. It mainly drives the increasing prevalence of overweight and obesity across diverse populations (Swinburn et al. 2011; Kluge 2022).

1.2 Pregnancy as a driver of overweight and obesity

Women of childbearing age are equally affected by this development, and thus, by overweight and obesity. In Germany, 26.6% of women aged 18–29 years and 40.8% of women aged 30–44 years are classified as having overweight or obesity (Schienkiewitz et al. 2022b). During this time, a potential pregnancy represents a crucial life event that additionally affects the health and weight development of women (Pegington et al. 2020). Women who have given birth experience a 3.5-fold higher 5-year risk of obesity than women who have never born a child (Davis et al. 2009). Data from Germany shows that weight gain among women up to the age of 45 remains consistently elevated and only gradually declines with increasing age (Haftenberger et al. 2016). Moreover, the number of women experiencing overweight and obesity at the onset of pregnancy has risen continuously in recent times (Strauss et al. 2021), with current rates around 16% of women having a pre-conception body mass index (BMI) ≥30 kg/m^2 (RKI 2020). Entering pregnancy with overweight or obesity increases the risk for adverse pregnancy and birth complications, such as preeclampsia, preterm birth, cesarean section, gestational diabetes mellitus (GDM) and large for gestational age (LGA) children (Poston et al. 2016; LifeCycle Project-Maternal Obesity and Childhood Outcomes Study Group 2019). These outcomes heighten a woman's risk of NCDs later in life (McNestry et al. 2023). Furthermore, a pre-pregnancy BMI of overweight and obesity increases the risk for excessive gestational weight gain (EGWG) (Sámano et al. 2023). According to the Institute of Medicine (recently renamed National Academy of Medicine, NAM), EGWG is defined as weight gain during pregnancy that exceeds a specific threshold, which is determined by the mother's pre-pregnancy BMI (Table 1) (Rasmussen and Yaktine 2009). EGWG is a strong predictor for the risk for subsequent postpartum weight retention (PPWR), defined as the difference between maternal postpartum and pre-pregnancy body weight (Nehring et al. 2011; Rong et al. 2015; Meyer et al. 2023). About one in four mothers still have substantial PPWR one year after delivery (>4.55/5kg) (McKinley et al. 2018). The weight retained after birth represents an elevated baseline BMI for a possible subsequent pregnancy, exposing women to a heightened risk for EGWG and perinatal complications, perpetuating the cycle (Luke et al. 2016; Teulings et al. 2019). Thus, both EGWG and PPWR seem to be key contributors to weight gain in women and the development of overweight and obesity later in life (Phelan 2010). This vicious cycle of maternal weight development has an intergenerational impact on the health and weight development of the future generation (Figure 1) as a high pre-pregnancy maternal body weight and EGWG are associated with increased risk for the development of metabolic disorders as well as overweight and obesity in childhood and young adolescence (Heslehurst et al. 2019; Voerman et al. 2019). The lifelong imprinting of

the child's metabolism in utero, by factors such as maternal obesity and overnutrition, with lasting consequences for long-term health or disease risk in childhood or adulthood embodies the principle of developmental programming or the Developmental Origins of Health and Disease (DOHaD) hypothesis (Fleming et al. 2018; Langley-Evans 2022).

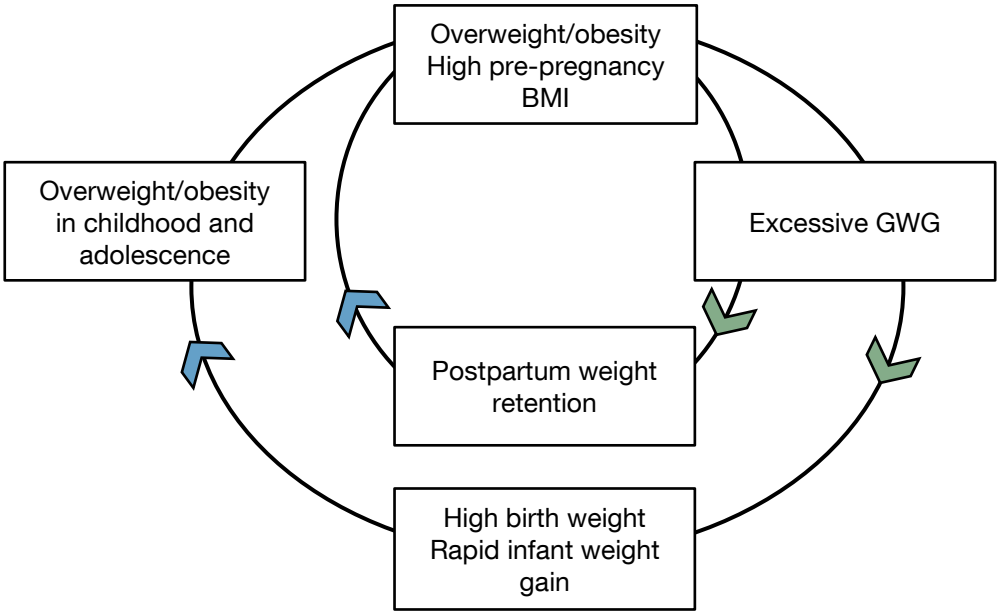


Figure 1 Intergenerational cycle of overweight and obesity.
Abbreviations: BMI: body mass index; GWG: gestational weight gain.
Data source: adapted from Raab et al. 2022a.

1.3 Excessive gestational weight gain

To reduce health risks associated with inappropriate gestational weight gain (GWG) and optimize the overall health of both the mother and the child, the NAM developed and updated the recommendations for optimal GWG based on a woman's pre-pregnancy BMI in 2009 (Table 1). These guidelines serve as a reasonable orientation for pregnant women and healthcare providers (Rasmussen and Yaktine 2009). For women of normal weight, a GWG of 11.5 kg to a maximum of 16.0 kg is recommended. Women with overweight and obesity should gain less weight during pregnancy. GWG below or above these specific thresholds is defined as inadequate or EGWG, respectively, and should be avoided (Rasmussen and Yaktine 2009). Despite the NAM recommendations, the proportion of pregnant women experiencing EGWG has risen in the last decades (Johnson et al. 2015). A recent meta-analysis using individual participant data (IPD) from over 218,000 women from 33 different cohorts worldwide reported that 44% of women gain excessive weight during pregnancy (Santos et al. 2018). In Germany, the prevalence of pregnant women who exceed the recommendations for adequate GWG has been reported to range from 42.9% to 68.5%

(Ensenauer et al. 2013; Ferrari et al. 2014; Noever et al. 2020; Krebs et al. 2022). There is strong evidence that EGWG is associated with adverse pregnancy outcomes, such as GDM, hypertensive disorders as well as, preterm birth, cesarean delivery, LGA at birth, and macrosomia (Goldstein et al. 2017; Champion and Harper 2020).

To comprehensively understand maternal characteristics associated with EGWG, several factors that favor susceptibility to EGWG are currently being investigated. A recent systematic review of 70 studies including more than 3.3 million participants found 58 different risk factors that were grouped into individual, family and social categories (Zhou et al. 2022). The subsequent meta-analysis conducted on 13 of these factors concluded that pre-pregnancy overweight and obesity, younger age (≤30 years), unemployment, being unmarried or divorced, primiparity and maternal smoking were each significantly associated with a higher risk of EGWG (Zhou et al. 2022). A high maternal pre-pregnancy BMI has been repeatedly shown as the strongest risk factor for EGWG (Samura et al. 2016; Sámano et al. 2023). The evidence regarding the relationship between sociodemographic characteristics of pregnant women (Samura et al. 2016; Zhou et al. 2022) and parity (Hill et al. 2017; Zhou et al. 2022; Sámano et al. 2023) with EGWG is still inconsistent, while foreign nationality (Heery et al. 2015), migration background (Restall et al. 2014) or ethnicity (Gaillard et al. 2013) seem to be predictive factors for EGWG according to the literature. In addition, cognitive factors, such as less knowledge, negative body image and attitudes towards weight gain, have been suggested to be linked with the risk for EGWG (Kapadia et al. 2015), while other results regarding the impact of psychological characteristics were inconclusive (Hill et al. 2013; Hartley et al. 2015; Zhou et al. 2022).

Table 1 Recommendations for adequate gestational weight gain provided by the NAM.

Pre-pregnancy BMI category	Gestational weight gain	
	Recommended minimum	Recommended maximum
Underweight: <18.5 kg/m^2	12.5 kg	18.0 kg
Normal weight: 18.5–24.9 kg/m^2	11.5 kg	16.0 kg
Overweight: 25.0–29.9 kg/m^2	7.0 kg	11.5 kg
Obesity: ≥30.0 kg/m^2	5.0 kg	9.0 kg

Abbreviations: NAM: National Academy of Medicine; BMI: body mass index.
Data source: adapted from the NAM guidelines (Rasmussen and Yaktine 2009).

1.4 Maternal lifestyle during and after pregnancy

In addition to the above-mentioned risk factors, an unhealthy maternal lifestyle has also been recognized as a negative influence on GWG (Zhou et al. 2022). For instance, women who engage in lower levels of PA (Restall et al. 2014), have a higher total energy consumption, and smoke while being pregnant (Gaillard et al. 2013) face an elevated risk of EGWG. Conversely, a healthy maternal lifestyle is beneficial for the course of pregnancy. Women who maintain a consistent exercise routine experience a lowered risk of EGWG (Deputy et al. 2015). A higher intake of fruits, vegetables, legumes and fish seems to be associated with favorable pregnancy outcomes (Chen et al. 2016). Furthermore, a healthy diet and exercise contribute to weight reduction in women after childbirth (Amorim Adegboye and Linne 2013) and are associated with various health benefits, such as aerobic fitness, psychological well-being (Larson-Meyer 2002), and improved symptoms of postpartum depression (Dipietro et al. 2019; Opie et al. 2020).

The intergenerational cycle of overweight and obesity forms the rationale for the interest in prevention strategies around pregnancy. While these efforts ideally should commence before conception, adequate maternal weight development can still be pursued during pregnancy, leveraging the potential of pregnancy as a “teachable moment”. This concept is generally understood to be a time point that arises from “naturally occurring life transitions or health events thought to motivate individuals to spontaneously adopt risk-reducing health behaviors” (McBride et al. 2003). Thus, pregnant women might be more receptive and willing to change their health behavior, given the direct impact on their child’s well-being (Phelan 2010). Even following childbirth, women are becoming more aware of both their health and the health of their families (McKinley et al. 2018). This motivation offers the chance to promote maternal health behaviors during and after pregnancy to improve pre- and postnatal weight development, including both gaining the recommended weight during pregnancy and preventing PPWR and, in turn, improving maternal and child health (Phelan 2010).

In the following, an overview of the recommendations regarding a healthy maternal lifestyle during and after pregnancy is given, which is summarized in Table 2. The recommendations are based on the German “Healthy Start – Young Family Network”, which has published evidence-based guidelines on a healthy lifestyle before and during pregnancy as a common basis to be disseminated to women (Koletzko et al. 2018). Recommendations for a healthy lifestyle during the postpartum period focus on breastfeeding women (Koletzko et al. 2016). PA recommendations for the postpartum period are mostly integrated into those for pregnancy (Evenson et al. 2014). Therefore, because of the missing concrete German

recommendations, the following information is additionally based on Ferrari and Graf (2017) who have compiled established international PA guidelines.

1.4.1 Dietary recommendations

During pregnancy, dietary recommendations center around advice on energy and nutrient intake, supplementation with critical nutrients and prevention of foodborne infections. While the energy requirements increase only slightly during pregnancy, the need for numerous micronutrients is elevated (Figure 2), so pregnant women should focus on the nutritional quality of their diet (Koletzko et al. 2018). The additional need for the most nutrients can be covered by suitable food choices and a varied and balanced diet as recommended by the German Nutrition Society (DGE) for generally healthy adults (DGE 2017). The elevated need for specific micronutrients cannot be provided by the nutritional environment in Germany and should therefore be ensured by dietary supplements (Koletzko et al. 2018; DGE 2021). Women who are planning a pregnancy should take a daily supplement containing 400 µg folic acid at least four weeks pre-conception until the end of the first trimester. A higher dosage should be used when folic acid supplementation starts less than four weeks pre-conceptionally (Koletzko et al. 2018). There is substantial evidence for the supplementation of folic acid as a prevention strategy for neural tube defects (NTD) (De-Regil et al. 2015; Viswanathan et al. 2017). Furthermore, pregnant women should take a supplement with 100–150 µg/day of iodine, in addition to consuming iodine-containing foods to reach the recommended reference value of 230 µg (Koletzko et al. 2018; DGE 2021). Insufficient iodine intake is associated with higher miscarriage and stillbirth rates and can harm the child's physical and cognitive development (Bougma et al. 2013; Redman et al. 2016; BfR 2021).

Depending on the state of nutrient supply, additional supplementation of iron, docosahexaenoic acid (DHA), and vitamin D may be recommended in conjunction with individual medical advice (Koletzko et al. 2018). The demand for iron during pregnancy is twice as high as for non-pregnant women (Figure 2), with a reference value of 30 mg/day; however, no general supplementation is recommended. Since there is no menstrual blood loss, and intestinal iron absorption increases during pregnancy, it is assumed that the alimentary iron requirement can be met by sufficient intake of iron-rich foods. Nevertheless, blood hemoglobin values, as well as serum ferritin, should be determined, and supplementation should be taken if there is a medically diagnosed deficiency (Koletzko et al. 2018). The risk for an iron deficiency is higher among women following a vegetarian diet (Koletzko et al. 2018). The recommended intake of 200 mg/day of DHA during pregnancy can be achieved with one to two fatty sea fish meals per week. However, pregnant women without

a regular intake of sea fish are advised to supplement DHA (Koletzko et al. 2018). Although the need for vitamin D is not increased during pregnancy, undersupply should be avoided to prevent negative effects on fetal vitamin D supply and bone health (Dawodu and Wagner 2012; Bischoff-Ferrari 2011). Therefore, pregnant women who rarely spend time in the sun, or who largely cover their skin or use sunscreen when exposed to the sun, as well as women with dark skin types, should daily supplement 20 µg of vitamin D per day (Koletzko et al. 2018). For women with a long-standing vegetarian diet before pregnancy, B_{12} and zinc are critical nutrients. Women with a strict vegan diet must also consider protein and calcium, in addition to B_{12} and zinc. In these cases, the supplementation of these nutrients should occur following individual consultation (Koletzko et al. 2018; Hauner 2022). To avoid foodborne infections, all pregnant women should avoid raw or smoked meat and fish products, unpasteurized milk products, and raw eggs. Pregnant women and women planning to become pregnant should abstain from alcohol. Caffeinated beverages should only be consumed in moderate amounts (≤200 mg/day) (Koletzko et al. 2018) (Table 2).

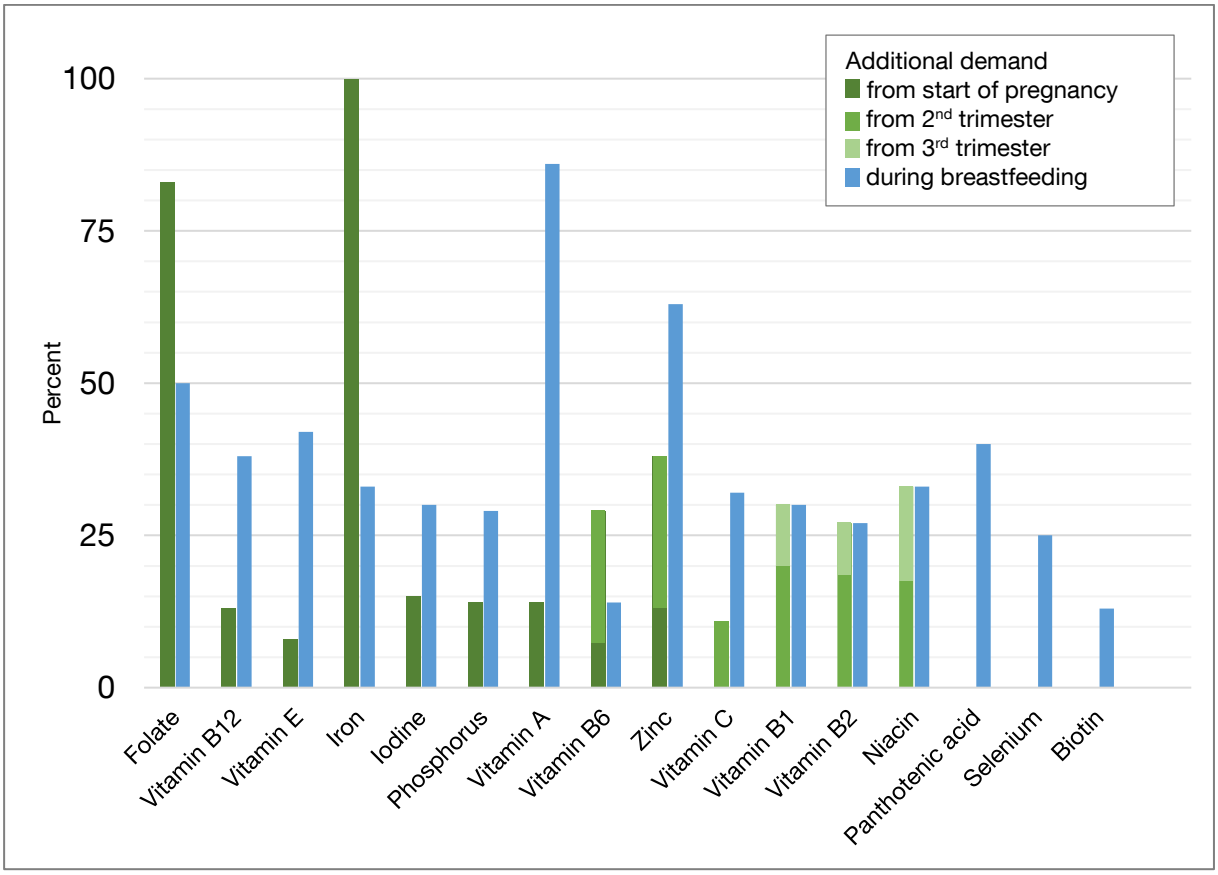


Figure 2 Additional demand of selected micronutrients for pregnant and breastfeeding women.
Expressed as a percentage of the reference value according to German Nutrition Society (DGE).
Data source: summarized from Koletzko et al. 2016; Koletzko et al. 2018; DGE 2021.

During the postpartum period, women should also follow a varied, balanced, and wholesome diet to cover the additional need for micronutrients (Figure 2). They should have regular meals to meet the increased energy needs of 500 kcal/day if exclusively breastfeeding for the first four to six months (Koletzko et al. 2016). Breastfeeding women should supplement 100 µg/day of iodine in addition to consuming iodine-containing foods to meet the reference value of 260 µg/day (Koletzko et al. 2016; DGE 2021). During the breastfeeding period, it is advisable to include sea fish in their diet twice a week. Otherwise, the required DHA reference intake (200 mg/day) should be ensured via supplements (Koletzko et al. 2016). DHA plays a vital role in the visual and neurological development of the child (Innis 2014). Breastfeeding women should hydrate regularly, as the fluid requirement due to milk production is higher. Alcohol consumption should be avoided, especially as long as the child is exclusively breastfed (Koletzko et al. 2016). Both smoking and passive smoking should be avoided by pregnant and breastfeeding women (Koletzko et al. 2016; Koletzko et al. 2018) (Table 2). There is no safe level or safe trimester for maternal smoking during pregnancy (Liu et al. 2020). Smoking and passive smoking during pregnancy and breastfeeding have been shown to have negative health effects, such as the increased risk of preterm birth, neurodevelopment and behavioral problems, fetal growth restriction, sudden infant death syndrome, impaired lung function, and obesity, amongst others (Banderali et al. 2015).

1.4.2 Physical activity recommendations

Pregnant, postpartum and breastfeeding women are recommended to follow the PA recommendations for the general adult population (Rütten and Pfeifer 2017). Women should engage in regular PA in their everyday life and limit sedentary behavior. Activities of moderate intensity should be practiced for at least 30 minutes on at least five days a week and combined with strength exercises twice weekly. The subjective marker for moderate intensity is either the 6–20 Borg scale (value should be between 12–14 for pregnant women), or the Talk Test, where there is no risk of overexertion if conversations are possible while exercising (Koletzko et al. 2016; Ferrari and Graf 2017; Koletzko et al. 2018). During pregnancy, strength training and exercises that use large muscle groups are recommended taking women's experience and training status into consideration. The focus should be to maintain fitness, not to increase performance. Women who were already physically active before pregnancy can be more intensively active compared to women who previously had a more sedentary lifestyle. Brisk walking, cycling, swimming/aquafitness, aerobics, and pregnancy yoga or pilates are examples of suitable sports activities during pregnancy. Sports with a risk of falling or injury (e.g., horse riding, fighting), contact sports or scuba diving are examples that should

be avoided (Ferrari and Graf 2017; Koletzko et al. 2018). After birth, resumption of sports activity should be gradual and assessed on an individual basis, depending on the stage of postpartum recovery, mode of labor and individual fitness. For the immediate time after delivery, brisk walking is suggested. From postpartum week six, pelvic floor exercises, and strength training of the large muscle groups are recommended, whereas high-impact sport and ballistic movements should be avoided. A return to sport is proposed between six and nine months after birth, with cycling, inline skating, walking, water sports and postnatal gymnastics as recommended activities (Koletzko et al. 2016; Ferrari and Graf 2017) (Table 2). The health benefits of PA during and after pregnancy are well established. PA during pregnancy is described to be associated with maternal cardiovascular and -metabolic benefits, decreased musculoskeletal discomfort and incidence of muscle cramps (Melzer et al. 2010; Aune et al. 2014). It leads to a reduced risk of EGWG, GDM, postpartum depression (Dipietro et al. 2019; Nakamura et al. 2019), and improved antenatal mental health (Evenson et al. 2019). Fetal benefits of maternal PA include a reduced risk for preterm birth, small for gestational age and LGA at birth, as well as infant's overweight and obesity in the long term (Chen et al. 2021). Women who are physically active during pregnancy are more likely to continue this postpartum. This leads to improved mental health and reduced anxiety, faster recovery, and weight reduction as well as enhanced cardiorespiratory fitness (Evenson et al. 2014). Furthermore, PA during the breastfeeding period has not been shown to affect breast milk volume and composition or infant growth (Evenson et al. 2014; ACOG 2020).

Table 2 Recommendations on a healthy maternal lifestyle.

	Recommendations for a healthy maternal lifestyle	
	during pregnancy	during postpartum period
Energy and nutrient intake	additional energy need: 10% in the last months of gestation	additional energy need: 500 kcal/day during exclusive breastfeeding
	balanced and varied diet according to the general recommendations for adults: regular meals rich in vegetables, fruits, whole grain products, moderate amounts of low-fat animal products, fatty fish, plant oils rich in essential fatty acids, limited intake of sweets, snacks	
	caffeinated beverages only moderately	
	avoidance of alcohol	avoidance of alcohol during breastfeeding
Dietary supplements	▪ 400 µg folic acid before pregnancy ▪ 100–150 µg iodine during pregnancy ▪ critical nutrients: DHA, iron, vitamin D	▪ 100 µg iodine during breastfeeding ▪ critical nutrient: DHA
Smoking	avoidance of (passive) smoking	avoidance of (passive) smoking during breastfeeding
Physical Activity	moderate intensity activity at least 30 minutes/week on most days of the week combined with strength exercises on two days per week reducing sedentary behavior	
	▪ low-impact PA ▪ aerobic endurance training and resistance training of the large muscle groups	▪ after delivery: walking ▪ >6th week pp: pelvic floor exercises, resistance training of the large muscle groups, non-ballistic PA ▪ 6–9 months pp: re-entry to sport
	examples of suitable sports activities	
	walking, swimming, low impact aerobics, cycling, pelvic floor exercise, aquafitness, pregnancy yoga, pilates, depending on experience/condition: setback games, moderate strength training, running	stretching, relaxation, breathing techniques, walking, gymnastics, for soft re-entry: cycling, inline skating, walking, sports in water, postnatal gymnastics
	examples for unsuitable sports activities	
	sports with a risk of injuries or falling (horse riding, mountain biking), team sports, contact sports, bodybuilding, weightlifting, extreme sports, excessive endurance exercise, scuba diving, ballistic movements, supine position (>16th week of gestation)	high-impact sport and ballistic movements

Abbreviations: DHA: docosahexaenoic acid; PA: physical activity; pp: postpartum.
Data source: summarized from Koletzko et al. 2016; Koletzko et al. 2018; Rütten and Pfeifer 2017; Ferrari and Graf 2017.

1.5 Research interest in antenatal lifestyle interventions

Despite the recommendations and evident health benefits of a health-promoting lifestyle during pregnancy, only a minority of pregnant women or those intending to become pregnant adhere to the suggested guidelines for lifestyle and nutrition requirements (Inskip et al. 2009; Caut et al. 2020). The intake of dietary supplements around pregnancy often occurs too late or not at all, while unnecessary nutrients are supplemented in excessive doses (Becker et al. 2011). Current evidence indicates that the majority of healthy pregnant women do not achieve the recommendations for PA, and their activity levels are inadequate to ensure the benefits of a healthy active lifestyle (Silva-Jose et al. 2022). Approximately 14% of pregnant women in Germany occasionally consume alcohol (Bergmann et al. 2007), while 10.9% smoke during their pregnancy (Kuntz et al. 2018). The prevalence of EGWG varies with about one in two women gaining excessive weight during pregnancy (Santos et al. 2018). Further, it has been shown that maintaining a healthy lifestyle after childbirth is challenging, and several studies have reported a decline in PA and the dietary quality postpartum (Faria-Schützer et al. 2018; Murray-Davis et al. 2019; Martin et al. 2020). The prevalence of suboptimal health behaviors, along with the substantial body of evidence supporting the preventive advantages of a healthy antenatal lifestyle and the acknowledged maternal motivation to embrace healthy habits (Phelan 2010), provides a justification for initiating lifestyle interventions during pregnancy.

1.5.1 Effect of antenatal lifestyle interventions on maternal weight gain

Antenatal lifestyle interventions aimed at limiting maternal weight gain and improving health outcomes are widespread. Their effects have been consolidated in systematic reviews and meta-analyses. The International Weight Management in Pregnancy Collaborative Group (i-WIP) conducted a meta-analysis using IPD from antenatal lifestyle intervention studies conducted between 1990 and 2017. This analysis, involving 36 randomized controlled trials (RCTs) with 12,526 women, found that diet and/or PA-based interventions had a modestly successful impact on reducing GWG, resulting in an average difference of -0.70 kg (95% confidence interval (CI) -0.92 to -0.48). This beneficial impact was consistently noted regardless of the maternal BMI, age, number of previous pregnancies, ethnic background, or pre-existing medical conditions. While no significant effects were observed on composite clinical outcomes for both mothers and offspring, there was a reduced likelihood of cesarean sections in the intervention groups (IG) (i-WIP Collaborative Group 2017). In a more recent systematic review and meta-analysis conducted by Teede et al. (2022), the authors aggregated the RCTs identified in the i-WIP study (2017) with RCTs from an updated search that considered papers published between 2017 and 2020. This extensive analysis covered

a total of 117 RCTs involving 34,546 women. The results suggested that antenatal lifestyle interventions incorporating structured diet and PA interventions were associated with decreased GWG (-1.15 kg, 95% CI -1.40 to -0.91), a reduced likelihood of GDM and fewer adverse maternal and neonatal outcomes compared to routine care. Notably, structured diet interventions seemed to have a greater effect on lowering GWG (-2.63 kg, 95% CI -3.87 to -1.40) than interventions involving only PA or combined PA and diet, when compared with routine care (Teede et al. 2022).

Numerous antenatal lifestyle intervention studies primarily focus on pregnant women with overweight or obesity, as reported in a meta-review of 15 systematic reviews. These findings indicated a reduction in GWG ranging from 0.3 to 2.4 kg with lifestyle interventions compared to standard care, although with limited certainty of evidence. There was some evidence that interventions focused solely on diet or solely on PA may reduce the risk of GDM (Fair and Soltani 2021). Two of the largest RCTs on antenatal lifestyle interventions specifically focus on women with overweight or obesity. In the UPBEAT trial, which involved 1,555 pregnant women with obesity, there was no improvement in the primary goal of reducing the incidence of GDM and LGA infants, but women in the IG experienced a 0.55 kg (95% CI -1.08 to -0.02) decrease in GWG (Poston et al. 2015). Conversely, the Australian LIMIT study, which included 2,212 pregnant women with overweight and obesity, did not show that interventions related to diet and PA resulted in a significant reduction in GWG (-0.04 kg, 95% CI -0.55 to 0.48) (Dodd et al. 2014b).

Several antenatal lifestyle interventions followed women during the postpartum period and reported data on PPWR. A comprehensive analysis of seven systematic reviews and meta-analyses revealed consistent evidence indicating a reduction in PPWR at various follow-up time points for women across different BMI categories who had undergone antenatal lifestyle interventions. The average between-group difference in PPWR ranged from -1.90 kg (95% CI -1.69 to -1.12) at six months to -0.68 kg (95% CI -1.28 to -0.09) at twelve months postpartum to. However, there was limited data available for distinct BMI subgroups (Hayes et al. 2021).

In summary, the results showed a modest yet statistically significant reduction in both GWG and PPWR following a lifestyle intervention during pregnancy, with some positive effects on other pregnancy outcomes. The findings support structured nutrition and PA interventions led by trained professionals (Teede et al. 2022). Elements like early intervention, supervised PA, personal counseling, weight monitoring, and predefined weight targets appear to contribute to the control of GWG and might be promising aspects for consideration (Farpour-Lambert et al. 2018). However, the most effective intervention components, the required frequency, delivery mode, behavioral strategies and level of supervision is difficult to identify due to the

pronounced methodological and statistical heterogeneity and have not been definitively established (Teede et al. 2022). The extent to which specific subgroups of women with diverse risk factors for EGWG can benefit from lifestyle interventions remains unexplored. Currently, there is no large-scale antenatal lifestyle intervention targeting women across different BMI categories.

1.5.2 Effect of antenatal lifestyle interventions on maternal health behaviors

While the weight-related changes resulting from behavioral interventions are unquestionably crucial in terms of clinical application, it is essential not to underestimate the importance of measuring health behaviors. This mechanistic perspective allows insight into behavioral factors that contribute to weight-related outcomes. A comprehensive analysis was conducted by Heslehurst et al. (2020) who assessed existing evidence from systematic reviews regarding the effectiveness of antenatal lifestyle interventions on pregnant women's behaviors related to smoking, alcohol, diet, and PA. Notably, identified studies primarily focused on the effect of antenatal interventions on health-related outcomes (e.g., GDM, weigh development, LGA infants), rather than thoroughly examining the impact on the targeted health behaviors. Therefore, out of 109 identified reviews, only 36 reviews reported relevant health behavior outcomes and were consequently included in the umbrella review. The most consistent findings were related to enhancing dietary behavior. Specifically, these interventions were shown to be effective in increasing fruit and vegetable consumption and reducing carbohydrate intake. Consistent evidence was lacking across reviews regarding improvements related to smoking cessation or PA behaviors (Heslehurst et al. 2020). Moreover, it does not appear that there exists any evidence for the efficacy of structured counseling on appropriate maternal dietary supplement intake around pregnancy. A systematic review by Currie et al (2013) examined antenatal interventions targeting PA behavior and found a reduction in the decline of PA throughout pregnancy. Interventions with regular face-to-face meetings seemed to be more likely to result in favorable changes in PA behavior, however, there was substantial heterogeneity in the duration, delivery, behavioral focus, and design of these interventions (Currie et al. 2013). Hence, the most effective intervention for PA is still unclear. To thoroughly comprehend how pregnancy can be used as a unique opportunity for behavioral change interventions, research efforts are required to measure changes in dietary and exercise behaviors. The positive effects of antenatal lifestyle interventions on PPWR suggest that a healthy antenatal lifestyle may help to maintain healthy lifestyle habits after birth. However, only few studies have investigated the long-term effects of antenatal lifestyle interventions on dietary and PA behavior in the postpartum period and

existing results were heterogeneous (Dodd et al. 2014a; Horan et al. 2014; Moran et al. 2017; Patel et al. 2017; Huvinen et al. 2018; O'Brien et al. 2019; Dalrymple et al. 2021a).

1.5.3 Antenatal lifestyle interventions within routine care setting

Despite some proof-of-concept RCTs, results from meta-analyses, and the urgent need to tackle the rising trend in maternal weight gain, no conclusive evidence to inform guidelines for effective implementation of antenatal lifestyle interventions into practice exists (Khomami et al. 2022). Notably, only a limited number of small RCTs have embedded lifestyle counseling under real-life conditions within routine antenatal care for managing appropriate GWG (Barroso et al. 2022). Up to this point, there has been no implementation at scale of antenatal lifestyle interventions aimed at preventing EGWG as a standard part of routine antenatal care. To close this gap, two lifestyle intervention trials were implemented within the German antenatal routine care setting with the primary aim of preventing EGWG according to the NAM recommendations. In the cluster-randomized **FeLIPO** (**Fe**asibility of a **l**ifestyle-**i**ntervention in **p**regnancy to **o**ptimize maternal weight development) pilot trial with 250 participants, women in the IG received two antenatal lifestyle counseling sessions, delivered by a dietician, alongside routine antenatal care. Women in the control group (CG) received the usual antenatal care. The intervention resulted in a noteworthy reduction in the percentage of IG women facing EGWG as compared to the CG (IG: 38.2% vs. CG: 59.5%; odds ratio 0.5, 95% CI 0.3 to 0.9). Furthermore, there was evidence of lower maternal weight retention at both four and twelve months postpartum as well as positive impacts on maternal energy intake and average PA levels (Rauh et al. 2013; Rauh et al. 2015). Following the promising results demonstrated by the FeLIPO trial, the subsequent large-scale **GeliS** (**Ge**sund **l**eben **i**n der **S**chwangerschaft/healthy living in pregnancy) trial was conducted across multiple districts in Bavaria, Germany, from 2013 to 2015. In total, 2,286 women were enrolled in the GeliS trail, where antenatal counseling was carried out by trained professionals in gynecological practices. However, the intervention did not result in a decreased proportion of IG women with EGWG. Indeed, 45.1% of women in the IG and 45.7% of women in the CG exceeded the NAM recommendations (Kunath et al. 2019). This thesis endeavors to elucidate the influence of the GeliS lifestyle intervention on different aspects of maternal health behaviors, and also involves the development of a screening questionnaire for EGWG. The specific research questions will comprehensively be elaborated in the subsequent chapter.

2 Aim of the thesis

The overall aim of this doctoral thesis is to examine the effectiveness of the GeliS lifestyle intervention trial beyond its primary outcome of reducing EGWG by investigating its influence on several maternal health behavior outcomes. In addition, this doctoral work used the extensive dataset from the GeliS cohort to identify risk factors for EGWG in order to develop and validate a practical screening tool.

The research questions of this thesis are addressed within four publications (chapters 4.1 to 4.4) with the following aims:

Publication I

Aim: to investigate the effect of the GeliS lifestyle intervention program on maternal PA behavior during pregnancy and to assess the influence of different PA intensities on GWG within the pooled GeliS cohort

Publication II

Aim: to investigate the sustained effect of the GeliS lifestyle intervention program on maternal health behaviors during the first year postpartum

Publication III

Aim: to investigate the effect of the GeliS lifestyle intervention program on dietary supplement intake behavior during and after pregnancy and to report on the dietary supplements taken by the pooled GeliS cohort before, during and after pregnancy

Publication IV

Aim: to identify early risk factors for EGWG from maternal anthropometric, sociodemographic, smoking, and mental health data using the pooled GeliS cohort to develop and validate a non-invasive screening questionnaire for identifying women at risk for EGWG at an early stage

Finally, the findings of this thesis will be discussed and used to draw conclusions from the GeliS concept, identify gaps, and derive suggestions for future lifestyle intervention approaches addressing maternal health and weight.

3 Materials and methods

The following section briefly summarizes the most important aspects of the research methods applied in this thesis. A detailed description of the methodological approach can be found in the study protocol (Rauh et al. 2014) and corresponding publications related to this thesis (Hoffmann et al. 2019b; Geyer et al. 2021; Geyer et al. 2022; Geyer et al. 2023).

3.1 Design and setting of the GeliS trial

The GeliS trial is a large-scale, prospective, cluster-randomized, controlled, open intervention trial that was conducted in five administrative regions of Bavaria, a federal state in the southeast of Germany. Within each region, a pairwise cluster-randomization was performed to randomly match one intervention and one control district per region according to similar birth rates, socio-demographic and geographic criteria. In the intervention and control districts, gynecologists and midwifery practices were recruited for participation, as the study was conducted as a public health project alongside routine antenatal care visit. The study practices were supervised for each region by an expert center for nutrition headed by the Bavarian State Ministry of Food, Agriculture and Forestry. The study was conducted in conformity with local regulatory requirements and laws as well as the declaration of Helsinki. The study protocol was approved by the Ethics Committee of the Faculty of Medicine at the Technical University of Munich (project number 5653/13) and retrospectively registered in the ClinicalTrials.gov Protocol Registration System (NCT01958307). The study protocol has published details on the study design, setting and cluster-randomization (Rauh et al. 2014). The primary aim was to decrease the proportion of women who gained excessive weight during pregnancy as defined by the NAM (Rasmussen and Yaktine 2009) through a comprehensive lifestyle intervention program. The effect of the GeliS intervention on EGWG and pregnancy outcomes (Kunath et al. 2019) as well as on various secondary endpoints, such as maternal dietary behavior during pregnancy (Günther et al. 2019a), maternal postpartum weight loss and breastfeeding behavior (Hoffmann et al. 2019c) and weight development of the children up to the third year of life (Hoffmann et al. 2021; Spies et al. 2022) have already been published. In addition, the comprehensive dataset enabled the investigation of several research questions in the pooled GeliS cohort. For instance, the association of antenatal maternal lifestyle and neonatal outcomes was examined (Günther et al. 2019b; Hoffmann et al. 2019a), the antibiotic treatments during pregnancy until six months postpartum were evaluated (Knoke et al. 2023), as well as factors influencing the occurrence

of preterm birth (Raab et al. 2022b), GDM (Günther et al. 2022), and postpartum depression (Johar et al. 2020) were investigated.

3.2 Study participants

The medical personnel in 71 participating practices were responsible for recruiting the participants. Between July 2013 and December 2015, 2,286 pregnant women were recruited for study participation (Rauh et al. 2014; Kunath et al. 2019). Women enrolled in practices in the control districts formed the CG, and women enrolled in practices in the intervention districts formed the IG. In a screening visit (≤12th week of gestation, visit 0), all pregnant women, irrespective of group allocation, provided basic information on sociodemographic and anthropometric data in a screening questionnaire. Based on this information, the inclusion and exclusion criteria for study participation were checked. The following criteria had to be fulfilled for inclusion in the study: singleton pregnancy before the end of the 12th week of gestation, pre-pregnancy BMI ≥18.5 kg/m^2 and ≤40.0 kg/m^2, age between 18 and 43 years, and sufficient knowledge of the German language. Women were excluded in case of multiple or high-risk pregnancies, pre-pregnancy diabetes mellitus or early GDM, uncontrolled metabolic diseases and psychiatric or psychosomatic disorders, or any other severe illness or complication that might interfere with compliance with the study protocol. Before study enrolment, women were obliged to give written informed consent (Rauh et al. 2014). While participants in the CG received routine antenatal care as well as flyers and brochures with brief and general recommendations on a healthy antenatal lifestyle, participants in the IG obtained a comprehensive lifestyle intervention program (Rauh et al. 2014).

3.3 The GeliS lifestyle intervention program

Within the intervention districts, gynecologists, medical personnel, and midwives delivered the lifestyle intervention program to participating women during routine antenatal care visits. Prior to the onset of the intervention, the participating medical staff attended a two-day training seminar to learn how to deliver the intervention in a standardized way according to the pre-defined curriculum (Rauh et al. 2014). The lifestyle intervention program encompassed three individually scheduled, face-to-face counseling sessions during pregnancy (12th–16th, 16th–20th, 30th–34th week of gestation), and one counseling session after delivery (6th–8th week postpartum). Figure 3 depicts the study scheme of the GeliS trial with the screening visit, the lifestyle counseling sessions, the examinations as well as information about the data collection that was carried out for both groups as part of the routine antenatal care visits (Rauh et al. 2014).

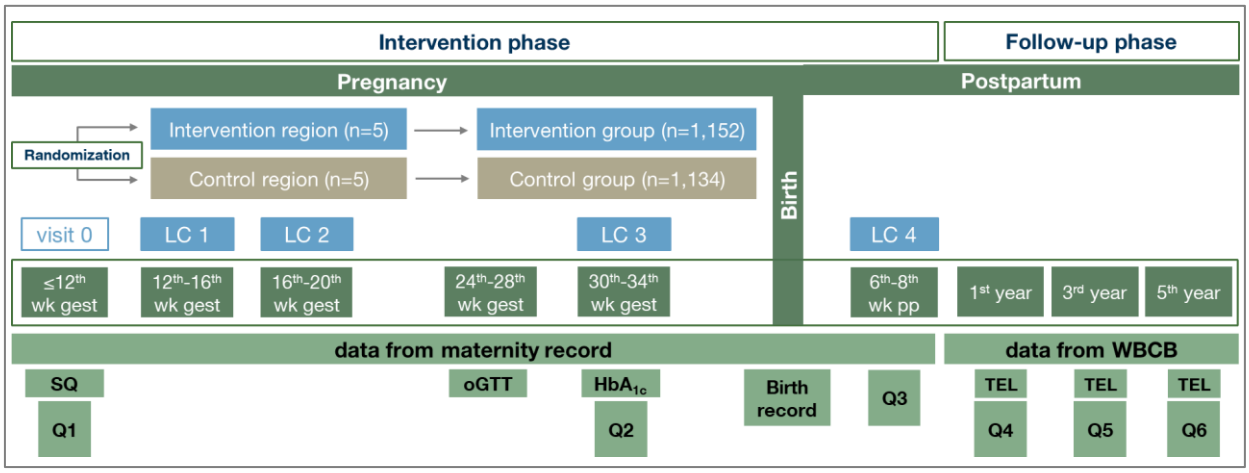


Figure 3 Study scheme of the GeliS trial.
Abbreviations: visit 0: screening visit; LC: lifestyle counseling session; wk gest: week of gestation; wk pp: weeks postpartum; SQ: screening questionnaire; Q: questionnaire set; OGTT: oral glucose tolerance test; HbA_{1c}: glycosylated hemoglobin A_{1c}; WBCB: well-baby check-up booklet; TEL: telephone interview.
Data source: adapted from both the GeliS study protocol (Rauh et al. 2014) and a figure previously developed and used by the GeliS study team.

The counseling sessions covered topics about the principles of a healthy diet and adequate dietary supplement intake during pregnancy and lactation. Details on the topics of the lifestyle counseling sessions have been published in the study protocol (Rauh et al. 2014). Women were informed about the increased need for certain micronutrients with an emphasis on the importance and adequate supplementation of iodine and folic acid. Iron supplements were to be taken only if a deficiency had been diagnosed. Furthermore, the risk of smoking and alcohol intake during pregnancy and breastfeeding was addressed. Women were informed about the recommendations of adequate antenatal PA and were encouraged to engage in PA for at least 150 minutes of moderate intensity per week as well as to decrease daily inactivity. In all counseling sessions, women were advised about adequate weight gain during pregnancy according to the NAM recommendations (Rasmussen and Yaktine 2009). Weight gain charts displaying gestational weight development were provided to self-monitor weight. Table 3 gives details about the curriculum of the lifestyle counseling program. Standardized presentation boards, teaching kits and brochures were used for communicating the counseling content based on the recommendations of the nationwide network “Healthy Start - Young Family Network” (Koletzko et al. 2012), a project of IN FORM, subsidized by the German Federal Ministry of Food and Agriculture. Participants of both the IG and CG were offered the opportunity to be screened for GDM between the 24th and 28th week of gestation using a two hours 75 g oral glucose tolerance test (OGTT). Participants’ blood was drawn during the third session to measure glycosylated hemoglobin A_{1c} (HbA_{1c}) (Rauh et al. 2014).

Table 3 Curriculum of the GeliS counseling sessions.

Counseling session	Content
LC1 12th–16th week of gestation	▪ information on a healthy lifestyle: the principle of a healthy diet and adequate PA during pregnancy ▪ critical nutrients ▪ risk of alcohol intake, smoking, and foodborne infections ▪ GWG and weight monitoring ▪ **specifics**: brochures of a balanced diet, list of antenatal PA programs, weight gain chart for self-monitoring weight development
LC2 16th–20th week of gestation	▪ individual dietary and PA habits ▪ **specifics**: invitation to participate in a standardized 2-hour OGTT between the 24th and 28th week of pregnancy
LC3 30th–34th week of gestation	▪ reinforcing of previous contents on healthy lifestyle during pregnancy ▪ emphasis on weight monitoring ▪ information on antenatal maternity courses and postnatal PA classes ▪ information on specific problems, e.g., water retention, back complaints ▪ importance of breastfeeding ▪ **specifics:** blood sampling for measuring HbA_{1c}
LC4 6th–8th week postpartum	▪ healthy diet during breastfeeding ▪ infant feeding principles ▪ breastfeeding recommendations

Abbreviations: LC: lifestyle counseling session; PA: physical activity; GWG: gestational weight gain; OGTT: oral glucose tolerance test; HbA_{1c}: glycosylated hemoglobin A_{1c}.
Data source: based on the GeliS study protocol (Rauh et al. 2014).

3.4 The GeliS follow-up observation program

After the last counseling session (6th–8th week postpartum), mother-child pairs of the IG and CG were followed-up until five years after birth (Figure 3) (Rauh et al. 2014). Women in both groups were contacted at one, three and five years after birth. Using paper-based questionnaire sets sent via post, information on maternal health and lifestyle, breastfeeding behavior, and infant feeding practices, as well as neurodevelopment and lifestyle of the children were collected. Data on children's anthropometric development and health status, derived from the well-baby check-up booklet (WBCB), which is collected as part of routine pediatric care, were obtained through telephone interviews conducted by the GeliS study team. Regarding lifestyle data, the focus at the first follow-up was on the mothers, while at the second and third follow-up, the focus was on the children.

3.5 Data collection and processing

The collection and processing of the data analyses of this thesis are outlined in the following. Details are described in the corresponding publications (Hoffmann et al. 2019b; Geyer et al. 2021; Geyer et al. 2022; Geyer et al. 2023).

Maternal baseline characteristics and weight during pregnancy

At study entry (visit 0), maternal anthropometric, demographic, and socioeconomic characteristics, such as age, height, pre-pregnancy weight, educational level, employment status, country of birth and number of previous births were collected using the screening questionnaire (SQ) (Appendix 1). The pre-pregnancy BMI was calculated based on self-reported pre-pregnancy weight and height. Women's weight during pregnancy was measured at routine antenatal care visits by medical staff and entered in the maternity record. Based on these data, GWG was calculated as the difference between maternal weight measured at the last and the first routine antenatal visit.

Data on maternal health

In a set of self-reported, paper-based questionnaires, maternal PA, dietary and smoking behaviors in early pregnancy (T0, ≤12th week of gestation, corresponds to baseline) and late pregnancy (T1, >29th week of gestation), as well as 6–8 weeks postpartum (T1pp) and one year postpartum (T2pp) were assessed. Dietary supplement intake behavior was evaluated at T0, T1 and T1pp. Maternal mental health status in terms of anxiety and depression was assessed at T0 and T1.

The validated Pregnancy Physical Activity Questionnaire (PPAQ) (Chasan-Taber et al. 2004), slightly modified to German habits (Appendix 2), was used to investigate the duration, frequency, and intensity of **maternal PA behavior** during pregnancy (T0, T1) and after birth (T1pp, T2pp). Using 32 questions, women were asked to estimate the average time engaging in various activities over the last four weeks (depending on the question: 0–6 or more h/day; 0–3 or more h/week). In two open-ended questions, women had the option to indicate additional sports activities that were not covered by previous questions (Chasan-Taber et al. 2004). The estimated hours engaged in each activity were multiplied by its intensity, defined by the metabolic equivalent of task (MET), and expressed as the average energy expenditure per week (MET-h/week) for each activity. The MET values of the 32 activities were derived from the calculation sheet of the PPAQ (DAPA Measurement Toolkit 2004). The 2011 Compendium of PA was used to assign MET values to the activities entered in the open-ended text field (Ainsworth et al. 2011). The sum of the average weekly energy expenditure in MET-h/week allowed both to estimate total PA and total activity of light intensity and above

(TALIA), and to group activities according to PA types (household/caregiving, occupational, sports/exercise, transportation, inactivity) and intensities (sedentary, light, moderate, vigorous) (DAPA Measurement Toolkit 2004). The PPAQ evaluations allowed us to determine whether the women adhered to national and international recommendations for PA (Rütten and Pfeifer 2017; ACOG 2020). A threshold of ≥7.5 MET-h/week in the category of sports activities of moderate intensity and above was set as meeting these recommendations (personal communication: Prof. L. Chasan-Taber, University of Massachusetts Amherst, 2018). As done by others (Dodd et al. 2014a), participants were excluded from PA analysis due to over-reporting if the sum of reported hours per week exceeded the total sum of hours in a week, and if the reported hours of occupational activity were more than 12 hours per day for seven days per week.

A slightly modified version of a validated food frequency questionnaire (FFQ) was used to assess **maternal dietary behavior** in the postpartum period at T1pp and T2pp (Appendix 3). The FFQ was originally developed for the "German Health Interview and Examination Survey for Adults" (DEGS)-study conducted by the Robert Koch-Institute, Berlin, Germany (Haftenberger et al. 2010). Women were questioned on their dietary behavior over the previous four weeks, such as the consumption frequency and portion sizes of 54 food items. The consumption frequency was assessed with the help of 11 different categories ranging from "never" to "more than five times per day". Portion sizes were asked for in standard household measurements, such as plates, bowls, cups, glasses, spoons, and pieces. In addition, four questions asked for information on food preparation, dietary choices, vegetarianism, and frequency of fresh food preparation. The evaluation of the average daily intake was done according to the scheme that the developers of the FFQ provided (personal communication: Dr. G. Mensink, Robert Koch-Institute, 2018) and has been previously used for dietary data analysis during pregnancy (Günther et al. 2019a). The food items were grouped into 17 different food groups. Participants were excluded from the analysis if over-reporting of food intake was assumed (liquids >15 kg, solid foods >10 kg, or liquids >4 kg and solid foods >6 kg) or if more than 20 out of 54 food items were not answered. Based on the German food composition database ("Bundeslebensmittelschlüssel") energy, macronutrient, and fibre intake were calculated using the OptiDiet PLUS software (version 6.0, GOE mbH, Linden, Germany). For questions of the FFQ that referred to more than one food item, a reference intake pattern derived from the German National Consumption Survey II was used to estimate energy and macronutrient intake (personal communication: Max Rubner-Institute, Federal Research Institute of Nutrition and Food, 2018). Participants who over- or underreported energy intake (>20,000 kJ or <4,500 kJ, respectively) were not

included in the analysis, as described previously (Günther et al. 2019a). The dietary quality was calculated using the DEGS-Healthy Eating Index (HEI) based on the DEGS-FFQ and developed by the Robert Koch-Institute (Kuhn). The HEI is based on the intake of 14 food groups. For each food group, a score value between 0 and 100 was computed based on compliance with the recommendations of the DGE. A combined HEI score was calculated from 0 to 100 from the mean score values. Higher score values represent better adherence to the DGE recommendations and thus higher dietary quality (Kuhn).

At four time points (T0, T1, T1pp, T2pp), **maternal smoking behavior** was assessed with the question "Do you currently smoke?". The available response options were "yes, regularly", "yes, occasionally (<1 cigarette per day)", "no, not anymore" and "never smoked" (Appendix 3, question 59).

At T0, T1 and T1pp, **maternal dietary supplement intake behavior** was assessed. An open text field asked for the name and manufacturer of the supplemented product. For the analyses of dietary supplement intake behavior, the entered data were considered that were supplements according to the German Food Supplements Regulation (NemV) from the Federal Ministry of Justice and Consumer Protection (2004) and the Directive 2002/46/EC103 of The European Parliament and the Council (2002). Information on prescription medication, pharmacy-only products, homoeopathic products, or pharmaceuticals were excluded from analyses. The exact period and frequency of the respective supplement intake were requested by predefined response options and can be found in the attached questionnaires (Appendix 4 and 5). Using the product name, the composition of micronutrients as well as the recommended dosage instruction were identified. To calculate the daily intake of the micronutrients, the amount of identified micronutrients according to the recommended dosage instruction was multiplied by the frequency of intake entered in the questionnaire.

The first two questions of the Patient Health Questionnaire (PHQ)-4, a short screening scale for anxiety and depression (Kroenke et al. 2009), were used to assess signs of **maternal depressive disorder** in early pregnancy. Thereby, a PHQ-2 score of at least three points suggested depressive symptoms (Kroenke et al. 2003).

3.6 Statistical analysis

The sample size was calculated based on the primary endpoint of the GeliS study which has been described in detail in the study protocol (Rauh et al. 2014). During the intervention phase, participants were defined as dropouts in case of miscarriage, late loss of pregnancy, termination, pregnancy complications that interfered with the intervention, maternal death, or the decline of further study participation or change of residence. During the follow-up period,

women were considered dropouts if they were no longer reachable, declined further study participation or did not provide contact information (Hoffmann et al. 2019c).
A comprehensive overview of the statistical analyses applied in the respective publications to answer the research questions of this thesis are presented in Table 4 and explained in the following sections.

3.6.1 Analysis of maternal health behavior

For antenatal PA analyses, all participants excluding those who dropped out before delivery were considered, with available data on PA at T0 and/or T1. Participants were excluded from specific analyses of intensities and types if one or more answers were missing in the corresponding category. For the pooled cohort analysis to examine the influence of different PA intensities on GWG, all participants with available data on GWG except those with a preterm delivery were included. For the analyses of the PA and dietary behavior in the first year postpartum, all participants, excluding those who dropped out in the follow-up phase, who had available data on diet and/or PA at T1pp and/or T2pp and were not pregnant again at T2pp were included. For the analysis of smoking behavior, the same criteria were applied, and the women had to provide information on their smoking behavior. Similar to the analysis during pregnancy, women were excluded from specific postpartum PA analyses if at least one answer was missing in the respective category. For the analyses of the dietary supplement intake behavior, all participants without those who dropped out during the intervention phase, with available data on at least one of the three questionnaires on dietary supplementation were considered. Participants were excluded from specific analyses, such as the daily intake of micronutrients if the necessary information was missing.
Linear or binary logistic regression models were used to estimate differences between the IG and the CG. As recommended for cluster-randomized trials (Donner and Klar 2000), the regression models were fit with generalized estimating equations (GEE). In exploratory analyses, selected health behavior variables were also analyzed by subgroup, such as pre-pregnancy BMI category, age, educational level, and parity. Group differences were presented as estimated mean differences or odds ratios with a 95% CI. Linear mixed models for repeated measures were applied to assess changes in antenatal PA between T0 and T1, as well as changes in PA and dietary behavior between T1pp and T2pp. In the pooled cohort (combining IG and CG to one cohort), association analyses of PA intensity on GWG as well as association analyses of maternal demographic and socioeconomic factors on the general intake of dietary supplements were analyzed using generalized linear and logistic regression models. For this, the group assignment was included as an additional adjustment factor. The

analyses were carried out using SPSS software (IBM SPSS Statistics for Windows, version 24.0 and 26.0, IBM Corp, Armonk, NY, USA) and *p* values <0.05 were defined as statistically significant. More information on the applied statistical analyses can be found in the corresponding publications (Hoffmann et al. 2019b; Geyer et al. 2021; Geyer et al. 2022).

3.6.2 Analysis of the risk score model for excessive gestational weight gain

For the pooled cohort analysis of the risk score model to develop and validate a screening questionnaire for EGWG, all participants with available data on GWG were included, except those who dropped out before delivery, who had a preterm delivery, or missing data on included variables. Potential risk factors of EGWG before the 12th week of gestation were designated a priori based on the evidence found in the literature concerning the assumed relationship to sociodemographic, anthropometrics, smoking behavior, mental health status (Hartley et al. 2015; Samura et al. 2016; Zhou et al. 2022). Finally, the following categorical variables were considered in statistical models:

- pre-pregnancy BMI category (BMI 18.5–24.9 kg/m^2 vs. BMI 25.0–29.9 kg/m^2 vs. BMI 30.0–40.0 kg/m^2)
- pre-pregnancy age (18–25 years vs. 26–35 years vs. 36–43 years)
- educational level (not (yet) graduated from school/general secondary school vs. intermediate secondary school vs. high school)
- country of birth (Germany vs. foreign country)
- parity (primiparous vs. multiparous)
- smoking status (never smoker vs. current and/or former smoker)
- signs of depressive disorder (PHQ-2 score ≥3 vs. PHQ-2 score <3)
- full-time employed (yes vs. no)

The GeliS data were randomly split into a development and validation dataset with a ratio of 80:20. Using the development dataset (80% of the data), a multivariate logistic regression model with stepwise backward elimination and considering the Akaike information criterion was run to identify a reduced set of risk factors most predictive of EGWG. These factors were used to develop a screening questionnaire based on the scoring system by Sullivan et al. (2004). The risk score was validated by internal cross-validation (20% of the data) and externally with the cohort data from the FeLIPO pilot study. Data for independent variables were accessible for all 250 FeLIPO participants and were included in the external validation analysis, despite the absence of data related to the dependent variable GWG in 25 participants. The definitions and measurements of anthropometric, sociodemographic, and lifestyle data in the FeLIPO study were largely similar to those in the GeliS dataset. However,

no data on maternal mental health was collected. Minor modifications were made to harmonize the FeLIPO variables with the GeliS variables. This involved condensing educational level categories from four to three by merging the “high school/grammar school” and “university degree” categories from the raw dataset. Additionally, the FeLIPO variable GWG was recalculated instead of the self-reported weight before pregnancy, women’s measured weight at the study’s entry and the last antenatal visit before delivery was used to calculate GWG. A detailed description of the FeLIPO trial and its result can be found elsewhere (Rauh et al. 2013; Rauh et al. 2015).

The area under the receiver operating characteristic (AUROC) curve was used to assess the discriminatory power of the risk score model. The analyses were performed with SPSS software (IBM SPSS Statistics for Windows, version 26.0, IBM Corp, Armonk, NY, USA) and RStudio software (RStudio Inc., version 4.0.3, Boston, MA, USA). Descriptive statistics were stratified based on the presence or absence of EGWG. Statistical differences between women with and without EGWG were assessed using the χ^2 test for categorical variables and the Kruskal-Wallis test for continuous variables. In all analyses, group assignment was included as an adjustment factor. A p value <0.05 was considered statistically significant. Details of the statistical approach have recently been published and are provided in the respective publication (Geyer et al. 2023).

Table 4 Overview of statistical analyses.

	Time point	Participant set	Outcome	Statistical model	Covariates
Intervention effect: analysis of maternal health behavior					
Physical activity	T0 T1	all women except those ▪ who dropped out before delivery ▪ no data T0 and T1	intervention effect: continuous, dichotomized variables	linear and binary logistic regression models fit with GEE	pre-preg. BMI category, age, parity, baseline PA (T0)
			time effects (T0 and T1)	linear mixed models for repeated measures	pre-preg. BMI category, age, parity
		all women except those ▪ who dropped out before delivery ▪ with a preterm delivery ▪ no data on gestational weight gain	pooled cohort: PA intensities on total gestational weight gain	generalized linear regression model	pre-preg. BMI category, age, parity, group assignment
Physical activity	T1pp T2pp	all women except those ▪ who dropped out in the follow-up phase ▪ no data on diet and PA at T1pp and T2pp ▪ pregnant again at T2pp	intervention effect: continuous, dichotomized variables	linear and binary logistic regression models fit with GEE	pre-preg. BMI category, age, parity, baseline dietary or PA assessment (T0), time interval between questionnaire completion date and birth date
Diet	T1pp T2pp		time effects (T1pp and T2pp)	linear mixed models for repeated measures	pre-preg. BMI category, age, parity
Smoking	T0 T1 T1pp T2pp	all women except those ▪ who dropped out in the follow-up phase ▪ no data on diet and PA at T1pp and T2pp ▪ pregnant again at T2pp ▪ no smoking data	intervention effect: dichotomized variables	binary logistic regression models fit with GEE	T0: pre-preg. BMI category, age, parity T1: T0 + baseline smoking assessment T1pp/T2pp: T1 + time interval between questionnaire completion date and birth date
Dietary supplements	T0 T1 T1pp	all women except those ▪ who dropped out in the intervention phase ▪ no dietary supplementation data	intervention effect: dichotomized variables	logistic regression models fit with GEE	pre-preg. BMI category, age, parity, educational level
			pooled cohort: influencing factors on dietary supplement intake	generalized logistic regression model	pre-preg. BMI category, age, parity, educational level, group assignment
Pooled cohort: analysis of the risk score model for EGWG					
Risk score model		all women except those ▪ who dropped out before delivery ▪ with a preterm delivery ▪ missing data for gestational weight gain, and all included variables	salient risk factors for EGWG ▪ sociodemographics (T0) ▪ anthropometrics (T0) ▪ smoking behavior (T0) ▪ mental health status (T0)	multivariate logistic regression with stepwise backward elimination (80% of data); ROC-statistics: cross-validation (20% of data), external validation	group assignment

Publication I Publication II Publication III Publication IV

Abbreviations: T0: ≤12th week of gestation; T1: 30th–34th week of gestation; T1pp: 6th–8th week postpartum, T2pp: one year postpartum; PA: physical activity; GEE: generalized estimating equations; pre-preg: pre-pregnancy; BMI: body mass index; EGWG: excessive gestational weight gain; ROC: receiver operating characteristic.

4 Results

In the following, the results of the corresponding publications considered in this thesis are briefly summarized, including the effect of the GeliS lifestyle intervention on maternal PA behavior during pregnancy (Hoffmann et al. 2019b), the sustained effect beyond the intervention phase on maternal health behavior during the first year postpartum (Geyer et al. 2021), followed by the effect on maternal dietary supplement intake, which is additionally analyzed in a cohort approach (Geyer et al. 2022). Finally, results of the publication on the development of a validated screening questionnaire for EGWG using a cohort approach are presented (Geyer et al. 2023)

4.1 Publication I: Effect of the GeliS lifestyle intervention on physical activity during pregnancy

Title: Effects of a lifestyle intervention in routine care on prenatal physical activity – findings from the cluster-randomised GeliS trial

Authors: Julia Hoffmann*, Julia Günther*, **Kristina Geyer**, Lynne Stecher, Kathrin Rauh, Julia Kunath, Dorothy Meyer, Christina Sitzberger, Monika Spies, Eva Rosenfeld, Luzia Kick, Renate Oberhoffer and Hans Hauner; *authors share first authorship.

Access: BMC Pregnancy and Childbirth 19, 414 (2019); open access article available from: https://doi.org/10.1186/s12884-019-2553-7.

Summary of findings: Of the original 2,286 women who participated in the cluster-randomized GeliS study, 2,101 women provided PA data.
At T1, a significant group difference in total PA (adjusted (adj.) effect size 6.00 MET-h/week, 95% CI 4.93 to 7.07 MET-h/week; $p<0.001$) as well as in TALIA (adj. effect size 6.78 MET-h/week, 95% CI 5.64 to 7.93 MET-h/week; $p<0.001$) was observed. The level of moderate-intensity activity (adj. effect size 2.39 MET-h/week, 95% CI 0.31 to 4.48 MET-h/week; $p=0.024$), vigorous-intensity activity (adj. effect size 0.32 MET-h/week, 95% CI 0.12 to 0.51 MET-h/week; $p=0.002$) and the level of sports activity (adj. effect size 1.88 MET-h/week, 95% CI 0.95 to 2.81 MET-h/week; $p<0.001$) differed significantly between groups. At T0, 50.0% of the IG and 44.4% of the CG met PA recommendations. At T1, the respective proportions were 63.6% and 49.2% yielding evidence of a between-group difference in meeting PA recommendations (adj. $p<0.001$). Irrespective of group allocation, a significant increase in mean MET-h/week in the level of sedentary activity (IG: adj. $p=0.001$; CG: adj. $p<0.001$) and inactivity (both groups, adj. $p<0.001$) throughout pregnancy were observed while most other

types and intensities of PA levels decreased. In addition, the mean MET-h/week in sports activity of women in the IG increased from T0 to T1 (adj. $p<0.001$), whereas the level of women in the CG remained constant (adj. $p=0.305$). In late pregnancy, TALIA (adj. $p<0.006$), light-intensity activity (adj. $p=0.002$) and vigorous-intensity activity (adj. $p=0.014$) were found to be significantly negatively associated with total GWG.

In conclusion, the GeliS lifestyle intervention, which provided basic PA advice and was conducted alongside routine antenatal care, had positive effects on the antenatal PA of women in the IG. Women adhered more often to the recommendations for antenatal PA. In late pregnancy, PA intensities were significantly negatively associated with total GWG.

Personal contribution: Kristina Geyer was involved in data processing, evaluation, and statistical analysis. Furthermore, **Kristina Geyer** was involved in writing the manuscript. Finally, **Kristina Geyer** revised the manuscript and commented on the publication as a co-author.

4.2 Publication II: Effect of the GeliS lifestyle intervention on maternal health behavior during the first year postpartum

Title: Effects of a prenatal lifestyle intervention in routine care on maternal health behaviour in the first year postpartum – secondary findings of the cluster-randomised GeliS trial

Authors: Kristina Geyer*, Monika Spies*, Julia Günther, Julia Hoffmann, Roxana Raab, Dorothy Meyer, Kathrin Rauh, Hans Hauner; *authors share first authorship.

Access: Nutrients 13, 1310 (2021); open access article available from: https://doi.org/10.3390/nu13041310.

Summary of findings: Data on health behavior at 6–8 weeks postpartum and/or one year postpartum were available from 1,899 women of the originally recruited 2,286 participants of the GeliS study.

The mean daily intake of soft drinks (T1pp: adj. effect size -72.44 ml/day, 95% CI -107.00 to -37.88 ml/day, $p<0.001$) and fast food (T1pp: adj. effect size -2.25 g/day, 95% CI -4.08 to -0.42 g/day, $p=0.016$; T2pp: adj. effect size -4.09 g/day, 95% CI -5.36 to -2.82 g/day, $p<0.001$) was lower among women in the IG compared to the CG. Lifestyle counseling induced a higher consumption of vegetables (T2pp: adj. effect size 17.90 g/day, 95% CI 3.53 to 32.27 g/day, $p=0.015$). Moreover, women in the IG were more likely to use rapeseed oil and olive oil than other oils for preparing meat and fish (T1pp: adj. $p=0.004$; T2pp: adj. $p=0.011$) and vegetables (T1pp: adj. $p=0.012$). Energy intake and macronutrient composition did not differ between groups. The diet quality assessed by the DEGS-HEI tended to differ

between groups at T1pp (adj. p=0.093) and significantly differed at T2pp (adj. p=0.043). In both groups, the mean energy intake decreased over the postpartum period (both groups, adj. p<0.001), while the dietary quality increased (adj. p<0.001). In congruence with this, the consumption of sweets and snacks declined (both groups, adj. p<0.001) and more vegetables were consumed (both groups adj. p<0.001). At T1pp, women in the IG had a lower total PA (adj. effect size -3.59 MET-h/week, 95% CI -6.69 to -0.50 MET-h/week; p=0.023). The increase in total PA in IG (adj. p<0.001), but not in CG (adj. p=0.061) led to similar total PA levels of both groups at T2pp. Women in IG showed significantly higher levels of occupational activity at T1pp (adj. effect size 8.09 MET-h/week, 95% CI 1.51 to 14.67 MET-h/week, p=0.016). There was no evidence for a difference between groups in PA types and intensities except for a trend for a higher proportion of women in the IG meeting PA recommendations at T1pp (IG: 52.7%, CG: 46.7%, adj. p=0.060). In both groups, the mean MET-h/week in sedentary activities and inactivity decreased significantly during the postpartum period (both groups, adj. p<0.001), while in most other categories the activity levels increased. The proportion of current smokers in early pregnancy was comparable in both groups (IG: 5.0%, CG: 5.0%). Throughout pregnancy, the intervention resulted in a reduction in the rate of current smokers in late pregnancy (IG: 3.8%, CG: 5.1%, adj. p<0.001). Despite an increased smoking rate in both groups in the postpartum period, there was significant evidence of a sustained intervention effect on smoking behavior at both postpartum time points (T1pp: IG: 7.1%, CG: 9.7%, adj. p<0.001; T2pp: IG: 13.1%, CG: 14.1%, adj. p<0.001).
In conclusion, the GeliS lifestyle intervention was modestly effective in modifying maternal dietary behavior and smoking behavior during the postpartum period beyond the intervention phase. However, no sustainable effect on maternal PA behavior could be achieved.

Personal contribution: Kristina Geyer, together with the other first author, designed the research question for the article, was responsible for data processing and statistical analyses, interpreted the data, prepared tables and figures and wrote the manuscript. Regarding the contribution on data processing and statistical analysis, the focus of **Kristina Geyer** was on the PA data and the focus of the other first author was on the dietary and smoking data.

4.3 Publication III: Dietary supplement intake before, during and after pregnancy in the randomization groups and GeliS cohort

Title: Dietary supplement intake before, during and after pregnancy: results of the cluster-randomized GeliS study

Authors: Kristina Geyer, Julia Günther, Julia Hoffmann, Monika Spies, Roxana Raab, Ana Zhelyazkova, Inga Rose, Hans Hauner

Access: Geburtshilfe und Frauenheilkunde 82, 07 (2022); open access article available from: doi 10.1055/a-1771-6368.

Summary of findings: Among the 2,286 enrolled participants, 2,099 provided information on their dietary supplement intake behavior.

Around pregnancy, 64.0% of women in the IG and 63.7% of women in the CG took dietary supplements (adj. p=0.840). Before pregnancy, folic acid was supplemented by 31.1% of women in the IG and 31.4% in the CG (adj. p=0.414). During pregnancy, about half of the women supplemented folic acid (IG: 54.1%, CG: 52.0%, adj. p=0.416) and iodine (IG: 50.2%, CG: 48.2%, adj. p=0.660). In the postpartum period, supplementation rates of folic acid (IG: 11.8%, CG: 22.0%, adj. p=0.213) and iodine (IG: 12.1%, CG: 24.0%, adj. p=0.151) decreased. No statistically significant evidence of a group difference either before study inclusion or during the intervention, neither in the general intake of supplements nor the supplementation of folic acid, iodine, iron, DHA, or vitamin D was observed. Irrespective of group allocation, a total of 467 different dietary supplements containing a total of 24 various micronutrients were used. During pregnancy, iron and DHA were supplemented by 21.8% and 23.0% of women, respectively. The proportion of women who additionally took Vitamin D and B_{12} was 49.4% and 50.5%, respectively. In both groups, the median daily intake of folic acid was 800 µg/day before and during the first trimester. The median of supplemented iodine before, during and after pregnancy was constant at 150 µg per day. The daily iron intake through supplementation averaged 15 mg and peaked at 37 mg in the last trimester of pregnancy. A higher educational level (adj. p<0.001), higher age (adj. p<0.001), primiparity (adj. p<0.001), non-smoking status (adj. p<0.001), and a vegetarian diet (adj. p=0.037) were associated with taking dietary supplements in general.

In conclusion, the GeliS lifestyle intervention providing basic advice on dietary supplementation was not able to improve maternal supplement intake behavior during and after pregnancy. In the pooled GeliS cohort, the supplementation rates of folic acid and iodine were too low, folic acid supplementation was often started later than recommended, and many different micronutrients were supplemented for which there was no need. The recommendations of the nationwide network “Healthy Start - Young Family Network” were only partially met.

Personal contribution: Kristina Geyer designed the research question for the article, was responsible for data processing and evaluation as well as statistical analyses and interpreted the data. Furthermore, **Kristina Geyer** wrote the manuscript and prepared the results in form of tables.

4.4 Publication IV: Development and validation of a screening questionnaire for excessive gestational weight gain

Title: Development and validation of a screening questionnaire for early identification of pregnant women at risk for excessive gestational weight gain

Authors: Kristina Geyer, Roxana Raab, Julia Hoffmann, Hans Hauner

Journal: BMC Pregnancy and Childbirth 23, 249 (2023); open access article available from: https://doi.org/10.1186/s12884-023-05569-7.

Summary of findings: Of the 2,286 women recruited for the GeliS study, 1,790 women were included in the EGWG risk score analysis. All women were grouped into one cohort, of which 45.6% of the women showed EGWG.

Using the stepwise backward elimination, six salient risk factors that best predicted EGWG were identified within the development dataset (80% of data; n=1,432): higher pre-pregnancy BMI category (adj. $p<0.001$, for both overweight and obesity), educational level (general secondary school: adj. $p=0.234$, intermediate secondary school: adj. $p=0.026$), being born abroad (adj. $p<0.085$), primiparity (adj. $p<0.001$), having ever smoked (adj. $p<0.001$), signs of depressive disorder (adj. $p=0.114$). Maternal age and full-time employment were eliminated by the stepwise backward approach due to their lower correlation with EGWG. The final factors were included in a screening questionnaire by translating their β coefficients into score points. The total score as a sum of the single score points varied from 0 to 15 and allowed the classification of women's risk for EGWG in low (0–5 score points), moderate (6–10 score points) and high (11–15 score points). The internal cross-validation (20% of data; n=358) and external validation with the FeLIPO cohort indicated a discriminatory power of the risk score model assessed by AUC of 0.709 (95% CI 0.66 to 0.76) and 0.738 (95% CI 0.67 to 0.81), respectively.

In conclusion, the developed screening questionnaire is a new and valid tool to screen women for their risk of EGWG at an early stage by incorporating self-reported data on maternal sociodemographics, anthropometrics, smoking behavior, and mental health status. The tool could be applied for tailored intervention strategies in routine care to prevent EGWG. The applicability, as well as the clinical benefit, still needs to be assessed.

Personal contribution: Kristina Geyer was responsible for designing the research question, data processing and statistical analyses, as well as data interpretation. Furthermore, **Kristina Geyer** wrote the manuscript and prepared tables and figures.

5 General discussion

The present thesis aimed to investigate the effect of the comprehensive GeliS lifestyle intervention program during pregnancy on maternal health behavior throughout and following pregnancy. The intervention effect on antenatal PA behavior and its relation to GWG was analyzed (Hoffmann et al. 2019b). Afterwards, the sustained effect beyond the intervention phase on maternal PA, dietary, and smoking behaviors during the first year postpartum was examined (Geyer et al. 2021). The intervention effect on dietary supplement intake behavior was addressed, while in addition, the intake of dietary supplements before, during and after pregnancy was investigated in the GeliS cohort (Geyer et al. 2022). In the following, the findings presented in chapter four are discussed and lessons learned from the GeliS intervention program are elaborated. Furthermore, a screening questionnaire using a retrospective pooled cohort analysis was developed and validated to assess women's risk of EGWG at an early stage (Geyer et al. 2023), which is also subject to discussion in the subsequent chapter. Ultimately, opportunities for future lifestyle interventions targeting maternal health behavior and weight development are derived.

5.1 Effect of the GeliS intervention on maternal health behavior

Physical activity and dietary behavior

The GeliS lifestyle intervention was successful in improving maternal PA behavior during pregnancy. Between-group differences (IG vs. CG) in late pregnancy were observed concerning the level of total PA, TALIA, moderate- and vigorous-intensity activities as well as in terms of the level of sports activity and the proportion of women who met the PA recommendations (Hoffmann et al. 2019b). Although no overall effect of the GeliS intervention on GWG was observed (Kunath et al. 2019), the cohort analysis suggested that TALIA, light- and vigorous-intensity activity were inversely associated with GWG in late pregnancy (Hoffmann et al. 2019b). This could highlight the importance of PA for the prevention of EGWG. However, this analysis was not adjusted for maternal dietary behaviors and might therefore have biased the estimate of the effect of PA on GWG. In the postpartum period, between-group differences of PA disappeared, except for a remaining trend towards a higher proportion of women in the IG who met the PA recommendations in the early postpartum period, and for a significant increase in total PA from early to late postpartum in women in the IG (Geyer et al. 2021). Regardless of group assignment, maternal antenatal and postpartum PA patterns align with findings from observational studies that rely on self-reported data (Borodulin et al. 2009; Amezcua-Prieto et al. 2013) and objectively recorded PA data (Richardsen et al. 2016). The decline in total PA throughout pregnancy may be attributed to

pregnancy-related symptoms (Lardon et al. 2018), inconsistent information regarding safety and benefits (Coll et al. 2017) or the perception that relaxation is more important than engaging in PA (Mudd et al. 2009). These factors may contribute to the observation that global antenatal PA levels remain below the recommendations of international guidelines and are insufficient to attain established health benefits (Silva-Jose et al. 2022). This underscores the necessity for tailored counseling approaches that consider individual motives and barriers as integral components of antenatal care. In the postpartum period, light-intensity activity played a significant role in the activity level of women (Geyer et al. 2021), likely due to increased caregiving responsibilities not separately captured by the PPAQ. This level of activity could potentially hinder the achievement of PA recommendations, which many women did not meet. When analyzing MET values for total PA from early pregnancy to one year postpartum, it exceeded the baseline level at six to eight weeks after childbirth and continued to increase to 12 months postpartum (Hoffmann et al. 2019b; Geyer et al. 2021). However, it is unclear when postpartum stability in PA levels was reached. Additionally, since the questionnaires were not filled in before pregnancy, we cannot determine from the data whether or when the women returned to their previous PA habits. Our findings showed that the proportion of women meeting PA recommendations at each antenatal and postpartum time point was even higher than that reported of women in the general German population (42.6%) (Finger et al. 2017). To address the potential for inaccuracies in estimating PA levels with frequency questionnaires (Shephard 2003), we mitigated the risk of overreporting by applying thresholds to exclude unreliable values from the analyses. While the PPAQ was extensively validated (Chasan-Taber et al. 2023), incorporating an objective measurement, such as accelerometers, could have improved the reliability of our results.

The present results indicated a positive effect of the GeliS lifestyle intervention on maternal dietary behavior in the first year postpartum (Geyer et al. 2021). Women who received lifestyle counseling consumed slightly less fast food, fewer soft drinks and showed a higher intake of vegetables. The IG women were also more likely to choose healthy oils for the preparation of meat, fish, and vegetables. The overall diet quality, estimated by the HEI, was slightly higher in women of the IG during the postpartum period (Geyer et al. 2021). These results align with the findings reported from pregnancy phase (Günther et al. 2019a), where the GeliS lifestyle intervention was observed to improve aspects of maternal dietary behavior, including the adoption of healthier oils, increased consumption of fish and vegetables, and reduced soft drink intake. No intervention effect was observed regarding the energy intake throughout the postpartum period (Geyer et al. 2021), which is also in line with the data of the antenatal phase (Günther et al. 2019a). Furthermore, the effect sizes of persisting group-differences in the postpartum dietary behavior were small. This raises the question of whether the reported

findings on dietary behavior are of clinical relevance. Moreover, the data on energy intake should be considered as approximations rather than accurate values due to the assessment using the self-administered, albeit validated, DEGS-FFQ (Haftenberger et al. 2010). When examining the dietary behavior of women regardless of their group assignment throughout the postpartum period, it was noted that there was an increase in vegetable consumption, a reduction in the consumption of sweets and snacks, and a significant enhancement in overall diet quality observed one year after childbirth compared to the early postpartum period (Geyer et al. 2021). These dietary patterns were similarly observed by others (Martin et al. 2020).
The decline in the PA intervention effect and attenuation of the intervention effect in improving dietary behavior beyond the intervention phase in the first year postpartum might be attributed to distinct challenges that women face in maintaining a healthy lifestyle during the postpartum period, as has been reported in several observational studies. These challenges include lack of time and flexibility, fatigue (McKinley et al. 2018), disrupted or inefficient sleep patterns (Montgomery-Downs et al. 2010), issues with capability and motivation, unrealistic expectations, prioritizing parental duties over personal health (Christiansen et al. 2021), inadequate guidance and reliable information about a healthy postpartum lifestyle (Murray-Davis et al. 2019). Liva et al. (2021) studied the postnatal PA decision-making processes and concluded that without proper support during postpartum for re-engaging in PA after childbirth, it is challenging for women to maintain motivation and confidence for health-promoting PA (Liva et al. 2021). Although the last GeliS counseling session took place between six to eight weeks after birth, it was obviously not efficient to overcome these barriers and to assist women in adopting appropriate long-term health behaviors, neither in PA nor extensive dietary adaptations. Thus, there is a need for more intensive and prolonged support during the postpartum period.

The current literature on antenatal lifestyle interventions presents a heterogenous picture, with variations in study design, settings, types of interventions, participant characteristics and data collection methods (i-WIP Collaborative Group 2017; Heslehurst et al. 2020; Teede et al. 2022). This diversity makes it challenging to directly compare our research findings with other data. Moreover, there are limited findings from similar RCTs that have examined both the immediate and sustained effects of a combined antenatal lifestyle intervention on maternal dietary and PA behaviors. Two large-scale RCTs are somewhat comparable to GeliS, but they were conducted exclusively in women with overweight and/or obesity and not as part of the antenatal routine care. In the Australian LIMIT trial, pregnant women with overweight and obesity (n=2,212) received comprehensive lifestyle counseling through three in-person sessions and additional phone calls, covering dietary, exercise, and behavioral strategies (Dodd et al. 2014a). The UPBEAT trial from the UK with women with obesity (n=1,555)

included eight counseling sessions focusing on a low glycemic diet, adequate PA, exercise videos and PA monitoring tools, and addressing behavior change barriers (Poston et al. 2015). In both studies, women who received the lifestyle intervention were able to improve their total PA during pregnancy that was attributable to more time spent walking (Dodd et al. 2014a; Poston et al. 2015). The between-group differences in antenatal PA in both the UPBEAT and LIMIT studies align with our findings. However, while the changes in antenatal PA behavior in the GeliS study were primarily related to increased intensity levels (Hoffmann et al. 2019b), the observed differences in the other two trials were mainly explained by increased walking time (Poston et al. 2015) driven by changes in household activities (Dodd et al. 2014a). In the LIMIT study, no differences in total antenatal PA were observed between a subgroup of women from the IG (n=287) who were additionally randomized into a supervised walking group (three times per week) and women who attended the intervention sessions (Dodd et al. 2014a). Therefore, it appears that an additional active PA component in antenatal interventions does not necessarily lead to enhanced effects. Furthermore, the reported dropout rate of 66% (Dodd et al. 2014a) suggests that participating in additional active sessions poses a challenge for pregnant women.

The findings of the LIMIT and UPBEAT studies concerning their sustained intervention effects on maternal PA and dietary behaviors during the postpartum period were heterogenous. In the LIMIT study, the improvements in diet quality and total PA during pregnancy were mostly not maintained at four months postpartum (Dodd et al. 2014a). The UPBEAT study was also not able to show a persistent effect on PA beyond the intervention phase during the postpartum period (Patel et al. 2017; Dalrymple et al. 2021a); however, positive changes in maternal antenatal diet persisted at six months (Patel et al. 2017) and three years postpartum (Dalrymple et al. 2021a). At three years postpartum, the IG still reported lower glycemic load, energy and saturated fat intake, and a higher protein intake compared to women in the CG. This sustained long-term effect on dietary behavior may be attributed to the increased intensity of the UPBEAT intervention program. In contrast to the four counseling sessions in the GeliS study, the UPBEAT intervention program comprised eight individual sessions, each lasting 1–1.5 hours, focusing on glycemic control (Poston et al. 2015). Nevertheless, the intervention intensity in none of the three studies appeared to be sufficient to achieve long-term effects on maternal PA behavior.

Smoking behavior

The GeliS lifestyle counseling, which included basic advice on smoking cessation, was proven to be successful in terms of reducing maternal smoking behavior. A lower proportion of women in the IG than in the CG smoked during late pregnancy and at both postpartum time

points, indicating a sustained effect of the intervention (Geyer et al. 2021). These results do not correspond with existing review evidence. Heslehurst et al. (2020) found a lack of consistent evidence based on 16 systematic reviews concerning the improvement of smoking cessation, abstinence, or relapse during pregnancy or the postpartum period through antenatal interventions. Chamberlain et al. (2017) concluded based on the results of a Cochrane review that it is unclear whether lifestyle counseling that encompasses multiple aspects of lifestyle, as opposed to non-smoking counseling alone, is effective in smoking cessation in pregnancy. Unfortunately, there is no large-scale antenatal lifestyle intervention trial comparable to the GeliS trial that has examined the intervention effects on maternal smoking behavior, including the LIMIT and UPBEAT trials. The sustained effect of the GeliS intervention on maternal smoking behavior could be interpreted according to the results of a Swedish study by Sohlberg and Bergmark (2020), which focused on non-pregnant adults. This study suggests that long-term improvements in overall health behavior may positively affect smoking outcomes. This might also be the explanation of reported results for the postpartum smoking habits. The persistent intervention effect of the GeliS study on maternal dietary behavior may have consequently influenced postpartum smoking habits, potentially leading to more women remaining smoke-free up to one year after childbirth.

Regardless of group assignment, the smoking rates among the GeliS cohort during both antenatal and postpartum period were lower compared to smoking rates for pregnant (10.9%) (Kuntz et al. 2018) and non-pregnant (24.0%) (Starker et al. 2022) women in Germany. Notably, in these two cohorts, smoking was less prevalent among women with higher socioeconomic status (Kuntz et al. 2018; Starker et al. 2022). Given that GeliS participants have a relatively high level of education might explain the deviation from the average German smoking rates. Additionally, the data collection mode (i.e., using unsupervised questionnaires) could have introduced a reporting bias that favored desirable responses.

Even when the GeliS counseling was successful, when one considers the unambiguous evidence of severe health consequences that can result from smoking during pregnancy and breastfeeding (Banderali et al. 2015; Liu et al. 2020), a rate towards zero should be the target of intervention approaches. Therefore, the most effective intervention strategy should urgently be further investigated. Considering Germany's poor performance in the international ranking of smoking prevention measures (Joossens et al. 2022), there is also still considerable scope for system-level smoking prevention programs targeting the general population, including childbearing, pregnant and postpartum women.

Dietary supplement intake behavior

In this thesis, the dietary supplement intake behavior of women from the GeliS cohort was reviewed, specifically to examine the impact of the GeliS lifestyle intervention on dietary supplement intake during and after pregnancy. The results revealed that the intervention did not lead to any significant changes in maternal dietary supplement intake behavior, and that the dietary supplement intake in general did not align with current recommendations (Geyer et al. 2022).

Only half of the women in both groups supplemented folic acid and iodine during pregnancy. Before conception, only one third of the women took folic acid (Geyer et al. 2022). Timely folic acid supplementation is crucial for the closure of the neural tube in a very early stage of pregnancy to prevent malformations (Moussa et al. 2016). After delivery, many women stopped taking iodine supplements, failing to meet the continuing need for iodine during breastfeeding (Geyer et al. 2022). Considering the widespread moderate iodine deficiency in the general German population and the increased requirement in pregnancy and during breastfeeding (DGE 2021), the low supplementation rate among women in the GeliS cohort is unsatisfactory. Findings from German observational studies from past years reported similarly inadequate iodine and folic acid supplementation rates among pregnant women (Becker et al. 2011; Kowoll et al. 2015). The latest cross-sectional study from 2018/19 among 966 women revealed a supplementation rate of 45.4% for pre-conceptional folic acid and 50.1% for iodine during pregnancy (Kersting et al. 2020). Apparently, there are still barriers to the adequate implementation of official recommendations for dietary supplementation around pregnancy. Although many other countries have issued guidelines for promoting folic acid supplementation, these alone have not proven to be effective, as the prevalence of NTDs in Europe did not decrease between 1991 and 2011 (Khoshnood et al. 2015). For this reason, some countries have implemented mandatory food fortification with folic acid and subsequently observed a decrease in NTD cases (Williams et al. 2002; De Wals et al. 2007; Cortés et al. 2012). In response to this public health failure, a recently published position statement by the European Board and College of Obstetrics and Gynaecology (EBCOG), urged European governments, including Germany, to decide on mandatory fortification of flour with folic acid (Petch et al. 2022).

Conversely, the present results of the GeliS cohort showed that various other micronutrients were taken frequently, and in high doses, for which no recommendation for supplementation exists. DHA, iron, and vitamin D are critical nutrients during pregnancy and were supplemented by 20%, 20%, and 50% of women of the GeliS cohort, respectively (Geyer et al. 2022). These micronutrients should be supplemented if medically indicated, which could unfortunately not be assessed based on the GeliS data. Half of the women took vitamin B_{12}

which is a critical nutrient in vegetarian or vegan diets (Koletzko et al. 2018). As the proportion of vegetarians in the GeliS cohort accounted for only around 5%, B_{12} was probably largely supplemented without medical indication (Geyer et al. 2022). Moreover, our findings revealed that a total of 24 different micronutrients were taken, and 467 different dietary supplement products, mostly as combination preparations, were used. A recent analysis of 50 breastfeeding supplements in Germany found that all 50 products contained numerous additional nutrients in addition to DHA and iodine, with 68% of them exceeding recommended amounts. In contrast, only five products contained the recommended levels of iodine and DHA (Delgas et al. 2023). These results suggest that the use of combination preparations, often lacking reasonable composition, may have contributed to an unintended micronutrient overconsumption in the GeliS cohort as well. Consequently, a reformulation of the supplements by the distributors, considering existing recommendations should be urgently pursued.

Several factors can influence the dietary supplement intake behavior of women around pregnancy. The herein presented results suggest that higher levels of education, older age, those following a vegetarian diet, or primiparity were more likely to take any dietary supplements, while smokers do so less frequently (Geyer et al. 2022). This result is consistent with observations from other studies (Egen and Hasford 2003; Berti et al. 2011; Aronsson et al. 2013; Livock et al. 2016). Overall, the findings showed that the advice given in the GeliS trial on current guidelines on dietary supplementation around pregnancy appeared inadequate, and consequently, there is a need of intense education of women in their childbearing years. Future intervention approaches should be adaptable to specific target-groups, account for individual circumstances and dietary habits, with the goal of ensuring adequate nutrient supply around pregnancy while avoiding untargeted dietary supplement intake, that could be harmful for both the mother and child's health (Parisi et al. 2019).

Strengths and limitations of maternal health behavior data

This thesis reports comprehensive results across various aspects of health behavior in women from different BMI categories. The data were obtained through repeated questionnaire assessment on PA, diet, smoking, and dietary supplement intake, and allowed to map behavior changes over time within a large cohort. Particularly, the insights into the health behavior of women after childbirth are unique, as there are hardly any such extensive datasets available. For the analysis up to one year after birth, 1899 women (83.7% of the original GeliS cohort) were still participating in the study, which represents a low dropout rate compared to other studies (Horan et al. 2016; Patel et al. 2017). However, the data of the present thesis have limitations in terms of generalizability. The lifestyle intervention was conducted between

2013 and 2015, which means that the data on maternal health behavior do not reflect the most current situation. While participants from different age groups, BMI categories, and socioeconomic backgrounds were included, they were only from one federal state in Germany. Pregnant women with language barriers or high-risk pregnancies had to be excluded from the study. These aspects restrict the transferability of the results to broader population groups and ethnicities.

To summarize, to the best of our knowledge, the GeliS trial is the largest antenatal lifestyle intervention trial that was embedded in the German routine care setting. The GeliS counseling sessions were a feasible way to induce improvements in maternal PA behavior during pregnancy. These changes could not be sustained throughout the postpartum period. However, the GeliS lifestyle counseling had modest sustained effects on dietary and smoking behaviors beyond the intervention phase, and thus, successfully improved maternal health behaviors in the first year postpartum. The GeliS lifestyle counseling did not influence women's dietary supplement intake. Ultimately, it seems that the extent of changes in the targeted health behaviors has not reached a significant threshold to exert a clinical influence on weight-related outcomes in mothers, as neither a reduction of the percentage of women encountering EGWG (Kunath et al. 2019), nor a reduction in PPWR one year after delivery could be observed (Hoffmann et al. 2019c). Meanwhile, published findings demonstrated that the GeliS intervention during pregnancy was unable to influence the risk of childhood overweight up to the third year of life (Hoffmann et al. 2021; Spies et al. 2022). Pending GeliS evaluations of the mother-child pairs data up to the children's age of five will provide further insights into the effect of the GeliS lifestyle intervention on maternal and infant health behavior and weight development in the long term and will help to advance the understanding of the potential intergenerational cycle of obesity.
In the light of the modest effectiveness on maternal health behavior and limited overall effectiveness on GWG, the next chapter reviews the GeliS concept to identify pivotal elements related to intervention implementation, delivery, and intensity. This aims to draw lessons that can facilitate the achievement of the desired behavior change.

5.2 Lessons learned from the GeliS intervention program

One reason for the lacking effectiveness of the GeliS lifestyle intervention could be attributed to the quality of the counseling sessions, which might not have been adequate for their intended purpose. The process evaluation revealed inconsistencies in the delivery of counseling sessions, as not all intended intervention components were consistently administered (Kunath et al. 2019). This could potentially arise from the constraints posed by

lack of time in the busy daily agenda within gynecological practices. Furthermore, a two-day seminar might have been insufficient time to adequately train the medical staff, i.e., gynecologists, midwives, and medical personnel, with requisite knowledge to proficiently engage them in high-quality lifestyle counseling. Consequently, the counseling sessions might have remained too superficial, thereby lacking the depth necessary to elicit profound and enduring behavior changes and improvements in weight development. The involvement of lifestyle experts, such as physiotherapists and dieticians, could have led to higher quality lifestyle counseling. These aspects are likely the primary reasons for the unsuccessful replication of the FeLIPO results. In that study, counseling was conducted by one nutrition expert (Rauh et al. 2013).

It appears to be a common phenomenon in the field of obesity prevention that scaling up of successful pilot studies poses a challenge (McCrabb et al. 2019). However, the effectiveness of interventions is measured by their scalability, which is crucial for achieving population-wide reach and impact, and thus for addressing the obesity epidemic. Future research endeavors should carefully examine the modifications made to intervention components during the scaling process and the rationale behind them, to avoid a decline in effect size of the scaled intervention (Marshall et al. 2023). Furthermore, the selection of the CG in intervention trials demands careful consideration due to its potential impact on the measured effectiveness of the intervention. In the GeliS trial, a cluster-randomized design was implemented to prevent spill-over effects from the IG. To sustain motivation within the CG, they received a healthy lifestyle leaflet as an incentive in addition to routine care. However, their awareness of study participation might have unintentionally enhanced their engagement in healthier behaviors. Research has also shown that passive interventions with leaflets could stimulate higher intrinsic motivation compared to active sessions (Braeken and Bogaerts 2020). Forthcoming antenatal intervention investigations should carefully select incentives for the CG to avoid unintended influence on lifestyle.

Another reason that contributed to the observed lack of effectiveness could be the inconsistent provision of individualized feedback based on participants' health behavior habits (Kunath et al. 2019). A uniform approach might not prove adequate for GeliS participants who differ in characteristics, such as BMI, age, and socio-demographic background. The regular integration of behavioral change techniques (BCT) within the GeliS counseling could have individualized the intervention to align with the specific needs and barriers of each woman, thereby facilitating a comprehensive and enduring change of health behavior. A recent component network meta-analysis highlighted key BCTs like goal setting, feedback, monitoring, natural consequences, comparison of outcomes, and shaping knowledge as vital elements for optimizing GWG through lifestyle interventions (Ranasinha et

al. 2022). Furthermore, enhancing individualization could additionally be attained through a tailored approach based on the specific risk profiles of women concerning EGWG. Such an approach has been underutilized in antenatal lifestyle interventions, and is currently under consideration as an improvement for protocols for lifestyle-focused RCTs involving pregnant women (Poston 2023). Following this idea, in this thesis, a validated screening questionnaire for identifying women at risk of EGWG was retrospectively developed, which can be regarded as the initial step towards a more individualized approach. The findings are summarized and discussed in the subsequent chapter.

5.3 The validated screening questionnaire for excessive gestational weight gain

Six early pregnancy variables were identified as risk factors for EGWG; namely a higher maternal pre-pregnancy BMI, intermediate educational level, nulliparity, being born in a country outside Germany, having ever smoked, and signs of depressive disorder. These variables were incorporated into a screening questionnaire designed to categorize the risk of EGWG into low, moderate, and high (Geyer et al. 2023). Maternal BMI before pregnancy emerged as the foremost risk factor for EGWG, a finding consistent with previous research (Zhou et al. 2022). According to recommendations, normalization of body weight before pregnancy is certainly advisable to avoid adverse health outcomes (Koletzko et al. 2018). Nonetheless, the prevalence of overweight and obesity among pregnant women has continued to rise in recent years (Strauss et al. 2021), highlighting the urgent need for pre-conception intervention strategies. Moreover, non-modifiable risk factors derived from early pregnancy data, such as educational level, parity, and the women's country of birth, were included in the screening questionnaire. Concerning the latter factor, unfortunately, precise determination of maternal migration background or ethnicity within the GeliS cohort was not available. As a result, we are not able to deduce how the nuanced aspects of social culture or ethnicity should be accounted for within the risk profile for EGWG. Grounded in the evidence that psychosocial factors are related to EGWG (Hill et al. 2013), the inclusion of the validated PHQ-2 for the assessment of women's mental health constitutes a major strength of the screening questionnaire. The mechanisms underlying the association between maternal mental health and EGWG have been suggested by secondary findings from the Irish PEARS study, wherein it was observed that pregnant women with lower subjective well-being, identified through early pregnancy screening, exhibited a lower tendency for behavioral changes throughout pregnancy (Roche et al. 2023). The prevalence of depressive symptoms in adults is increasing in Germany, especially affecting women of childbearing age (18–29 years: 16.4%; 30–44 years: 10.9%) (Brettschneider et al. 2017). Hence, the importance of women's well-being must be recognized as a priority in both maternal care and targeted

intervention approaches. This is also advocated by the Health in Pre-conception, Pregnancy and Postpartum (HiPPP) Global Alliance (Hill et al. 2020). The screening questionnaire omits inquiries about maternal diet and PA, notwithstanding their potential impact on EGWG (Zhou et al. 2022). The dietary and PA data of the GeliS study, collected using extensive questionnaires, couldn't be incorporated as single and precise lifestyle items in the questionnaire. Inherently, the inclusion of lifestyle-related queries as single, precise items in a questionnaire may introduce a higher susceptibility to inaccuracies. Additionally, the screening questionnaire is designed for early pregnancy, where lifestyle can be further affected by temporary changes in dietary habits and episodes of nausea or vomiting (Crozier et al. 2017). Nonetheless, the screening questionnaire did inquire about the women's smoking behavior, which has been linked to EGWG in previous findings (Deputy et al. 2015) and might serve as an indicator for a general unhealthier lifestyle (Dallongeville et al. 1998).

The ROC statistics of the ultimate variables revealed that 71% of the women could be correctly assessed for their EGWG risk (AUC 0.709), indicating moderate discriminatory power (Metz 1978; Hosmer et al. 2013). This discriminatory power was even higher in the external FeLIPO cohort (AUC 0.738), despite the absence of the mental-health related variable in the dataset (Geyer et al. 2023). Our validated screening questionnaire offers the potential to bridge the existing gap between research, the lack of targeted interventions and the translation into clinical practice. According to a study by Cao et al. (2020), very few novel concepts from health research and life sciences that correspond to the low double-digit percentage range are currently translated into general healthcare. As a practical, time- and resource-efficient tool, the screening questionnaire could be applied in gynecological and obstetrical clinical settings to raise awareness among both women and healthcare providers about the issue of EGWG, which up till now receives inadequate attention. RCTs are needed to assess whether women identified by the screening questionnaire to be "at risk" would benefit more from early lifestyle interventions compared to women with lower risk, and to examine whether interventions become more cost-effective. Further validation studies in diverse populations are required to evaluate the clinical value of our screening tool.

5.4 Opportunities for future lifestyle interventions

The findings of this thesis provide suggestions for future lifestyle intervention strategies (Figure 4) that could potentially overcome existing limitations to optimize their effectiveness on maternal health behaviors, and consequently, to improve maternal and infant health.

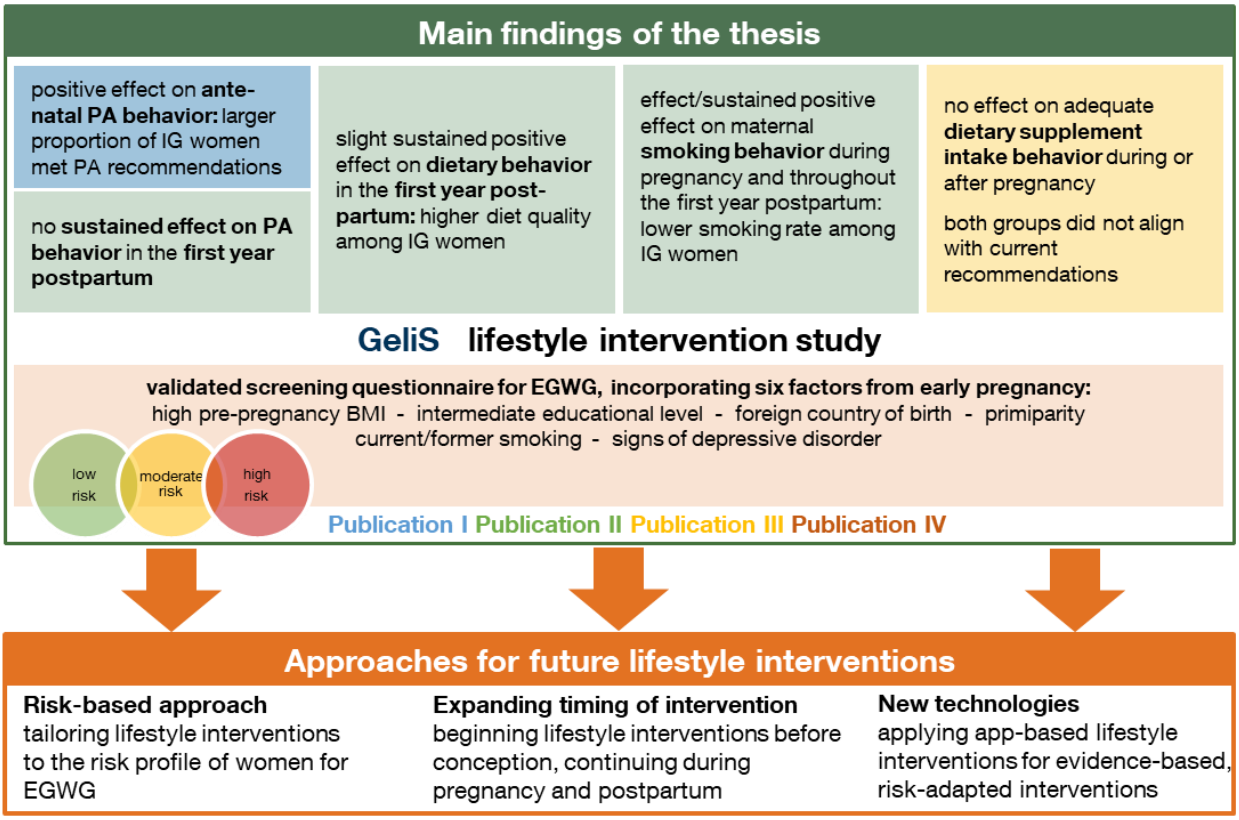


Figure 4 From the results presented in this work from the GeliS study to future approaches for lifestyle interventions.
Abbreviations: PA: physical activity; IG: intervention group; EGWG: excessive gestational weight gain; BMI: body mass index.

Firstly, tailoring lifestyle interventions to the risk profile of women for EGWG. Considering the individuality of pregnancies and the heterogenous picture of existing research, it is evident that the optimal lifestyle intervention strategy for addressing EGWG remains uncertain. To improve intervention effectiveness, a shift from a one-size-fits-all approach to a precision-based approach may be required to identify women who are most likely to benefit from preventive measures. Hence, interventions should consider individual risk factors for EGWG. By conducting early pregnancy screening using our screening questionnaire based on non-modifiable self-reported data, it could be determined at the onset of pregnancy or even before conception whether a woman has a low, moderate, or high risk for developing EGWG. This risk assessment tool can be combined with RCTs for targeted behavior change interventions. Implementing this risk-based strategy might have the potential to reduce time, expenses, and resources, as women with low-risk profiles receive less intensive interventions, potentially improving cost-efficiency in primary healthcare settings. Currently, algorithms are under evaluation using early pregnancy risk factors to predict GDM development (Sparks et al. 2022). However, there is limited evidence regarding the advantages of early pregnancy screening for EGWG. Future research is required to assess

how intervention strategies can support women according to their risk profiles, enhance intervention adherence, and facilitate appropriate behavioral changes.

Secondly, beginning lifestyle interventions before conception, and continuing during pregnancy and postpartum. Previous research on lifestyle interventions and GWG has primarily concentrated on the pregnancy period, often starting late in the first or early second trimester and concluding in the early third trimester (i-WIP Collaborative Group 2017). The GeliS intervention, similarly, began with the first counseling during the 12th and 16th week of pregnancy and concluded with the final counseling between the 6th and 8th week postpartum. This limited intervention timeframe may explain the modest effectiveness observed in the GeliS intervention program and other antenatal lifestyle studies.

Shifting the research focus to lifestyle interventions that start before conception, span the entire pregnancy and postpartum period could be critical to assist women in establishing lifestyle habits that endure and effectively improve health and weight outcomes. Observational studies indicate that robust links exist between the maternal pre-conception health and health outcomes of both mothers and their offspring, which can have long-lasting intergenerational effects; however, there is limited awareness of these connections among women of reproductive age (Stephenson et al. 2018). Crucial pre-conception health behaviors include ensuring adequate micronutrient supply, especially folic acid, achieving a healthy pre-pregnancy weight, and adopting a balanced diet, smoking cessation, and regular PA (Koletzko et al. 2018). Given the challenges of changing these behaviors in the short term, early interventions in the pre-conception period are warranted to enable sustainable change towards healthy habits (Toivonen et al. 2017). Moreover, initiating interventions before conception can target critical embryonic developmental processes that occur very early in pregnancy, often before the woman is aware of her pregnancy (Catalano and deMouzon 2015). Previous antenatal interventions have often been initiated after this vulnerable stage, which also fails to address the high number of unintended pregnancies (ESHRE Capri Workshop Group 2018). Due to the challenges of implementation, there is limited scientific evidence regarding pre-conception lifestyle interventions. Nevertheless, there have been some achievements in pre-conceptional health nutrition using smartphone applications (apps) and telemedicine to deliver healthy messages to couples planning pregnancy (van Dijk et al. 2020).

In addition, continued interventions beyond birth are required to assist women in maintaining healthy dietary and exercise habits following pregnancy, which can be difficult due to the unique challenges that women face in the postpartum period (Murray-Davis et al. 2019; Christiansen et al. 2021). The benefits of a healthy postpartum lifestyle are supported by

substantial evidence (Larson-Meyer 2002; Dipietro et al. 2019; Opie et al. 2020). In particular, it has a high relevance in mitigating maternal PPWR, which is a major contributor to overweight and obesity in women after childbirth (McKinley et al. 2018). For instance, moderate to high level of postpartum PA, along with a GWG ≤9 kg and exclusive breastfeeding for ≥4 months, were found to be significant determinants in returning to pre-pregnancy weight for women with obesity (Dalrymple et al. 2021b). Furthermore, there might be an association between unhealthy lifestyle habits and poor mental health, as postnatal depression is associated with increased PPWR (McKinley et al. 2018). Less acknowledged is the importance of post-pregnancy weight management as a means to improve pre-conceptional health for subsequent pregnancies, as interpregnancy weight gain is linked to a higher risk of maternal and perinatal complications (McKinley et al. 2018; Teulings et al. 2019). An analysis of systematic reviews revealed that multi-component diet and PA interventions during the postpartum period have been successful in promoting postpartum weight loss for women across all weight categories (Farpour-Lambert et al. 2018). However, to the best of our knowledge, no study has implemented an intervention from pre-conception through pregnancy to the postpartum period. Using an alternative approach, the INTER-ACT RCT enrolled women with EGWG in the previous pregnancy at six weeks postpartum into a comprehensive e-health supported lifestyle intervention extended until the end of a new pregnancy (Bogaerts et al. 2017). While improvements in dietary behavior were observed by the end of the six-month intervention, there was no significant change in PA. The improvements were not sustained at the one-year follow-up (Bijlholt et al. 2021). Improved dietary behaviors were associated with more favorable weight and body composition outcomes (van Uytsel et al. 2022). However, the long-term benefits of this intervention remain unclear. If interventions starting before conception, continuing during pregnancy, and persisting into the postpartum period are found to effectively promote long-term health and reduce the burden of intergenerational obesity, lifestyle counseling could be integrated into routine maternity and gynecological care within a systemic approach. The HiPPP Global Alliance, as an international network, is dedicated to both identifying gaps and updating evidence-based guidelines for weight and lifestyle management in the HiPPP field. Additionally, it focuses on developing strategies for the effective translation of knowledge into policy and practice (CRE HiPP 2021).

Thirdly, applying app-based lifestyle interventions. The advancing digitalization offers the potential to overcome traditional barriers in implementing lifestyle interventions at the patient, provider, and system levels. Health apps show promise in this context. Given the ease of app installation on various mobile devices and the global prevalence of smartphones, app-supported lifestyle interventions hold significant potential for modifying health behavior and

associated outcomes (Ali et al. 2016), including GWG and PPWR (Mertens et al. 2019). App-based lifestyle interventions offer a multitude of benefits, such as incorporating evidence-based and risk-adapted intervention strategies (Bardus et al. 2016). For example, nutrition and PA experts could be involved via coaching functions which would improve the quality of counseling content. The questions from our screening questionnaire could be integrated into the apps' onboarding process during registration, enabling risk-adapted lifestyle counseling. Another advantage of apps is that BCTs, which constitute a core element of lifestyle interventions for GWG (Ranasinha et al. 2022; Barroso et al. 2022), can be integrated as features within apps and thus into lifestyle interventions. It has been shown that a digital health intervention with problem-solving or goal-setting components is associated with a greater reduction in energy intake in postpartum women (Lim et al. 2020).

The existing limitations regarding over- and underreporting of self-reported diet and PA data could be addressed within app-based interventions by integrating wearables, e.g., PA trackers, and e-health technologies, e.g., a Bluetooth scale, to obtain objective data. Monitoring these real-time data allows just-in-time adaptive interventions (JITAI) by intervening in real-life situations through direct feedback (Heron and Smyth 2010; Riley et al. 2011; Nahum-Shani et al. 2015). Hence, intervention intensity and modality can be refined if necessary and tailored to each woman. JITAIs have demonstrated effectiveness in weight management for non-pregnant women (Hardeman et al. 2019) and hold potential for pregnant women with type 1 diabetes (Scott et al. 2020).

In recent years, several studies have been initiated to develop app-supported lifestyle interventions that address maternal health behavior and GWG. Our research group is currently conducting an online survey for pregnant women in Germany (German Clinical Trials Register: DRKS00028808) which assesses needs and barriers related to lifestyle apps and will offer valuable insights for future app-based intervention strategies targeting maternal lifestyle and EGWG. In Germany, the large-scale GeMuKi trial was conducted between 2017 and 2022. The GeMuKi lifestyle intervention was conducted alongside the routine antenatal care in Germany and was similar to the GeliS program but was supplemented with a digital component in the form of an app and behavior-oriented methods (Alayli et al. 2020). Recently published data (n=1,466) suggested an intervention effect from the app-based intervention on the proportion of women with EGWG (Krebs et al. 2022). Further results are expected about maternal health behaviors. As in GeliS, these data were collected with the PPAQ and the DEGS-FFQ in early and late pregnancy and repeatedly in the postpartum period. In addition to the GeMuKi study, digital-based lifestyle interventions have also been increasingly tested internationally. An overview of this emerging research field is provided by a recently conducted scoping review by our research group at the Institute for Nutritional Medicine

(Raab et al. 2022a). However, there is still no proof of efficacy in terms of pregnancy and perinatal outcomes (Overdijkink et al. 2018; Chan and Chen 2019; Rhodes et al. 2020; Coleman et al. 2020; Iyawa et al. 2021). It is too early to inform evidence-based decisions and assess its potential role as a large-scale preventive intervention.

6 Conclusion and outlook

The gestational period is an opportune time to improve maternal health behavior and avoid EGWG, thereby breaking the intergenerational cycle of overweight and obesity. The GeliS lifestyle intervention trial delivered lifestyle counseling sessions to mitigate EGWG and change maternal health behaviors. Positive effects on maternal PA and dietary behaviors were observed during pregnancy (Hoffmann et al. 2019b; Günther et al. 2019a). Although the improvements in PA were not sustained beyond the intervention phase, the changes in dietary behavior slightly persisted up to one year postpartum. Furthermore, there was evidence of an intervention effect on smoking behavior during pregnancy and up to one year postpartum (Geyer et al. 2021). However, no influence on dietary supplement intake was observed during or after pregnancy, and both groups did not align with current recommendations (Geyer et al. 2022). There is an urgent need to significantly enhance awareness of adequate dietary supplementation around pregnancy by delivering individualized guidance on supplement use to leverage the established preventive benefits. As the improvements in maternal health behavior might have not been sufficient to ultimately impact maternal weight outcomes (Kunath et al. 2019; Hoffmann et al. 2019c), further research is needed to elucidate effective strategies. In this regard, the thesis has already provided a first step for future lifestyle interventions. The pooled GeliS cohort was used to retrospectively develop and validate an easy-to-use screening questionnaire, incorporating six questions from early pregnancy (Geyer et al. 2023). This questionnaire can be applied for tailored intervention strategies through early screening to identify women at the highest risk. Future interventions should seek to understand if there are differential effects on EGWG and pregnancy outcomes based on individual risk profiles.

To further advance the field, future lifestyle interventions should attribute greater significance to the relevance of pre-conceptional and postpartum maternal health behaviors and test whether expanding the timing of intervention matters. Furthermore, future research is positioned to take advantage of emerging technologies that may hold promise in overcoming implementation barriers of previous lifestyle interventions. Thereby, harnessing our screening questionnaire to develop app-based lifestyle interventions, combined with JITAIs to continuously assess women's responses to intervention and adapt them in real-time, is a promising approach for future research efforts. Incorporating key healthcare professionals for women of childbearing age, such as gynecologists, midwives, obstetricians, pediatricians, and nutritionists, into a multidisciplinary prevention team within an app-based approach could provide a framework for sustainable health promotion for women. This approach has the potential to bridge the gap in preventive measures within the established antenatal structures

of the German healthcare system. In addition to the crucial role of individual intervention strategies, strategies for health behavioral change throughout life at the system level, and thus addressing the social determinants of health, should be advocated, with a particular focus on addressing the obesogenic environment. This requires supportive, inclusive, and decisive policies that shape and strengthen the health system to facilitate health-promoting behaviors to combat the burden of obesity in society.

References

ACOG (2020). Physical Activity and Exercise During Pregnancy and the Postpartum Period: ACOG (The American College of Obstetricians and Gynecologists) Committee Opinion, Number 804. *Obstetrics and gynecology* **135**, e178-e188.

Ainsworth, B. E., Haskell, W. L., Herrmann, S. D., Meckes, N., Bassett, D. R., Tudor-Locke, C., Greer, J. L., Vezina, J., Whitt-Glover, M. C. and Leon, A. S. (2011). 2011 Compendium of Physical Activities: a Second Update of Codes and MET Values. *Medicine and science in sports and exercise* **43**, 1575–1581.

Alayli, A., Krebs, F., Lorenz, L., Nawabi, F., Bau, A.-M., Lück, I., Moreira, A., Kuchenbecker, J., Tschiltschke, E., John, M. et al. (2020). Evaluation of a computer-assisted multi-professional intervention to address lifestyle-related risk factors for overweight and obesity in expecting mothers and their infants: protocol for an effectiveness-implementation hybrid study. *BMC public health* **20**, 482.

Ali, E. E., Chew, L. and Yap, K. Y.-L. (2016). Evolution and current status of mhealth research: a systematic review. *BMJ Innovations* **2**, 33–40.

Amezcua-Prieto, C., Olmedo-Requena, R., Jímenez-Mejías, E., Hurtado-Sánchez, F., Mozas-Moreno, J., Lardelli-Claret, P. and Jiménez-Moleón, J. J. (2013). Changes in Leisure Time Physical Activity During Pregnancy Compared to the Prior Year. *Matern Child Health Journal* **17**, 632–638.

Amorim Adegboye, A. R. and Linne, Y. M. (2013). Diet or exercise, or both, for weight reduction in women after childbirth. *The Cochrane database of systematic reviews* **2013**, CD005627.

Aronsson, C. A., Vehik, K., Yang, J., Uusitalo, U., Hay, K., Joslowski, G., Riikonen, A., Ballard, L., Virtanen, S. M. and Norris, J. M. (2013). Use of dietary supplements in pregnant women in relation to sociodemographic factors - a report from The Environmental Determinants of Diabetes in the Young (TEDDY) study. *Public health nutrition* **16**, 1390–1402.

Aune, D., Saugstad, O. D., Henriksen, T. and Tonstad, S. (2014). Physical Activity and the Risk of Preeclampsia: a Systematic Review and Meta-Analysis. *Epidemiology* **25**, 331–343.

Banderali, G., Martelli, A., Landi, M., Moretti, F., Betti, F., Radaelli, G., Lassandro, C. and Verduci, E. (2015). Short and long term health effects of parental tobacco smoking during pregnancy and lactation: a descriptive review. *Journal of Translational Medicine* **13**, 327.

Bardus, M., van Beurden, S. B., Smith, J. R. and Abraham, C. (2016). A review and content analysis of engagement, functionality, aesthetics, information quality, and change techniques in the most popular commercial apps for weight management. *International journal of behavioral nutrition and physical activity* **13**, 35.

Barroso, C. S., Yockey, A., Degon, E., Gautam Poudel, P., Brown, S. D., Hedderson, M. M., Moreno-Hunt, C. and Ehrlich, S. F. (2022). Efficacious lifestyle interventions for appropriate gestational weight gain in women with overweight or obesity set in the health care system: a scoping review. *The journal of maternal-fetal & neonatal medicine* **35**, 6411–6424.

Becker, S., Schmid, D., Amann-Gassner, U. and Hauner, H. (2011). Verwendung von Nährstoffsupplementen vor und während der Schwangerschaft. *Ernährungs Umschau* **58**, 36–41.

Bergmann, K. E., Bergmann, R. L., Ellert, U. and Dudenhausen, J. W. (2007). Perinatale Einflussfaktoren auf die spätere Gesundheit. Ergebnisse des Kinder- und Jugendgesundheitssurveys (KiGGS). *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* **50**, 670–676.

Berti, C., Biesalski, H. K., Gärtner, R., Lapillonne, A., Pietrzik, K., Poston, L., Redman, C., Koletzko, B. and Cetin, I. (2011). Micronutrients in pregnancy: Current knowledge and unresolved questions. *Clinical Nutrition* **30**, 689–701.

BfR (2021). Jod, Folat/Folsäure und Schwangerschaft. https://www.bfr.bund.de/cm/350/jod-folat-folsaeure-und-schwangerschaft.pdf Accessed August 23, 2023.

Bijlholt, M., Ameye, L., van Uytsel, H., Devlieger, R. and Bogaerts, A. (2021). The INTER-ACT E-Health Supported Lifestyle Intervention Improves Postpartum Food Intake and Eating Behavior, but Not Physical Activity and Sedentary Behavior - A Randomized Controlled Trial. *Nutrients* **13**, 1287.

Bischoff-Ferrari, H. A. (2011). Vitamin D: role in pregnancy and early childhood. *Annals of nutrition & metabolism* **59**, 17–21.

Bogaerts, A., Ameye, L., Bijlholt, M., Amuli, K., Heynickx, D. and Devlieger, R. (2017). INTER-ACT: prevention of pregnancy complications through an e-health driven interpregnancy lifestyle intervention - study protocol of a multicentre randomised controlled trial. *BMC pregnancy and childbirth* **17**, 154.

Borodulin, K., Evenson, K. R. and Herring, A. H. (2009). Physical activity patterns during pregnancy through postpartum. *BMC Women's Health* **9**, 1–7.

Bougma, K., Aboud, F. E., Harding, K. B. and Marquis, G. S. (2013). Iodine and Mental Development of Children 5 Years Old and Under: A Systematic Review and Meta-Analysis. *Nutrients* **5**, 1384–1416.

Braeken, M. A. K. A. and Bogaerts, A. (2020). Effect of Lifestyle Interventions in Obese Pregnant Women on the Neurocognitive Development and Anthropometrics of Preschool Children. *Obesity facts* **13**, 256–266.

Brettschneider, J., Kuhnert, R. and Hapke, U. (2017). Depressive Symptomatik bei Erwachsenen in Deutschland. *Journal of Health Monitoring* **2**, 81–88.

Brock, J. M., Billeter, A., Müller-Stich, B. P. and Herth, F. (2020). Obesity and the Lung: What We Know Today. *Respiration* **99**, 856–866.

Cao, H., Cheng, M., Cen, Z., McFarland, D. A. and Ren, X. (2020). Will This Idea Spread Beyond Academia? Understanding Knowledge Transfer of Scientific Concepts across Text Corpora. *Findings of the Association for Computational Linguistics* **EMNLP: 2020**, 1746–1757.

Catalano, P. and deMouzon, S. H. (2015). Maternal obesity and metabolic risk to the offspring: why lifestyle interventions may have not achieved the desired outcomes. *International journal of obesity* **39**, 642–649.

Caut, C., Leach, M. and Steel, A. (2020). Dietary guideline adherence during preconception and pregnancy: A systematic review. *Maternal & child nutrition* **16**, e12916.

Chamberlain, C., O'Mara-Eves, A., Porter, J., Coleman, T., Perlen, S. M., Thomas, J. and McKenzie, J. E. (2017). Psychosocial interventions for supporting women to stop smoking in pregnancy. *Cochrane database of systematic reviews* **2**, CD001055.

Champion, M. L. and Harper, L. M. (2020). Gestational Weight Gain: Update on Outcomes and Interventions. *Current diabetes reports* **20**, 11.

Chan, K. L. and Chen, M. (2019). Effects of Social Media and Mobile Health Apps on Pregnancy Care: Meta-Analysis. *JMIR mHealth and uHealth* **7**, e11836.

Chasan-Taber, L., Park, S., Marcotte, R. T., Staudenmayer, J., Strath, S. and Freedson, P. (2023). Update and Novel Validation of a Pregnancy Physical Activity Questionnaire. *American journal of epidemiology* **192**, 1743–1753.

Chasan-Taber, L., Schmidt, M. D., Roberts, D. E., Hosmer, D., Markenson, G. and Freedson, P. S. (2004). Development and Validation of a Pregnancy Physical Activity Questionnaire. *Medicine and science in sports and exercise* **36**, 1750–1760.

Chen, X., Zhao, D., Mao, X., Xia, Y., Baker, P. N. and Zhang, H. (2016). Maternal Dietary Patterns and Pregnancy Outcome. *Nutrients* **8**, 351.

Chen, Y., Ma, G., Hu, Y., Yang, Q., Deavila, J. M., Zhu, M.-J. and Du, M. (2021). Effects of Maternal Exercise During Pregnancy on Perinatal Growth and Childhood Obesity Outcomes: A Meta-analysis and Meta-regression. *Sports Medicine* **51**, 2329–2347.

Christiansen, P. K., Skjøth, M. M., Lorenzen, L. E., Draborg, E., Vinter, C. A., Kjær, T. and Rothmann, M. J. (2021). Barriers to a healthy postpartum lifestyle and the possibilities of an information technology-based intervention: A qualitative study. *Midwifery* **98**, 102994.

Coleman, J., Badawy, S., Pimentel, M. d. G., Shah, S. G. S., Hussain, T., Smith, P. and Yee, L. M. (2020). Mobile Phone–Based Behavioral Interventions in Pregnancy to Promote Maternal and Fetal Health in High-Income Countries: Systematic Review. *JMIR mHealth and uHealth* **8**, e15111.

Coll, C. V., Domingues, Gonçalves, H. and Bertoldi, A. D. (2017). Perceived barriers to leisure-time physical activity during pregnancy: A literature review of quantitative and qualitative evidence. *Journal of science and medicine in sport* **20**, 17–25.

Cortés, F., Mellado, C., Pardo, R. A., Villarroel, L. A. and Hertrampf, E. (2012). Wheat flour fortification with folic acid: changes in neural tube defects rates in Chile. *American journal of medical genetics* **158A**, 1885–1890.

CRE HiPP (2021). Centre of Research Excellence Health in Preconception & Pregnancy. Global HiPPP Alliance. About Us. https://hipp.org.au/networks/global-hippp-alliance/ Accessed September 23, 2023.

Crozier, S. R., Inskip, H. M., Godfrey, K. M., Cooper, C. and Robinson, S. M. (2017). Nausea and vomiting in early pregnancy: Effects on food intake and diet quality. *Maternal & child nutrition* **13**, e12389.

Currie, S., Sinclair, M., Murphy, M. H., Madden, E., Dunwoody, L. and Liddle, D. (2013). Reducing the Decline in Physical Activity during Pregnancy: A Systematic Review of Behaviour Change Interventions. *PloS one* **8**, e66385.

Dallongeville, J., Marécaux, N., Fruchart, J. C. and Amouyel, P. (1998). Cigarette smoking is associated with unhealthy patterns of nutrient intake: a meta-analysis. *The Journal of nutrition* **128**, 1450–1457.

Dalrymple, K. V., Tydeman, F. A. S., Taylor, P. D., Flynn, A. C., O'Keeffe, M., Briley, A. L., Santosh, P., Hayes, L., Robson, S. C., Nelson, S. M. et al. (2021a). Adiposity and cardiovascular outcomes in three-year-old children of participants in UPBEAT, an RCT of a complex intervention in pregnant women with obesity. *Pediatric obesity* **16**, e12725.

Dalrymple, K. V., Uwhubetine, O., Flynn, A. C., Pasupathy, D., Briley, A. L., Relph, S. A., Seed, P. T., O'Keeffe, M. and Poston, L. (2021b). Modifiable Determinants of Postpartum Weight Loss in Women with Obesity: A Secondary Analysis of the UPBEAT Trial. *Nutrients* **13**, 1979.

DAPA Measurement Toolkit (2004). Pregnancy Physical Activity Questionnaire. https://www.measurement-toolkit.org/pdf/pa/PPAQ_instructions_1.pdf Accessed January 23, 2023.

Davis, E. M., Zyzanski, S. J., Olson, C. M., Stange, K. C. and Horwitz, R. I. (2009). Racial, Ethnic, and Socioeconomic Differences in the Incidence of Obesity Related to Childbirth. *American Journal of Public Health* **99**, 294–299.

Dawodu, A. and Wagner, C. L. (2012). Prevention of vitamin D deficiency in mothers and infants worldwide - a paradigm shift. *Paediatrics and international child health* **32**, 3–13.

De Wals, P. de, **Tairou, F., van Allen, M. I., Uh, S.-H., Lowry, R. B., Sibbald, B., Evans, J. A., van den Hof, M. C., Zimmer, P., Crowley, M. et al.** (2007). Reduction in Neural-Tube Defects after Folic Acid Fortification in Canada. *New England journal of medicine* **357**, 135–142.

Delgas, F., Lederer, A., Holzäpfel, S. and Podszun, M. C. (2023). Nahrungsergänzungsmittel in der Stillzeit. Viel hilft nicht immer viel. *Ernährungs Umschau* **70**, 64–75.

Deputy, N. P., Sharma, A. J., Kim, S. Y. and Hinkle, S. N. (2015). Prevalence and Characteristics Associated With Gestational Weight Gain Adequacy. *Obstetrics and gynecology* **125**, 773–781.

De-Regil, L. M., Peña-Rosas, J. P., Fernández-Gaxiola, A. C. and Rayco-Solon, P. (2015). Effects and safety of periconceptional oral folate supplementation for preventing birth defects. *The Cochrane database of systematic reviews* **2015**, CD007950.

DGE (2017). Vollwertig essen und trinken nach den 10 Regeln der Deutschen Gesellschaft für Ernährung. https://www.dge.de/fileadmin/public/doc/fm/10-Regeln-der-DGE.pdf Accessed March 23, 2023.

DGE (2021). DGE/ÖGE-Referenzwerte für die Nährstoffzufuhr. https://www.dge.de/wissenschaft/referenzwerte/ Accessed October 23, 2023.

Dipietro, L., Evenson, K. R., Bloodgood, B., Sprow, K., Troiano, R. P., Piercy, K. L., Vaux-Bjerke, A. and Powell, K. E. (2019). Benefits of Physical Activity during Pregnancy and Postpartum: An Umbrella Review. *Medicine and science in sports and exercise* **51**, 1292–1302.

Dodd, J. M., Cramp, C., Sui, Z., Yelland, L. N., Deussen, A. R., Grivell, R. M., Moran, L. J., Crowther, C. A., Turnbull, D., McPhee, A. J. et al. (2014a). The effects of antenatal dietary and lifestyle advice for women who are overweight or obese on maternal diet and physical activity: the LIMIT randomised trial. *BMC medicine* **12**, 161.

Dodd, J. M., Turnbull, D., McPhee, A. J., Deussen, A. R., Grivell, R. M., Yelland, L. N., Crowther, C. A., Wittert, G., Owens, J. A. and Robinson, J. S. (2014b). Antenatal lifestyle advice for women who are overweight or obese: LIMIT randomised trial. *BMJ* **348**, g1285.

Donner, A. and Klar, N. (2000). *Design and analysis of cluster randomization trials in health research*. Chichester: John Wiley & Sons.

Egen, V. and Hasford, J. (2003). Prevention of neural tube defects: effect of an intervention aimed at implementing the official recommendations. *Sozial- und Praventivmedizin* **48**, 24–32.

Ensenauer, R., Chmitorz, A., Riedel, C., Fenske, N., Hauner, H., Nennstiel-Ratzel, U. and von Kries, R. (2013). Effects of suboptimal or excessive gestational weight gain on childhood overweight and abdominal adiposity: results from a retrospective cohort study. *International journal of obesity* **37**, 505–512.

ESHRE Capri Workshop Group (2018). Why after 50 years of effective contraception do we still have unintended pregnancy? A European perspective. *Human reproduction* **33**, 777–783.

Evenson, K. R., Mottola, M. F. and Artal, R. (2019). Review of Recent Physical Activity Guidelines During Pregnancy to Facilitate Advice by Health Care Providers. *Obstetrical & gynecological survey* **74**, 481–489.

Evenson, K. R., Mottola, M. F., Owe, K. M., Rousham, E. K. and Brown, W. J. (2014). Summary of International Guidelines for Physical Activity Following Pregnancy. *Obstetrical & gynecological survey* **69**, 407–414.

Fair, F. and Soltani, H. (2021). A meta-review of systematic reviews of lifestyle interventions for reducing gestational weight gain in women with overweight or obesity. *Obesity Reviews* **22**, e13199.

Faria-Schützer, D. B., Surita, F. G., Rodrigues, L. and Turato, E. R. (2018). Eating Behaviors in Postpartum: A Qualitative Study of Women with Obesity. *Nutrients* **10**, 885.

Farpour-Lambert, N. J., Ells, L. J., Martinez de Tejada, B. and Scott, C. (2018). Obesity and Weight Gain in Pregnancy and Postpartum: an Evidence Review of Lifestyle Interventions to Inform Maternal and Child Health Policies. *Frontiers in Endocrinology* **9**, 546.

Federal Ministry of Justice and Consumer Protection (2004). Bundesministerium der Justiz: Verordnung über Nahrungsergänzungsmittel (NemV) § 1 Anwendungsbereich. https://www.gesetze-im-internet.de/nemv/BJNR101110004.html Accessed January 23, 2023.

Ferrari, N. and Graf, C. (2017). Bewegungsempfehlungen für Frauen während und nach der Schwangerschaft. *Gesundheitswesen* **79**, 36-39.

Ferrari, N., Mallmann, P., Brockmeier, K., Strüder, H. K. and Graf, C. (2014). Secular trends in pregnancy weight gain in German women and their influences on foetal outcome: a hospital-based study. *BMC pregnancy and childbirth* **14**, 228.

Finger, J. D., Mensink, G. B., Lange, C. and Manz, K. (2017). Gesundheitsfördernde körperliche Aktivität in der Freizeit bei Erwachsenen in Deutschland. *Journal of Health Monitoring* **2**, 37–44.

Fleming, T. P., Watkins, A. J., Velazquez, M. A., Mathers, J. C., Prentice, A. M., Stephenson, J., Barker, M., Saffery, R., Yajnik, C. S., Eckert, J. J. et al. (2018). Origins of lifetime health around the time of conception: causes and consequences. *Lancet* **391**, 1842–1852.

G.B.D. Obesity Collaborators, Afshin, A., Forouzanfar, M. H., Reitsma, M. B., Sur, P., Estep, K., Lee, A., Marczak, L., Mokdad, A. H., Moradi-Lakeh, M. et al. (2017). Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *New England journal of medicine* **377**, 13–27.

Gaillard, R., Durmuş, B., Hofman, A., Mackenbach, J. P., Steegers, E. A. P. and Jaddoe, V. W. V. (2013). Risk Factors and Outcomes of Maternal Obesity and Excessive Weight Gain During Pregnancy. *Obesity* **21**, 1046–1055.

Geyer, K., Günther, J., Hoffmann, J., Spies, M., Raab, R., Zhelyazkova, A., Rose, I. and Hauner, H. (2022). Dietary Supplementation Before, During and After Pregnancy: Results of the Cluster-Randomized GeliS Study. *Geburtshilfe und Frauenheilkunde* **82**, 736–746.

Geyer, K., Raab, R., Hoffmann, J. and Hauner, H. (2023). Development and validation of a screening questionnaire for early identification of pregnant women at risk for excessive gestational weight gain. *BMC pregnancy and childbirth* **23**, 249.

Geyer, K., Spies, M., Günther, J., Hoffmann, J., Raab, R., Meyer, D., Rauh, K. and Hauner, H. (2021). Effects of a Prenatal Lifestyle Intervention in Routine Care on Maternal Health Behaviour in the First Year Postpartum - Secondary Findings of the Cluster-Randomised GeliS Trial. *Nutrients* **13**, 1310.

Goldstein, R. F., Abell, S. K., Ranasinha, S., Misso, M., Boyle, J. A., Black, M. H., Li, N., Hu, G., Corrado, F., Rode, L. et al. (2017). Association of Gestational Weight Gain With Maternal and Infant Outcomes: A Systematic Review and Meta-analysis. *JAMA* **317**, 2207–2225.

Günther, J., Hoffmann, J., Kunath, J., Spies, M., Meyer, D., Stecher, L., Rosenfeld, E., Kick, L., Rauh, K. and Hauner, H. (2019a). Effects of a Lifestyle Intervention in Routine Care on Prenatal Dietary Behavior - Findings from the Cluster-Randomized GeliS Trial. *Journal of clinical medicine* **8**, 960.

Günther, J., Hoffmann, J., Spies, M., Meyer, D., Kunath, J., Stecher, L., Rosenfeld, E., Kick, L., Rauh, K. and Hauner, H. (2019b). Associations between the Prenatal Diet and Neonatal Outcomes - A Secondary Analysis of the Cluster-Randomised GeliS Trial. *Nutrients* **11**, 1889.

Günther, J., Hoffmann, J., Stecher, L., Spies, M., Geyer, K., Raab, R., Meyer, D., Rauh, K. and Hauner, H. (2022). How does antenatal lifestyle affect the risk for gestational diabetes mellitus? A secondary cohort analysis from the GeliS trial. *European journal of clinical nutrition* **76**, 150–158.

Haftenberger, M., Heuer, T., Heidemann, C., Kube, F., Krems, C. and Mensink, G. B. M. (2010). Relative validation of a food frequency questionnaire for national health and nutrition monitoring. *Nutrition journal* **9**, 36.

Haftenberger, M., Mensink, G. B. M., Herzog, B., Kluttig, A., Greiser, K. H., Merz, B., Nöthlings, U., Schlesinger, S., Vogt, S., Thorand, B. et al. (2016). Changes in body weight and obesity status in German adults: results of seven population-based prospective studies. *European journal of clinical nutrition* **70**, 300–305.

Hardeman, W., Houghton, J., Lane, K., Jones, A. and Naughton, F. (2019). A systematic review of just-in-time adaptive interventions (JITAIs) to promote physical activity. *International journal of behavioral nutrition and physical activity* **16**, 31.

Hartley, E., McPhie, S., Skouteris, H., Fuller-Tyszkiewicz, M. and Hill, B. (2015). Psychosocial risk factors for excessive gestational weight gain: A systematic review. *Women and Birth* **28**, e99-e109.

Hauner, H. (2022). Stoffwechsel und Ernährung in der Schwangerschaft. *Monatsschrift Kinderheilkunde* **170**, 116–124.

Hayes, L., McParlin, C., Azevedo, L. B., Jones, D., Newham, J., Olajide, J., McCleman, L. and Heslehurst, N. (2021). 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* **13**, 1036.

Heery, E., Kelleher, C. C., Wall, P. G. and McAuliffe, F. M. (2015). Prediction of gestational weight gain - a biopsychosocial model. *Public health nutrition* **18**, 1488–1498.

Heron, K. E. and Smyth, J. M. (2010). Ecological Momentary Interventions: Incorporating Mobile Technology Into Psychosocial and Health Behaviour Treatments. *British journal of health psychology* **15**, 1–39.

Heslehurst, N., Hayes, L., Jones, D., Newham, J., Olajide, J., McLeman, L., McParlin, C., de Brun, C. and Azevedo, L. (2020). The effectiveness of smoking cessation, alcohol reduction, diet and physical activity interventions in changing behaviours during pregnancy: A systematic review of systematic reviews. *PLOS ONE* **15**, e0232774.

Heslehurst, N., Vieira, R., Akhter, Z., Bailey, H., Slack, E., Ngongalah, L., Pemu, A. and Rankin, J. (2019). The association between maternal body mass index and child obesity: A systematic review and meta-analysis. *PLoS medicine* **16**, e1002817.

Hill, B., Bergmeier, H., McPhie, S., Fuller-Tyszkiewicz, M., Teede, H., Forster, D., Spiliotis, B. E., Hills, A. P. and Skouteris, H. (2017). Is parity a risk factor for excessive weight gain during pregnancy and postpartum weight retention? A systematic review and meta-analysis. *Obesity Reviews* **18**, 755–764.

Hill, B., Skouteris, H., Boyle, J. A., Bailey, C., Walker, R., Thangaratinam, S., Sundseth, H., Stephenson, J., Steegers, E., Redman, L. M. et al. (2020). Health in Preconception, Pregnancy and Postpartum Global Alliance: International Network Pregnancy Priorities for the Prevention of Maternal Obesity and Related Pregnancy and Long-Term Complications. *Journal of clinical medicine* **9**, 822.

Hill, B., Skouteris, H., McCabe, M., Milgrom, J., Kent, B., Herring, S. J., Hartley-Clark, L. and Gale, J. (2013). A conceptual model of psychosocial risk and protective factors for excessive gestational weight gain. *Midwifery* **29**, 110–114.

Hoffmann, J., Günther, J., Geyer, K., Stecher, L., Kunath, J., Meyer, D., Spies, M., Rosenfeld, E., Kick, L., Rauh, K. et al. (2019a). Associations between Prenatal Physical Activity and Neonatal and Obstetric Outcomes - A Secondary Analysis of the Cluster-Randomized GeliS Trial. *Journal of clinical medicine* **8**, 1735.

Hoffmann, J., Günther, J., Geyer, K., Stecher, L., Rauh, K., Kunath, J., Meyer, D., Sitzberger, C., Spies, M., Rosenfeld, E. et al. (2019b). Effects of a lifestyle intervention in routine care on prenatal physical activity – findings from the cluster-randomised GeliS trial. *BMC pregnancy and childbirth* **19**, 414.

Hoffmann, J., Günther, J., Stecher, L., Spies, M., Geyer, K., Raab, R., Meyer, D., Rauh, K. and Hauner, H. (2021). Infant growth during the first year of life following a pregnancy lifestyle intervention in routine care - Findings from the cluster-randomised GeliS trial. *Pediatric obesity* **16**, e12705.

Hoffmann, J., Günther, J., Stecher, L., Spies, M., Meyer, D., Kunath, J., Raab, R., Rauh, K. and Hauner, H. (2019c). Effects of a Lifestyle Intervention in Routine Care on Short- and Long-Term Maternal Weight Retention and Breastfeeding Behavior - 12 Months Follow-up of the Cluster-Randomized GeliS Trial. *Journal of clinical medicine* **8**, 876.

Horan, M. K., McGowan, C. A., Gibney, E. R., Byrne, J., Donnelly, J. M. and McAuliffe, F. M. (2016). Maternal Nutrition and Glycaemic Index during Pregnancy Impacts on Offspring Adiposity at 6 Months of Age - Analysis from the ROLO Randomised Controlled Trial. *Nutrients* **8**, 7.

Horan, M. K., McGowan, C. A., Gibney, E. R., Donnelly, J. M. and McAuliffe, F. M. (2014). Maternal Diet and Weight at 3 Months Postpartum Following a Pregnancy Intervention with a Low Glycaemic Index Diet: Results from the ROLO Randomised Control Trial. *Nutrients* **6**, 2946–2955.

Hosmer, D. W., Lemeshow, S. and Sturdivant, R. X. (2013). *Applied Logistic Regression*. New York: John Wiley & Sons.

Innis, S. M. (2014). Impact of maternal diet on human milk composition and neurological development of infants. *The American journal of clinical nutrition* **99**, 734–41.

Inskip, H. M., Crozier, S. R., Godfrey, K. M., Borland, S. E., Cooper, C. and Robinson, S. M. (2009). Women's compliance with nutrition and lifestyle recommendations before pregnancy: general population cohort study. *BMJ* **338**, b481.

i-WIP Collaborative Group (2017). Effect of diet and physical activity based interventions in pregnancy on gestational weight gain and pregnancy outcomes: meta-analysis of individual participant data from randomised trials. *BMJ* **358**, j3119.

Iyawa, G. E., Dansharif, A. R. and Khan, A. (2021). Mobile apps for self-management in pregnancy: a systematic review. *Health and Technology* **11**, 283–294.

Johar, H., Hoffmann, J., Günther, J., Atasoy, S., Stecher, L., Spies, M., Hauner, H. and Ladwig, K.-H. (2020). Evaluation of antenatal risk factors for postpartum depression: a secondary cohort analysis of the cluster-randomised GeliS trial. *BMC medicine* **18**, 227.

Johnson, J. L., Farr, S. L., Dietz, P. M., Sharma, A. J., Barfield, W. D. and Robbins, C. L. (2015). Trends in gestational weight gain: the Pregnancy Risk Assessment Monitoring System, 2000-2009. *American journal of obstetrics and gynecology* **212**, 806.e1-8.

Joossens, L., Olefir, L., Feliu, A. and Fernandez, E. (2022). The Tobacco Control Scale 2021 in Europe. https://www.tobaccocontrolscale.org/ Accessed July 23, 2023.

Kapadia, M. Z., Gaston, A., van Blyderveen, S., Schmidt, L., Beyene, J., McDonald, H. and McDonald, S. D. (2015). Psychological antecedents of excess gestational weight gain: a systematic review. *BMC pregnancy and childbirth* **15**, 107.

Kersting, M., Hockamp, N., Burak, C. and Lücke, T., eds. (2020). *Studie zur Erhebung von Daten zum Stillen und zur Säuglingsernährung in Deutschland – SuSe II. In: Deutsche Gesellschaft für Ernährung, Hrsg. 14. DGE-Ernährungsbericht (Vorveröffentlichung Kapitel 3)*: Deutsche Gesellschaft für Ernährung e. V. Bonn.

Khomami, M. B., Teede, H. J., Enticott, J., O'Reilly, S., Bailey, C. and Harrison, C. L. (2022). Implementation of Antenatal Lifestyle Interventions Into Routine Care: Secondary Analysis of a Systematic Review. *JAMA network open* **5**, e2234870.

Khoshnood, B., Loane, M., Walle, H. de, **Arriola, L., Addor, M.-C., Barisic, I., Beres, J., Bianchi, F., Dias, C., Draper, E. et al.** (2015). Long term trends in prevalence of neural tube defects in Europe: population based study. *BMJ* **351**, h5949.

Kluge, H. H. P. (2022). *WHO European Regional Obesity Report 2022*. Copenhagen: World Health Organization.

Knoke, J., Raab, R., Geyer, K., Spies, M., Haller, B. and Hauner, H. (2023). Antibiotic Treatment During Pregnancy and the First Six Months Postpartum - a Secondary Analysis of the "Healthy Living in Pregnancy" (GeliS) Study. *Geburtshilfe und Frauenheilkunde* **83**, 850–861.

Koletzko, B., Bauer, C.-P., Bung, P., Cremer, M., Flothkötter, M., Hellmers, C., Kersting, M., Krawinkel, M., Przyrembel, H., Rasenack, R. et al. (2012). Ernährung in der Schwangerschaft - Teil 1 [Nutrition in pregnancy - Practice recommendations of the Network "Healthy Start - Young Family Network"]. *Deutsche medizinische Wochenschrift* **137**, 1309–1314.

Koletzko, B., Bauer, C.-P., Cierpka, M., Cremer, M., Flothkötter, M., Graf, C., Heindl, I., Hellmers, C., Kersting, M., Krawinkel, M. et al. (2016). Ernährung und Bewegung von Säuglingen und stillenden Frauen. Aktualisierte Handlungsempfehlungen von „Gesund ins Leben – Netzwerk Junge Familie“, eine Initiative von IN FORM. *Monatsschrift Kinderheilkunde* **164**, 771–798.

Koletzko, B., Cremer, M., Flothkötter, M., Graf, C., Hauner, H., Hellmers, C., Kersting, M., Krawinkel, M., Przyrembel, H., Röbl-Mathieu, M. et al. (2018). Diet and Lifestyle Before and During Pregnancy - Practical Recommendations of the Germany-wide Healthy Start - Young Family Network. *Geburtshilfe und Frauenheilkunde* **78**, 1262–1282.

Kowoll, S., Kurzenhäuser-Carstens, S., Martin, A. and Weißenborn, A. (2015). Folsäure zur Prävention von Neuralrohrdefekten – Wissen und Einstellungen sowie Beratungs- und Einnahmepraxis in Berlin. *Zeitschrift für Geburtshilfe und Neonatologie* **219**, P11_8.

Krebs, F., Lorenz, L., Nawabi, F., Alayli, A. and Stock, S. (2022). Effectiveness of a Brief Lifestyle Intervention in the Prenatal Care Setting to Prevent Excessive Gestational Weight Gain and Improve Maternal and Infant Health Outcomes. *International journal of environmental research and public health* **19**, 5863.

Kroenke, K., Spitzer, R. L. and Williams, J. B. (2003). The Patient Health Questionnaire-2: validity of a two-item depression screener. *Medical care* **41**, 1284–1292.

Kroenke, K., Spitzer, R. L., Williams, J. B. and Löwe, B. (2009). An ultra-brief screening scale for anxiety and depression: the PHQ-4. *Psychosomatics* **50**, 613–621.

Kuhn, D.-A. *Entwicklung eines Index zur Bewertung der Ernährungsqualität in der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1). Master´s Thesis*: Robert Koch-Institut.

Kunath, J., Günther, J., Rauh, K., Hoffmann, J., Stecher, L., Rosenfeld, E., Kick, L., Ulm, K. and Hauner, H. (2019). Effects of a lifestyle intervention during pregnancy to prevent excessive gestational weight gain in routine care - the cluster-randomised GeliS trial. *BMC medicine* **17**, 5.

Kuntz, B., Zeiher, J., Starker, A., Prütz, F. and Lampert, T. (2018). Rauchen in der Schwangerschaft – Querschnittergebnisse aus KiGGS Welle 2 und Trends. *Journal of Health Monitoring* **3**, 47–54.

Langley-Evans, S. C. (2022). Early life programming of health and disease: The long-term consequences of obesity in pregnancy. *Journal of human nutrition and dietetics* **35**, 816–832.

Lardon, E., St-Laurent, A., Babineau, V., Descarreaux, M. and Ruchat, S.-M. (2018). Lumbopelvic pain, anxiety, physical activity and mode of conception: a prospective cohort study of pregnant women. *BMJ open* **8**, e022508.

Larson-Meyer, D. E. (2002). Effect of postpartum exercise on mothers and their offspring: a review of the literature. *Obesity research* **10**, 841–853.

Lauby-Secretan, B., Scoccianti, C., Loomis, D., Grosse, Y., Bianchini, F. and Straif, K. (2016). Body Fatness and Cancer - Viewpoint of the IARC Working Group. *New England journal of medicine* **375**, 794–798.

LifeCycle Project-Maternal Obesity and Childhood Outcomes Study Group (2019). Association of Gestational Weight Gain With Adverse Maternal and Infant Outcomes. *JAMA* **321**, 1702–1715.

Lim, S., Hill, B., Pirotta, S., O'Reilly, S. and Moran, L. (2020). What Are the Most Effective Behavioural Strategies in Changing Postpartum Women's Physical Activity and Healthy Eating Behaviours? A Systematic Review and Meta-Analysis. *Journal of clinical medicine* **9**, 237.

Liu, B., Xu, G., Sun, Y., Qiu, X., Ryckman, K. K., Yu, Y., Snetselaar, L. G. and Bao, W. (2020). Maternal cigarette smoking before and during pregnancy and the risk of preterm birth: A dose-response analysis of 25 million mother-infant pairs. *PLoS medicine* **17**, e1003158.

Liva, S. J., Hall, W. A. and Oliffe, J. (2021). Reconciling relationships with physical activity: a qualitative study of women's postnatal physical activity decision-making. *BMC pregnancy and childbirth* **21**, 81.

Livock, M., Anderson, P. J., Lewis, S., Bowden, S., Muggli, E. and Halliday, J. (2016). Maternal micronutrient consumption periconceptionally and during pregnancy: a prospective cohort study. *Public health nutrition* **20**, 294–304.

Luke, S., Kirby, R. S. and Wright, L. (2016). Postpartum Weight Retention and Subsequent Pregnancy Outcomes. *The Journal of perinatal & neonatal nursing* **34**, 292–301.

Marshall, S., Johnson, B. J., Hesketh, K. D., Campbell, K. J., Fraser, K., Love, P., Denney-Wilson, E., Salmon, J., McCallum, Z. and Laws, R. (2023). Mapping intervention

components from a randomized controlled trial to scale-up of an early life nutrition and movement intervention: The INFANT program. *Frontiers in public health* **10**, 1026856.

Martin, J. C., Joham, A. E., Mishra, G. D., Hodge, A. M., Moran, L. J. and Harrison, C. L. (2020). Postpartum Diet Quality: A Cross-Sectional Analysis from the Australian Longitudinal Study on Women's Health. *Journal of clinical medicine* **9**, 446.

McBride, C. M., Emmons, K. M. and Lipkus, I. M. (2003). Understanding the potential of teachable moments: the case of smoking cessation. *Health education research* **18**, 156–170.

McCrabb, S., Lane, C., Hall, A., Milat, A., Bauman, A., Sutherland, R., Yoong, S. and Wolfenden, L. (2019). Scaling-up evidence-based obesity interventions: A systematic review assessing intervention adaptations and effectiveness and quantifying the scale-up penalty. *Obesity Reviews* **20**, 964–982.

McKinley, M. C., Allen-Walker, V., McGirr, C., Rooney, C. and Woodside, J. V. (2018). Weight loss after pregnancy: challenges and opportunities. *Nutrition research reviews* **31**, 1–14.

McNestry, C., Killeen, S. L., Crowley, R. K. and McAuliffe, F. M. (2023). Pregnancy complications and later life women's health. *Acta obstetricia et gynecologica Scandinavica* **102**, 523–531.

Melzer, K., Schutz, Y., Boulvain, M. and Kayser, B. (2010). Physical Activity and Pregnancy. *Sports Medicine* **40**, 493–507.

Mertens, L., Braeken, M. A. K. A. and Bogaerts, A. (2019). Effect of lifestyle coaching including telemonitoring and telecoaching on gestational weight gain and postnatal weight Loss: A systematic review. *Telemedicine journal and e-health* **25**, 889–901.

Metz, C. E. (1978). Basic principles of ROC analysis. *Seminars in nuclear medicine* **8**, 283–298.

Meyer, D., Gjika, E., Hauner, H., Michel, S. and Raab, R. (2023). Gestational Weight Gain and Its Effect on Short-and Long-Term Postpartum Weight Retention: An Updated Systematic Review and Meta-Analysis (OR21-07-23). *Current Developments in Nutrition - Abstracts from NUTRITION 2023* **7**, 100991.

Montgomery-Downs, H. E., Insana, S. P., Clegg-Kraynok, M. M. and Mancini, L. M. (2010). Normative longitudinal maternal sleep: the first 4 postpartum months. *American Journal of Obstetrics & Gynecology* **203**, 465.e1-465.e7.

Moran, L. J., Flynn, A. C., Louise, J., Deussen, A. R. and Dodd, J. M. (2017). The Effect of a Lifestyle Intervention on Pregnancy and Postpartum Dietary Patterns Determined by Factor Analysis. *Obesity* **25**, 1022–1032.

Moussa, H. N., Hosseini Nasab, S., Haidar, Z. A., Blackwell, S. C. and Sibai, B. M. (2016). Folic acid supplementation: what is new? Fetal, obstetric, long-term benefits and risks. *Future science OA* **2**, FSO116.

Mudd, L. M., Nechuta, S., Pivarnik, J. M. and Paneth, N. (2009). Factors associated with women's perceptions of physical activity safety during pregnancy. *Preventive medicine* **49**, 194–199.

Murray-Davis, B., Grenier, L., Atkinson, S. A., Mottola, M. F., Wahoush, O., Thabane, L., Xie, F., Vickers-Manzin, J., Moore, C. and Hutton, E. K. (2019). Experiences regarding nutrition and exercise among women during early postpartum: a qualitative grounded theory study. *BMC pregnancy and childbirth* **19**, 368.

Nahum-Shani, I., Hekler, E. B. and Spruijt-Metz, D. (2015). Building health behavior models to guide the development of just-in-time adaptive interventions: A pragmatic framework. *Health psychology* **34**, 1209–1219.

Nakamura, A., van der Waerden, J., Melchior, M., Bolze, C., El-Khoury, F. and Pryor, L. (2019). Physical activity during pregnancy and postpartum depression: Systematic review and meta-analysis. *Journal of Affective Disorders* **246**, 29–41.

NCD Risk Factor Collaboration (2016). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. *Lancet* **387**, 1377–1396.

NCD Risk Factor Collaboration (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet* **390**, 2627–2642.

Nehring, I., Schmoll, S., Beyerlein, A., Hauner, H. and von Kries, R. (2011). Gestational weight gain and long-term postpartum weight retention: a meta-analysis. *American journal of clinical nutrition* **94**, 1225–1231.

Noever, K., Schubert, J., Reuschel, E., Timmesfeld, N. and Arabin, B. (2020). Changes in Maternal Body Mass Index, Weight Gain and Outcome of Singleton Pregnancies from 2000 to 2015: A Population-based Retrospective Cohort Study in Hesse/Germany. *Geburtshilfe und Frauenheilkunde* **80**, 508–517.

Opie, R. S., Uldrich, A. C. and Ball, K. (2020). Maternal Postpartum Diet and Postpartum Depression: A Systematic Review. *Maternal and child health journal* **24**, 966–978.

Overdijkink, S. B., Velu, A. V., Rosman, A. N., van Beukering, M. D., Kok, M. and Steegers-Theunissen, R. P. (2018). The Usability and Effectiveness of Mobile Health Technology-Based Lifestyle and Medical Intervention Apps Supporting Health Care During Pregnancy: Systematic Review. *JMIR mHealth and uHealth* **6**, e109.

Parisi, F., Di Bartolo, I., Savasi, V. M. and Cetin, I. (2019). Micronutrient supplementation in pregnancy: Who, what and how much? *Obstetric medicine* **12**, 5–13.

Patel, N., Godfrey, K. M., Pasupathy, D., Levin, J., Flynn, A. C., Hayes, L., Briley, A. L., Bell, R., Lawlor, D. A., Oteng-Ntim, E. et al. (2017). Infant adiposity following a randomised controlled trial of a behavioural intervention in obese pregnancy. *International journal of obesity* **41**, 1018–1026.

Pegington, M., French, D. P. and Harvie, M. N. (2020). Why young women gain weight: A narrative review of influencing factors and possible solutions. *Obesity Reviews* **21**, e13002.

Petch, S., McAuliffe, F., O'Reilly, S., Murphy, C., Coulter-Smith, S., de Campos, D., Khattak, H. and Mahmood, T. (2022). Folic acid fortification of flour to prevent neural tube defects in Europe - A position statement by the European Board and college of obstetrics and gynaecology (EBCOG). *European journal of obstetrics, gynecology, and reproductive biology* **279**, 109–111.

Phelan, S. (2010). Pregnancy: A "teachable moment" for weight control and obesity prevention. *American journal of obstetrics and gynecology* **202**, 135.e1-8.

Poston, L. (2023). Interventions to Prevent DOHaD Effects in Pregnancy. In *Developmental origins of health and disease* (ed. L. Poston, K. Godfrey, P. D. Gluckman and M. A. Hanson), pp. 177–188. Cambridge, United Kingdom: Cambridge University Press.

Poston, L., Bell, R., Croker, H., Flynn, A. C., Godfrey, K. M., Goff, L., Hayes, L., Khazaezadeh, N., Nelson, S. M., Oteng-Ntim, E. et al. (2015). Effect of a behavioural intervention in obese pregnant women (the UPBEAT study): a multicentre, randomised controlled trial. *Lancet Diabetes & endocrinology* **3**, 767–777.

Poston, L., Caleyachetty, R., Cnattingius, S., Corvalán, C., Uauy, R., Herring, S. and Gillman, M. W. (2016). Preconceptional and maternal obesity: epidemiology and health consequences. *The lancet. Diabetes & endocrinology* **4**, 1025–1036.

Raab, R., Geyer, K., Zagar, S. and Hauner, H. (2022a). App-Supported Lifestyle Interventions in Pregnancy to Manage Gestational Weight Gain and Prevent Gestational Diabetes – A Scoping Review Protocol. https://doi.org/10.17605/OSF.IO/HJDC8 Accessed 26.10.23.

Raab, R., Hoffmann, J., Spies, M., Geyer, K., Meyer, D., Günther, J. and Hauner, H. (2022b). Are pre- and early pregnancy lifestyle factors associated with the risk of preterm birth? A secondary cohort analysis of the cluster-randomised GeliS trial. *BMC pregnancy and childbirth* **22**, 230.

Ranasinha, S., Hill, B., Teede, H. J., Enticott, J., Wang, R. and Harrison, C. L. (2022). Efficacy of behavioral interventions in managing gestational weight gain (GWG): A component network meta-analysis. *Obesity Reviews* **23**, e13406.

Rasmussen, K. M. and Yaktine, A. L., eds. (2009). *Weight Gain During Pregnancy: Reexamining the Guidelines*: National Academies Press. Washington (DC).

Rauh, K., Gabriel, E., Kerschbaum, E., Schuster, T., Kries, R. von, **Amann-Gassner, U. and Hauner, H.** (2013). Safety and efficacy of a lifestyle intervention for pregnant women to prevent excessive maternal weight gain: a cluster-randomized controlled trial. *BMC pregnancy and childbirth* **13**, 151.

Rauh, K., Günther, J., Kunath, J., Stecher, L. and Hauner, H. (2015). Lifestyle intervention to prevent excessive maternal weight gain: mother and infant follow-up at 12 months postpartum. *BMC pregnancy and childbirth* **15**, 265.

Rauh, K., Kunath, J., Rosenfeld, E., Kick, L., Ulm, K. and Hauner, H. (2014). Healthy living in pregnancy: a cluster-randomized controlled trial to prevent excessive gestational weight gain - rationale and design of the GeliS study. *BMC Pregnancy Childbirth* **14**, 119.

Redman, K., Ruffman, T., Fitzgerald, P. and Skeaff, S. (2016). Iodine Deficiency and the Brain: Effects and Mechanisms. *Critical reviews in food science and nutrition* **56**, 2695–2713.

Restall, A., Taylor, R. S., Thompson, J. M. D., Flower, D., Dekker, G. A., Kenny, L. C., Poston, L. and McCowan, L. M. E. (2014). Risk Factors for Excessive Gestational Weight Gain in a Healthy, Nulliparous Cohort. *Journal of obesity* **2014**, 148391.

Rhodes, A., Smith, A. D., Chadwick, P., Croker, H. and Llewellyn, C. H. (2020). Exclusively Digital Health Interventions Targeting Diet, Physical Activity, and Weight Gain in Pregnant Women: Systematic Review and Meta-Analysis. *JMIR mHealth and uHealth* **8**, e18255.

Richardsen, K. R., Mdala, I., Berntsen, S., Ommundsen, Y., Martinsen, E. W., Sletner, L. and Jenum, A. K. (2016). Objectively recorded physical activity in pregnancy and postpartum in a multi-ethnic cohort: association with access to recreational areas in the neighbourhood. *International journal of behavioral nutrition and physical activity* **13**, 78.

Riley, W. T., Rivera, D. E., Atienza, A. A., Nilsen, W., Allison, S. M. and Mermelstein, R. (2011). Health behavior models in the age of mobile interventions: are our theories up to the task? *Translational behavioral medicine* **1**, 53–71.

RKI (2020). AdiMon-Themenblatt: Schwangerschaft. www.rki.de/adimon Accessed August 23, 2023.

Roche, D., Rafferty, A., Holden, S., Killeen, S. L., Kennelly, M. and M. McAuliffe, F. (2023). Maternal Well-Being and Stage of Behaviour Change during Pregnancy: A Secondary Analysis of the PEARS Randomised Controlled Trial. *International journal of environmental research and public health* **20**, 34.

Rong, K., Yu, K., Han, X., Szeto, I. M. Y., Qin, X., Wang, J., Ning, Y., Wang, P. and Ma, D. (2015). Pre-pregnancy BMI, gestational weight gain and postpartum weight retention: a meta-analysis of observational studies. *Public health nutrition* **18**, 2172–2182.

Rütten, A. and Pfeifer, K., eds. (2017). *Nationale Empfehlungen für Bewegung und Bewegungsförderung*. Forschung und Praxis der Gesundheitsförderung, Sonderheft 03: Bundeszentrale für gesundheitliche Aufklärung (BZgA). Köln.

Sámano, R., Martínez-Rojano, H., Ortiz-Hernández, L., Nájera-Medina, O., Chico-Barba, G., Gamboa, R. and Mendoza-Flores, M. E. (2023). Individual, Family, and Social Factors Associated with Gestational Weight Gain in Adolescents: A Scoping Review. *Nutrients* **15**, 1530.

Samura, T., Steer, J., Michelis, L. D., Carroll, L., Holland, E. and Perkins, R. (2016). Factors Associated With Excessive Gestational Weight Gain: Review of Current Literature. *Global advances in health and medicine* **5**, 87–93.

Santos, S., Eekhout, I., Voerman, E., Gaillard, R., Barros, H., Charles, M.-A., Chatzi, L., Chevrier, C., Chrousos, G. P., Corpeleijn, E. et al. (2018). Gestational weight gain charts for different body mass index groups for women in Europe, North America, and Oceania. *BMC medicine* **16**, 201.

Schienkiewitz, A., Damerow, S., Richter, A. and Mensink, G. B. (2022a). Hat sich das Körpergewicht seit Beginn der COVID-19 Pandemie verändert? *Journal of Health Monitoring* **7**, 58–65.

Schienkiewitz, A., Kuhnert, R., Blume, M. and Mensink, G. B.M. (2022b). Übergewicht und Adipositas bei Erwachsenen in Deutschland - Ergebnisse der Studie GEDA 2019/2020-EHIS. *Journal of Health Monitoring* **7**, 23–31.

Scott, E. M., Feig, D. S., Murphy, H. R. and Law, G. R. (2020). Continuous Glucose Monitoring in Pregnancy: Importance of Analyzing Temporal Profiles to Understand Clinical Outcomes. *Diabetes care* **43**, 1178–1184.

Shephard, R. J. (2003). Limits to the measurement of habitual physical activity by questionnaires. *British journal of sports medicine* **37**, 197-206.

Silva-Jose, C., Sánchez-Polán, M., Barakat, R., Gil-Ares, J. and Refoyo, I. (2022). Level of Physical Activity in Pregnant Populations from Different Geographic Regions: A Systematic Review. *Journal of clinical medicine* **11**, 4638.

Sohlberg, T. and Bergmark, K. H. (2020). Lifestyle and Long-Term Smoking Cessation. *Tobacco use insights* **13**, 1179173X20963062.

Sparks, J., Ghildayal, N., Hivert, M. F. and Redman, L. M. (2022). Lifestyle interventions in pregnancy targeting GDM prevention: looking ahead to precision medicine. *Diabetologia* **65**, 1814–1824.

Spies, M., Geyer, K., Raab, R., Brandt, S., Meyer, D., Günther, J., Hoffmann, J. and Hauner, H. (2022). Child Anthropometrics and Neurodevelopment at 2 and 3 Years of Age Following an Antenatal Lifestyle Intervention in Routine Care - A Secondary Analysis from the Cluster-Randomised GeliS Trial. *Journal of clinical medicine* **11**, 1688.

Starker, A., Kuhnert, R., Hoebel, J. and Richter, A. (2022). Rauchverhalten und Passivrauchbelastung Erwachsener – Ergebnisse aus GEDA 2019/2020-EHIS. *Journal of Health Monitoring* **7**, 7–22.

Stephenson, J., Heslehurst, N., Hall, J., M Schoenaker, D. A. J., Hutchinson, J., Cade, J. E., Poston, L., Barrett, G., Crozier, S. R., Barker, M. et al. (2018). Before the beginning: nutrition and lifestyle in the preconception period and its importance for future health. *Lancet* **391**, 1830–1841.

Strauss, A., Rochow, N., Kunze, M., Hesse, V., Dudenhausen, J. W. and Voigt, M. (2021). Obesity in pregnant women: a 20-year analysis of the German experience. *European journal of clinical nutrition* **75**, 1757–1763.

Sullivan, L. M., Massaro, J. M. and D'Agostino, R. B. (2004). Presentation of multivariate data for clinical use: The Framingham Study risk score functions. *Statistics in Medicine* **23**, 1631–1660.

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L. and Gortmaker, S. L. (2011). The global obesity pandemic: shaped by global drivers and local environments. *Lancet* **378**, 804–814.

Swinburn, B. A., Sacks, G., Lo, S. K., Westerterp, K. R., Rush, E. C., Rosenbaum, M., Luke, A., Schoeller, D. A., DeLany, J. P., Butte, N. F. et al. (2009). Estimating the changes in energy flux that characterize the rise in obesity prevalence. *American journal of clinical nutrition* **89**, 1723–1728.

Teede, H. J., Bailey, C., Moran, L. J., Bahri Khomami, M., Enticott, J., Ranasinha, S., Rogozinska, E., Skouteris, H., Boyle, J. A., Thangaratinam, S. et al. (2022). Association of Antenatal Diet and Physical Activity-Based Interventions With Gestational Weight Gain and Pregnancy Outcomes: A Systematic Review and Meta-analysis. *JAMA internal medicine* **182**, 106–114.

Teulings, N. E. W. D., Masconi, K. L., Ozanne, S. E., Aiken, C. E. and Wood, A. M. (2019). Effect of interpregnancy weight change on perinatal outcomes: systematic review and meta-analysis. *BMC Pregnancy Childbirth* **19**, 386.

The European Parliament and the Council (2002). Directive 2002/46/EC on the approximation of the laws of the Member States relating to food supplements. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02002L0046-20060421&from=DE Accessed January 22, 2022.

Toivonen, K. I., Oinonen, K. A. and Duchene, K. M. (2017). Preconception health behaviours: A scoping review. *Preventive medicine* **96**, 1–15.

van Dijk, M. R., Koster, M. P.H., Oostingh, E. C., Willemsen, S. P., Steegers, E. A.P. and Steegers-Theunissen, R. P.M. (2020). A Mobile App Lifestyle Intervention to Improve Healthy Nutrition in Women Before and During Early Pregnancy: Single-Center Randomized Controlled Trial. *Journal of medical Internet research* **22**, e15773.

van Uytsel, H., Bijlholt, M., Devlieger, R., Ameye, L., Jochems, L., van Holsbeke, C., Schreurs, A., Catry, V. and Bogaerts, A. (2022). Effect of the e-health supported INTER-ACT lifestyle intervention on postpartum weight retention and body composition, and associations with lifestyle behavior: A randomized controlled trial. *Preventive medicine* **164**, 107321.

Viswanathan, M., Treiman, K. A., Kish-Doto, J., Middleton, J. C., Coker-Schwimmer, E. J. L. and Nicholson, W. K. (2017). Folic Acid Supplementation for the Prevention of Neural Tube Defects: An Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA* **317**, 190–203.

Voerman, E., Santos, S., Patro Golab, B., Amiano, P., Ballester, F., Barros, H., Bergström, A., Charles, M.-A., Chatzi, L., Chevrier, C. et al. (2019). Maternal body mass index, gestational weight gain, and the risk of overweight and obesity across childhood: An individual participant data meta-analysis. *PLoS medicine* **16**, e1002744.

WHO (2021). Fact sheet obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight Accessed August 23, 2023.

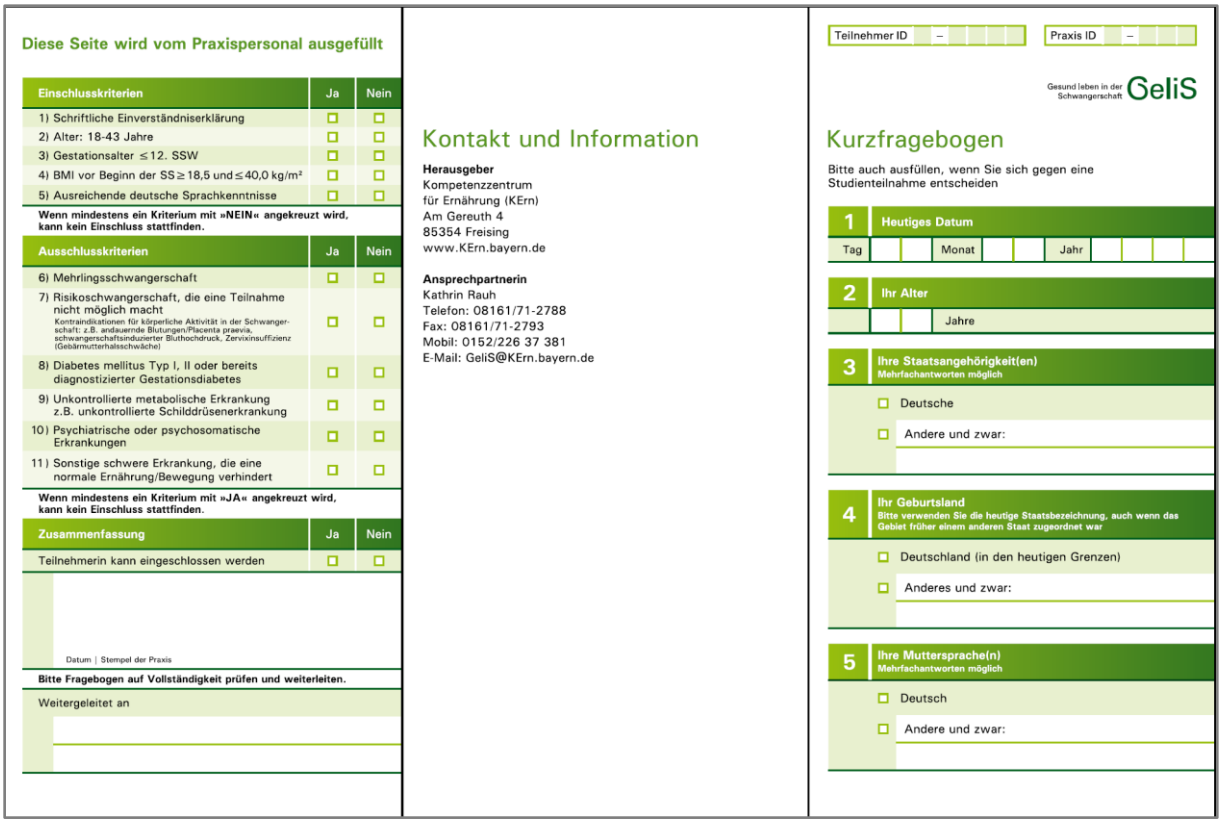
Williams, L. J., Mai, C. T., Edmonds, L. D., Shaw, G. M., Kirby, R. S., Hobbs, C. A., Sever, L. E., Miller, L. A., Meaney, F. J. and Levitt, M. (2002). Prevalence of spina bifida and anencephaly during the transition to mandatory folic acid fortification in the United States. *Teratology* **66**, 33–39.

World Obesity Federation (2022). World Obesity Atlas 2022. https://www.worldobesity.org/resources/resource-library/world-obesity-atlas-2022 Accessed August 23, 2023.

Zhou, M., Peng, X., Yi, H., Tang, S. and You, H. (2022). Determinants of excessive gestational weight gain: a systematic review and meta-analysis. *Archives of public health* **80**, 129.

Appendix

Appendix 1 – Screening questionnaire.



Diese Seite wird vom Praxispersonal ausgefüllt

Einschlusskriterien	Ja	Nein
1) Schriftliche Einverständniserklärung	☐	☐
2) Alter: 18-43 Jahre	☐	☐
3) Gestationsalter ≤ 12. SSW	☐	☐
4) BMI vor Beginn der SS ≥ 18,5 und ≤ 40,0 kg/m²	☐	☐
5) Ausreichende deutsche Sprachkenntnisse	☐	☐

Wenn mindestens ein Kriterium mit »NEIN« angekreuzt wird, kann kein Einschluss stattfinden.

Ausschlusskriterien	Ja	Nein
6) Mehrlingsschwangerschaft	☐	☐
7) Risikoschwangerschaft, die eine Teilnahme nicht möglich macht Kontraindikationen für körperliche Aktivität in der Schwangerschaft: z.B. andauernde Blutungen/Placenta praevia, schwangerschaftsinduzierter Bluthochdruck, Zervixinsuffizienz (Gebärmutterhalsschwäche)	☐	☐
8) Diabetes mellitus Typ I, II oder bereits diagnostizierter Gestationsdiabetes	☐	☐
9) Unkontrollierte metabolische Erkrankung z.B. unkontrollierte Schilddrüsenerkrankung	☐	☐
10) Psychiatrische oder psychosomatische Erkrankungen	☐	☐
11) Sonstige schwere Erkrankung, die eine normale Ernährung/Bewegung verhindert	☐	☐

Wenn mindestens ein Kriterium mit »JA« angekreuzt wird, kann kein Einschluss stattfinden.

Zusammenfassung	Ja	Nein
Teilnehmerin kann eingeschlossen werden	☐	☐

Datum | Stempel der Praxis

Bitte Fragebogen auf Vollständigkeit prüfen und weiterleiten.

Weitergeleitet an

Kontakt und Information

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Teilnehmer ID – Praxis ID –

Gesund leben in der Schwangerschaft GeliS

Kurzfragebogen

Bitte auch ausfüllen, wenn Sie sich gegen eine Studienteilnahme entscheiden

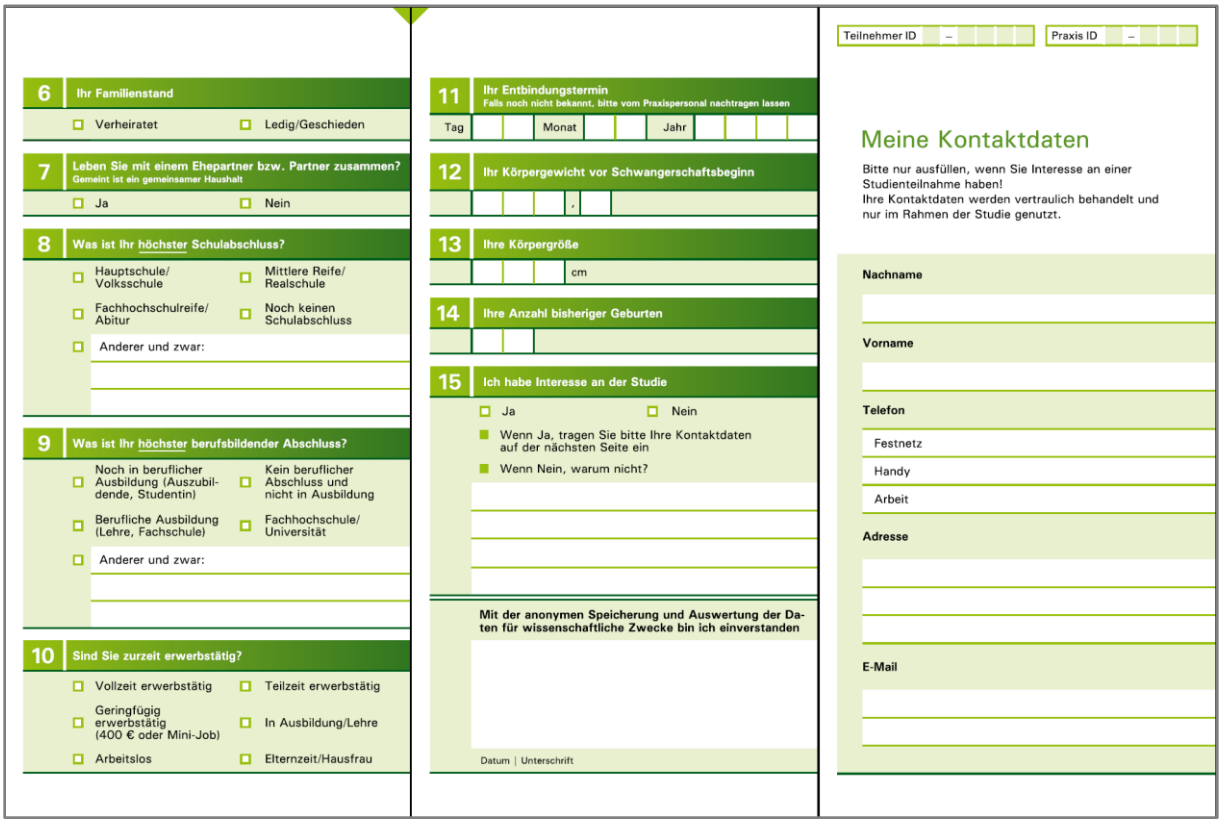
1 Heutiges Datum
Tag Monat Jahr

2 Ihr Alter
Jahre

3 Ihre Staatsangehörigkeit(en)
Mehrfachantworten möglich
☐ Deutsche
☐ Andere und zwar:

4 Ihr Geburtsland
Bitte verwenden Sie die heutige Staatsbezeichnung, auch wenn das Gebiet früher einem anderen Staat zugeordnet war
☐ Deutschland (in den heutigen Grenzen)
☐ Anderes und zwar:

5 Ihre Muttersprache(n)
Mehrfachantworten möglich
☐ Deutsch
☐ Andere und zwar:



6 Ihr Familienstand
☐ Verheiratet ☐ Ledig/Geschieden

7 Leben Sie mit einem Ehepartner bzw. Partner zusammen?
Gemeint ist ein gemeinsamer Haushalt
☐ Ja ☐ Nein

8 Was ist Ihr höchster Schulabschluss?
☐ Hauptschule/ Volksschule
☐ Mittlere Reife/ Realschule
☐ Fachhochschulreife/ Abitur
☐ Noch keinen Schulabschluss
☐ Anderer und zwar:

9 Was ist Ihr höchster berufsbildender Abschluss?
☐ Noch in beruflicher Ausbildung (Auszubildende, Studentin)
☐ Kein beruflicher Abschluss und nicht in Ausbildung
☐ Berufliche Ausbildung (Lehre, Fachschule)
☐ Fachhochschule/ Universität
☐ Anderer und zwar:

10 Sind Sie zurzeit erwerbstätig?
☐ Vollzeit erwerbstätig
☐ Teilzeit erwerbstätig
☐ Geringfügig erwerbstätig (400 € oder Mini-Job)
☐ In Ausbildung/Lehre
☐ Arbeitslos
☐ Elternzeit/Hausfrau

11 Ihr Entbindungstermin
Falls noch nicht bekannt, bitte vom Praxispersonal nachtragen lassen
Tag Monat Jahr

12 Ihr Körpergewicht vor Schwangerschaftsbeginn
, kg

13 Ihre Körpergröße
cm

14 Ihre Anzahl bisheriger Geburten

15 Ich habe Interesse an der Studie
☐ Ja ☐ Nein
■ Wenn Ja, tragen Sie bitte Ihre Kontaktdaten auf der nächsten Seite ein
■ Wenn Nein, warum nicht?

Mit der anonymen Speicherung und Auswertung der Daten für wissenschaftliche Zwecke bin ich einverstanden

Datum | Unterschrift

Teilnehmer ID – Praxis ID –

Meine Kontaktdaten

Bitte nur ausfüllen, wenn Sie Interesse an einer Studienteilnahme haben!
Ihre Kontaktdaten werden vertraulich behandelt und nur im Rahmen der Studie genutzt.

Nachname

Vorname

Telefon
Festnetz
Handy
Arbeit

Adresse

E-Mail

Appendix 2 – Pregnancy physical activity questionnaire applied for the physical activity assessment in the GeliS trial.

GeliS Gesund leben in der Schwangerschaft

Teilnehmer ID – Praxis ID –

Fragebogen zur Bewegung

- Sie werden gefragt, **wie viel Zeit** Sie in den letzten vier Wochen mit verschiedenen körperlichen Aktivitäten verbracht haben.
- Bitte beantworten Sie **jede** Frage. Wenn Sie sich nicht sicher sind, dann schätzen Sie. Eine ungefähre Schätzung ist besser als gar keine Antwort.
- Denken Sie bitte nur an Ihre Bewegung **in den letzten vier Wochen!**
- Bei den Zeitangaben geht es um **durchschnittliche Werte.**
- Bitte bei jeder Frage nur **eine Antwort** ankreuzen.

Beispiel:
Wie viel Zeit haben Sie **während der letzten 4 Wochen** durchschnittlich mit folgender Tätigkeit verbracht:

→ Wenn Sie täglich 2 Stunden lang Ihre Mutter pflegen, dann sollte Ihre Antwort folgendermaßen aussehen:

7	Ältere Erwachsene pflegen
	☐ Keine
	☐ Weniger als ½ Stunde pro Tag
	☐ ½ bis annähernd 1 Stunde pro Tag
	☐ 1 bis annähernd 2 Stunden pro Tag
	☒ 2 bis annähernd 3 Stunden pro Tag
	☐ 3 oder mehr Stunden pro Tag

Gesund leben in der Schwangerschaft GeliS

Zu Hause…

Wie viel Zeit haben Sie **während der letzten 4 Wochen** durchschnittlich mit folgenden Tätigkeiten verbracht:

1 Mahlzeiten vor- oder zubereiten (Kochen, Tisch decken, Geschirr spülen)

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

2 Im Sitzen Kinder ankleiden, baden oder füttern

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

3 Im Stehen Kinder ankleiden, baden oder füttern

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

4 Im Sitzen oder Stehen mit Kindern spielen

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

5 Im Gehen oder Rennen mit Kindern spielen

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

6 Kinder tragen

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

7 Ältere Erwachsene pflegen

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

8 Am Schreibtisch oder Computer sitzen, ohne in der Arbeit zu sein

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 1 Stunde pro Tag
- ☐ 1 bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 3 Stunden pro Tag
- ☐ 3 oder mehr Stunden pro Tag

GeliS Gesund leben in der Schwangerschaft

9	Fernsehen oder DVD schauen
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 4 Stunden pro Tag
☐	4 bis annähernd 6 Stunden pro Tag
☐	6 oder mehr Stunden pro Tag

10	Sitzen und lesen, reden oder telefonieren, **ohne** in der Arbeit zu sein
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 4 Stunden pro Tag
☐	4 bis annähernd 6 Stunden pro Tag
☐	6 oder mehr Stunden pro Tag

11	Mit Tieren spielen
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 1 Stunde pro Tag
☐	1 bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 3 Stunden pro Tag
☐	3 oder mehr Stunden pro Tag

12	**Leichte** Aufräum- oder Putzarbeiten erledigen (Betten machen, Wäsche waschen)
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 1 Stunde pro Tag
☐	1 bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 3 Stunden pro Tag
☐	3 oder mehr Stunden pro Tag

13	Einkaufen (Essen, Kleidung oder Sonstiges)
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 1 Stunde pro Tag
☐	1 bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 3 Stunden pro Tag
☐	3 oder mehr Stunden pro Tag

14	**Anstrengende** Putzarbeiten erledigen (Staub saugen, Fenster putzen, fegen)
☐	Keine
☐	Weniger als ½ Stunde pro **Woche**
☐	½ bis annähernd 1 Stunde pro **Woche**
☐	1 bis annähernd 2 Stunden pro **Woche**
☐	2 bis annähernd 3 Stunden pro **Woche**
☐	3 oder mehr Stunden pro **Woche**

15	Rasen mähen (kein Rasenmähertraktor), rechen oder andere Gartenarbeiten erledigen
☐	Keine
☐	Weniger als ½ Stunde pro **Woche**
☐	½ bis annähernd 1 Stunde pro **Woche**
☐	1 bis annähernd 2 Stunden pro **Woche**
☐	2 bis annähernd 3 Stunden pro **Woche**
☐	3 oder mehr Stunden pro **Woche**

Gesund leben in der Schwangerschaft GeliS

An Orte gehen...

Wie viel Zeit haben Sie **während der letzten 4 Wochen** durchschnittlich mit folgenden Tätigkeiten verbracht:

16	**Langsam** an diverse Orte gehen (z.B. zum Bus, zur Arbeit, zu Besuchen) **nicht** zum Spaß oder Sport
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 1 Stunde pro Tag
☐	1 bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 3 Stunden pro Tag
☐	3 oder mehr Stunden pro Tag

17	**Schnell** an diverse Orte gehen (z.B. zum Bus, zur Arbeit, zu Besuchen) **nicht** zum Spaß oder Sport
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 1 Stunde pro Tag
☐	1 bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 3 Stunden pro Tag
☐	3 oder mehr Stunden pro Tag

18	Mit Auto oder Bus fahren
☐	Keine
☐	Weniger als ½ Stunde pro Tag
☐	½ bis annähernd 1 Stunde pro Tag
☐	1 bis annähernd 2 Stunden pro Tag
☐	2 bis annähernd 3 Stunden pro Tag
☐	3 oder mehr Stunden pro Tag

Spaß oder Sport...

Wie viel Zeit haben Sie **während der letzten 4 Wochen** durchschnittlich mit folgenden Tätigkeiten verbracht:

19	**Langsam** gehen zum Spaß oder Sport
☐	Keine
☐	Weniger als ½ Stunde pro **Woche**
☐	½ bis annähernd 1 Stunde pro **Woche**
☐	1 bis annähernd 2 Stunden pro **Woche**
☐	2 bis annähernd 3 Stunden pro **Woche**
☐	3 oder mehr Stunden pro **Woche**

20	**Schnell** gehen zum Spaß oder Sport
☐	Keine
☐	Weniger als ½ Stunde pro **Woche**
☐	½ bis annähernd 1 Stunde pro **Woche**
☐	1 bis annähernd 2 Stunden pro **Woche**
☐	2 bis annähernd 3 Stunden pro **Woche**
☐	3 oder mehr Stunden pro **Woche**

GeliS Gesund leben in der Schwangerschaft

21	Schnell Berge hoch gehen, zum Spaß oder Sport
☐	Keine
☐	Weniger als ½ Stunde pro Woche
☐	½ bis annähernd 1 Stunde pro Woche
☐	1 bis annähernd 2 Stunden pro Woche
☐	2 bis annähernd 3 Stunden pro Woche
☐	3 oder mehr Stunden pro Woche

22	Joggen
☐	Keine
☐	Weniger als ½ Stunde pro Woche
☐	½ bis annähernd 1 Stunde pro Woche
☐	1 bis annähernd 2 Stunden pro Woche
☐	2 bis annähernd 3 Stunden pro Woche
☐	3 oder mehr Stunden pro Woche

23	Geburtsvorbereitungskurse besuchen
☐	Keine
☐	Weniger als ½ Stunde pro Woche
☐	½ bis annähernd 1 Stunde pro Woche
☐	1 bis annähernd 2 Stunden pro Woche
☐	2 bis annähernd 3 Stunden pro Woche
☐	3 oder mehr Stunden pro Woche

24	Schwimmen
☐	Keine
☐	Weniger als ½ Stunde pro Woche
☐	½ bis annähernd 1 Stunde pro Woche
☐	1 bis annähernd 2 Stunden pro Woche
☐	2 bis annähernd 3 Stunden pro Woche
☐	3 oder mehr Stunden pro Woche

25	Tanzen
☐	Keine
☐	Weniger als ½ Stunde pro Woche
☐	½ bis annähernd 1 Stunde pro Woche
☐	1 bis annähernd 2 Stunden pro Woche
☐	2 bis annähernd 3 Stunden pro Woche
☐	3 oder mehr Stunden pro Woche

Andere Dinge zum Spaß oder Sport getan?
Bitte sagen Sie uns welche:

26	
☐	Keine
☐	Weniger als ½ Stunde pro Woche
☐	½ bis annähernd 1 Stunde pro Woche
☐	1 bis annähernd 2 Stunden pro Woche
☐	2 bis annähernd 3 Stunden pro Woche
☐	3 oder mehr Stunden pro Woche

27	
☐	Keine
☐	Weniger als ½ Stunde pro Woche
☐	½ bis annähernd 1 Stunde pro Woche
☐	1 bis annähernd 2 Stunden pro Woche
☐	2 bis annähernd 3 Stunden pro Woche
☐	3 oder mehr Stunden pro Woche

Gesund leben in der Schwangerschaft GeliS

Bitte füllen Sie den nächsten Abschnitt nur aus, wenn Sie erwerbstätig sind, ehrenamtlich arbeiten oder Schülerin/Studentin sind. Wenn Sie Hausfrau, arbeitslos oder arbeitsunfähig sind, bitte weiter mit dem Fragebogen zur Ernährung (Seite 14).

In der Arbeit...

Wie viel Zeit haben Sie **während der letzten 4 Wochen** durchschnittlich mit folgenden Tätigkeiten verbracht:

28 In der Arbeit/Schule/Studium sitzen

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 4 Stunden pro Tag
- ☐ 4 bis annähernd 6 Stunden pro Tag
- ☐ 6 oder mehr Stunden pro Tag

29 In der Arbeit stehen oder langsam gehen und dabei nichts tragen

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 4 Stunden pro Tag
- ☐ 4 bis annähernd 6 Stunden pro Tag
- ☐ 6 oder mehr Stunden pro Tag

30 In der Arbeit stehen oder langsam gehen und dabei Dinge tragen (schwerer als 4 kg = 4 Flaschen Wasser oder 4 Kartons Milch)

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 4 Stunden pro Tag
- ☐ 4 bis annähernd 6 Stunden pro Tag
- ☐ 6 oder mehr Stunden pro Tag

31 Bei der Arbeit schnell gehen und dabei nichts tragen

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 4 Stunden pro Tag
- ☐ 4 bis annähernd 6 Stunden pro Tag
- ☐ 6 oder mehr Stunden pro Tag

32 In der Arbeit schnell gehen und dabei Dinge tragen (schwerer als 4 kg = 4 Flaschen Wasser oder 4 Kartons Milch)

- ☐ Keine
- ☐ Weniger als ½ Stunde pro Tag
- ☐ ½ bis annähernd 2 Stunden pro Tag
- ☐ 2 bis annähernd 4 Stunden pro Tag
- ☐ 4 bis annähernd 6 Stunden pro Tag
- ☐ 6 oder mehr Stunden pro Tag

Quelle: modifiziert nach Chasan-Taber L, Schmidt MD, Roberts DE, Hosmer D, Markenson G, Freedson PS. Development and Validation of a Pregnancy Physical Activity Questionnaire. Med Sci Sports Exer 2004 36(10):1750-1760.

Appendix 3 – Food frequency questionnaire applied for the dietary assessment in the GeliS trial.

GeliS Gesund leben in der Schwangerschaft

Teilnehmer ID – Praxis ID –

Fragebogen zur Ernährung

- Sie werden gefragt, **wie oft** und **in welcher Menge** Sie in den letzten vier Wochen verschiedene Lebensmittel gegessen haben. Denken Sie dabei auch an Mahlzeiten, die Sie außer Haus (z. B. im Restaurant, in der Kantine) eingenommen haben.
- Bitte beantworten Sie **jede** Frage. Wenn Sie sich nicht sicher sind, dann schätzen Sie. Eine ungefähre Schätzung ist besser als gar keine Antwort.
- Denken Sie bitte nur an Ihre Ernährung **in den letzten vier Wochen!**
- Es kommt vielleicht vor, dass Sie bestimmte Sachen nicht essen oder trinken. Kreuzen Sie dann bitte »nie« an und gehen weiter zur nächsten Frage.
- Bei den Mengenangaben geht es um die **durchschnittliche** Menge.
- Bitte bei jeder Frage nur **eine Antwort** ankreuzen.

Beispiel:
Sie essen morgens 1 Vollkornbrötchen und abends 3 Scheiben Vollkornbrot. Bitte kreuzen Sie dann wie unten »2 Mal am Tag« und als Menge »2 Scheiben« (den Durchschnitt) an:

18	Wie oft haben Sie Vollkornbrot oder Vollkornbrötchen gegessen?		18a	Wenn Sie Vollkornbrot oder Vollkornbrötchen essen, wie viel essen Sie davon meistens?
	☐ Nie → Bitte weiter mit Frage 19			☐ ½ Scheibe oder ½ Brötchen (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ 1 Scheibe oder 1 Brötchen
	☐ 2–3 Mal im Monat	☒ 2 Mal am Tag		☒ 2 Scheiben oder 2 Brötchen
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 3 Scheiben oder 3 Brötchen
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 4 Scheiben (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

14 Fragebogen zur Ernährung 1

Gesund leben in der Schwangerschaft GeliS

1	Wie oft haben Sie **Milch** (einschließlich Milch für Kaffee, Müsli) getrunken?
☐	**Nie → Bitte weiter mit Frage 2**
☐	1 Mal im Monat
☐	2–3 Mal im Monat
☐	1–2 Mal pro Woche
☐	3–4 Mal pro Woche
☐	5–6 Mal pro Woche
☐	1 Mal am Tag
☐	2 Mal am Tag
☐	3 Mal am Tag
☐	4–5 Mal am Tag
☐	Öfter als 5 Mal am Tag

1a	Wenn Sie **Milch** trinken, wie viel trinken Sie davon meistens?
☐	½ Glas (oder weniger)
☐	1 Glas (200 ml)
☐	2 Gläser
☐	3 Gläser
☐	4 Gläser (oder mehr)

1b	Welche Art von **Milch** trinken Sie meistens?
☐	Vollmilch (mindestens 3,5 % Fett)
☐	Fettarme Milch (1,5 % Fett)
☐	Magermilch (max. 0,3 % Fett)
☐	Sojamilch
☐	Laktosefreie Milch
☐	Andere

2	Wie oft haben Sie **zuckerhaltige Erfrischungsgetränke** (z. B. Cola, Limonade, Eistee, Malzbier) getrunken? Nicht gemeint sind Light-Getränke.
☐	**Nie → Bitte weiter mit Frage 3**
☐	1 Mal im Monat
☐	2–3 Mal im Monat
☐	1–2 Mal pro Woche
☐	3–4 Mal pro Woche
☐	5–6 Mal pro Woche
☐	1 Mal am Tag
☐	2 Mal am Tag
☐	3 Mal am Tag
☐	4–5 Mal am Tag
☐	Öfter als 5 Mal am Tag

2a	Wenn Sie **zuckerhaltige Erfrischungsgetränke** trinken, wie viel trinken Sie davon meistens?
☐	½ Glas (oder weniger)
☐	1 Glas (200 ml)
☐	2 Gläser
☐	3 Gläser
☐	4 Gläser (oder mehr)

3	Wie oft haben Sie **Energydrinks** getrunken?
☐	**Nie → Bitte weiter mit Frage 4**
☐	1 Mal im Monat
☐	2–3 Mal im Monat
☐	1–2 Mal pro Woche
☐	3–4 Mal pro Woche
☐	5–6 Mal pro Woche
☐	1 Mal am Tag
☐	2 Mal am Tag
☐	3 Mal am Tag
☐	4–5 Mal am Tag
☐	Öfter als 5 Mal am Tag

3a	Wenn Sie **Energydrinks** trinken, wie viel trinken Sie davon meistens?
☐	1/2 Dose (oder weniger)
☐	1 Dose (250 ml)
☐	2 Dosen
☐	3 Dosen
☐	4 Dosen (oder mehr)

GeliS Gesund leben in der Schwangerschaft

4 Wie oft haben Sie **kalorienreduzierte Erfrischungsgetränke (z. B. Light-Getränke) getrunken?**

- ☐ **Nie → Bitte weiter mit Frage 5**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

4a Wenn Sie **kalorienreduzierte Erfrischungsgetränke trinken, wie viel trinken Sie davon meistens?**

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

5 Wie oft haben Sie **Fruchtsaft (z. B. Orangen-, Apfel-, Kirschsaft) getrunken?** Gemeint ist auch verdünnter Fruchtsaft.

- ☐ **Nie → Bitte weiter mit Frage 6**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

5a Wenn Sie **Fruchtsaft trinken, wie viel trinken Sie davon meistens?**

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

5b Wie trinken Sie Ihren **Fruchtsaft meistens?**

- ☐ Unverdünnt
- ☐ Etwa ¼ Saft und ¾ Wasser
- ☐ Etwa ½ Saft und ½ Wasser
- ☐ Etwa ¾ Saft und ¼ Wasser

6 Wie oft haben Sie **Gemüsesaft (z. B. Tomaten-, Karottensaft) getrunken?** Gemeint ist auch verdünnter Gemüsesaft.

- ☐ **Nie → Bitte weiter mit Frage 7**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

6a Wenn Sie **Gemüsesaft trinken, wie viel trinken Sie davon meistens?**

- ☐ ½ Glas (oder weniger)
- ☐ 1 Glas (200 ml)
- ☐ 2 Gläser
- ☐ 3 Gläser
- ☐ 4 Gläser (oder mehr)

6b Wie trinken Sie Ihren **Gemüsesaft meistens?**

- ☐ Unverdünnt
- ☐ Etwa ¼ Saft und ¾ Wasser
- ☐ Etwa ½ Saft und ½ Wasser
- ☐ Etwa ¾ Saft und ¼ Wasser

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7	Wie oft haben Sie **Wasser** (Leitungswasser, Mineralwasser, aromatisiertes Wasser) getrunken?		7a	Wenn Sie **Wasser** trinken, wie viel trinken Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 8**		☐	½ Glas (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Glas (200 ml)
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Gläser
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Gläser
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Gläser (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

8	Wie oft haben Sie **Früchte- oder Kräutertee** getrunken?		8a	Wenn Sie **Früchte- oder Kräutertee** trinken, wie viel trinken Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 9**		☐	½ Tasse (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Tasse (150 ml)
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Tassen
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Tassen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Tassen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

8b	Nehmen Sie üblicherweise **Zucker** in Ihren Früchte- oder Kräuertee? Nicht gemeint sind Süßstoffe.
☐	Nein
☐	Ja, etwa 1 Teelöffel pro Tasse
☐	Ja, 2 Teelöffel pro Tasse
☐	Ja, 3 Teelöffel (oder mehr) pro Tasse

9	Wie oft haben Sie **schwarzen oder grünen Tee** getrunken?		9a	Wenn Sie **schwarzen oder grünen Tee** trinken, wie viel trinken Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 10**		☐	½ Tasse (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Tasse (150 ml)
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Tassen
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Tassen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Tassen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

9b	Nehmen Sie üblicherweise **Zucker** in Ihren schwarzen oder grünen Tee? Nicht gemeint sind Süßstoffe.
☐	Nein
☐	Ja, etwa 1 Teelöffel pro Tasse
☐	Ja, 2 Teelöffel pro Tasse
☐	Ja, 3 Teelöffel (oder mehr) pro Tasse

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10 Wie oft haben Sie **Kaffee** (auch Cappuccino, Latte Macchiato, Espresso) getrunken?

- ☐ **Nie → Bitte weiter mit Frage 11**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

10a Wenn Sie **Kaffee** trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Tasse (oder weniger)
- ☐ 1 Tasse (150 ml)
- ☐ 2 Tassen
- ☐ 3 Tassen
- ☐ 4 Tassen (oder mehr)

10b Nehmen Sie üblicherweise **Zucker** in Ihren Kaffee? Nicht gemeint sind Süßstoffe.

- ☐ Nein
- ☐ Ja, etwa 1 Teelöffel pro Tasse
- ☐ Ja, 2 Teelöffel pro Tasse
- ☐ Ja, 3 Teelöffel (oder mehr) pro Tasse

10c Trinken Sie in der Regel Kaffee **mit** oder **ohne** Koffein?

- ☐ mit Koffein
- ☐ ohne Koffein

11 Wie oft haben Sie **Bier** (alkoholhaltig) getrunken?

- ☐ **Nie → Bitte weiter mit Frage 12**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

11a Wenn Sie **Bier** trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Flasche (oder weniger)
- ☐ 1 Flasche (330 ml)
- ☐ 2 Flaschen
- ☐ 3 Flaschen
- ☐ 4 Flaschen (oder mehr)

12 Wie oft haben Sie **alkoholfreies Bier** getrunken?

- ☐ **Nie → Bitte weiter mit Frage 13**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

12a Wenn Sie **alkoholfreies Bier** trinken, wie viel trinken Sie davon meistens?

- ☐ ½ Flasche (oder weniger)
- ☐ 1 Flasche (330 ml)
- ☐ 2 Flaschen
- ☐ 3 Flaschen
- ☐ 4 Flaschen (oder mehr)

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13	Wie oft haben Sie **Wein, Sekt oder Obstwein** getrunken?		13a	Wenn Sie **Wein, Sekt oder Obstwein** trinken, wie viel trinken Sie davon meistens?
	☐ **Nie → Bitte weiter mit Frage 14**			☐ 1 Glas (125 ml oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ 2 Gläser
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 3 Gläser
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 4 Gläser
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 5 Gläser (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

14	Wie oft haben Sie **Cocktails oder andere alkoholische Mischgetränke** getrunken?		14a	Wenn Sie **Cocktails oder andere alkoholische Mischgetränke** trinken, wie viel trinken Sie davon meistens?
	☐ **Nie → Bitte weiter mit Frage 15**			☐ ½ Getränk (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ 1 Getränk
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 2 Getränke
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 3 Getränke
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 4 Getränke (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

15	Wie oft haben Sie **hochprozentige alkoholische Getränke** (z. B. Rum, Weinbrand, Likör, klare Schnäpse) getrunken?		15a	Wenn Sie **hochprozentige alkoholische Getränke** trinken, wie viel trinken Sie davon meistens?
	☐ **Nie → Bitte weiter mit Frage 16**			☐ ½ Glas (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ 1 Glas (2 cl)
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 2 Gläser
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 3 Gläser
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 4 Gläser (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

16	Wie oft haben Sie **Cornflakes** (auch z. B. Choco Pops, Nougat Bits, Fruit Rings) gegessen?		16a	Wenn Sie **Cornflakes** essen, wie viel essen Sie davon meistens? Mengenangabe bitte ohne Milch.
	☐ **Nie → Bitte weiter mit Frage 17**			☐ ¼ Schale (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ ½ Schale
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 1 Schale
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 2 Schalen
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 3 Schalen (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Dessertschale von 150 ml.

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17 Wie oft haben Sie **Müsli** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 18**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

17a Wenn Sie **Müsli** essen, wie viel essen Sie davon meistens? Mengenangabe bitte ohne Milch.

- ☐ ¼ Schale (oder weniger)
- ☐ ½ Schale
- ☐ 1 Schale
- ☐ 2 Schalen
- ☐ 3 Schalen (oder mehr)

Gemeint ist eine Dessertschale von 150 ml.

18 Wie oft haben Sie **Vollkornbrot oder Vollkornbrötchen** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 19**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

18a Wenn Sie **Vollkornbrot oder Vollkornbrötchen** essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe oder ½ Brötchen (oder weniger)
- ☐ 1 Scheibe oder 1 Brötchen
- ☐ 2 Scheiben oder 2 Brötchen
- ☐ 3 Scheiben oder 3 Brötchen
- ☐ 4 Scheiben (oder mehr)

19 Wie oft haben Sie **Graubrot oder Mischbrot** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 20**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

19a Wenn Sie **Graubrot oder Mischbrot** essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe oder ½ Brötchen (oder weniger)
- ☐ 1 Scheibe oder 1 Brötchen
- ☐ 2 Scheiben oder 2 Brötchen
- ☐ 3 Scheiben oder 3 Brötchen
- ☐ 4 Scheiben (oder mehr)

20 Wie oft haben Sie **Weißbrot oder Brötchen** (auch Laugenbrötchen, Fladenbrot) gegessen?

- ☐ **Nie → Bitte weiter mit Frage 21**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

20a Wenn Sie **Weißbrot oder Brötchen** essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe oder ½ Brötchen (oder weniger)
- ☐ 1 Scheibe oder 1 Brötchen
- ☐ 2 Scheiben oder 2 Brötchen
- ☐ 3 Scheiben oder 3 Brötchen
- ☐ 4 Scheiben (oder mehr)

21	Wie oft haben Sie **Butter oder Margarine** (auf Brot etc.) gegessen?	
☐	**Nie → Bitte weiter mit Frage 22**	
☐	1 Mal im Monat	☐ 1 Mal am Tag
☐	2–3 Mal im Monat	☐ 2 Mal am Tag
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

21a	Wenn Sie **Butter oder Margarine** essen, wie viel essen Sie davon meistens?
☐	½ Teelöffel (oder weniger)
☐	1 Teelöffel (gestrichen)
☐	2 Teelöffel (gestrichen)
☐	3 Teelöffel (gestrichen)
☐	4 Teelöffel (oder mehr)

22	Wie oft haben Sie **Frischkäse** (z. B. Philadelphia, Hüttenkäse) gegessen?	
☐	**Nie → Bitte weiter mit Frage 23**	
☐	1 Mal im Monat	☐ 1 Mal am Tag
☐	2–3 Mal im Monat	☐ 2 Mal am Tag
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

22a	Wenn Sie **Frischkäse** essen, wie viel essen Sie davon meistens?
☐	½ Esslöffel (oder weniger)
☐	1 Esslöffel (gestrichen)
☐	2 Esslöffel (gestrichen)
☐	3 Esslöffel (gestrichen)
☐	4 Esslöffel (oder mehr)

22b	Essen Sie **fettarmen Frischkäse**?
☐	Selten oder nie
☐	Etwa zur Hälfte
☐	Überwiegend
☐	Weiß ich nicht

23	Wie oft haben Sie **Käse** (Weich-, Schnitt- oder Hartkäse) gegessen?	
☐	**Nie → Bitte weiter mit Frage 24**	
☐	1 Mal im Monat	☐ 1 Mal am Tag
☐	2–3 Mal im Monat	☐ 2 Mal am Tag
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

23a	Wenn Sie **Käse** essen, wie viel essen Sie davon meistens?
☐	½ Scheibe oder ½ Portion (oder weniger)
☐	1 Scheibe oder 1 Portion
☐	2 Scheiben oder 2 Portionen
☐	3 Scheiben oder 3 Portionen
☐	4 Scheiben oder 4 Portionen (oder mehr)
	1 Scheibe oder 1 Portion sind ca. 30 g.

23b	Essen Sie **fettarmen Käse**?
☐	Selten oder nie
☐	Etwa zur Hälfte
☐	Überwiegend
☐	Weiß ich nicht

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24 Wie oft haben Sie **Quark, Joghurt oder Dickmilch** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 25**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

24a Wenn Sie **Quark, Joghurt oder Dickmilch** essen, wie viel essen Sie davon meistens?

- ☐ ½ Becher (oder weniger)
- ☐ 1 Becher (200 g)
- ☐ 2 Becher
- ☐ 3 Becher
- ☐ 4 Becher

24b Essen Sie **fettarmen Quark, Joghurt oder fettarme Dickmilch**?

- ☐ Selten oder nie
- ☐ Etwa zur Hälfte
- ☐ Überwiegend
- ☐ Weiß ich nicht

25 Wie oft haben Sie **Honig oder Marmelade (auch Sirup)** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 26**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

25a Wenn Sie **Honig oder Marmelade** essen, wie viel essen Sie davon meistens?

- ☐ 1 Teelöffel (oder weniger)
- ☐ 2 Teelöffel (gehäuft)
- ☐ 3 Teelöffel (gehäuft)
- ☐ 4 Teelöffel (gehäuft)
- ☐ 5 Teelöffel (oder mehr)

26 Wie oft haben Sie **Nuss-Nougatcreme** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 27**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

26a Wenn Sie **Nuss-Nougatcreme** essen, wie viel essen Sie davon meistens?

- ☐ 1 Teelöffel (oder weniger)
- ☐ 2 Teelöffel (gehäuft)
- ☐ 3 Teelöffel (gehäuft)
- ☐ 4 Teelöffel (gehäuft)
- ☐ 5 Teelöffel (oder mehr)

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27	Wie oft haben Sie **Eier** (z. B. Spiegelei, Rührei, gekochtes Ei) gegessen?	
☐	**Nie → Bitte weiter mit Frage 28**	
☐	1 Mal im Monat	☐ 1 Mal am Tag
☐	2–3 Mal im Monat	☐ 2 Mal am Tag
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

27a	Wenn Sie **Eier** essen, wie viel essen Sie davon meistens?
☐	½ Ei (oder weniger)
☐	1 Ei
☐	2 Eier
☐	3 Eier
☐	4 Eier (oder mehr)

28	Wie oft haben Sie **Geflügel** (z. B. Hähnchen, Chicken Nuggets) gegessen?	
☐	**Nie → Bitte weiter mit Frage 29**	
☐	1 Mal im Monat	☐ 1 Mal am Tag
☐	2–3 Mal im Monat	☐ 2 Mal am Tag
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

28a	Wenn Sie **Geflügel** essen, wie viel essen Sie davon meistens?
☐	¼ Portion (oder weniger)
☐	½ Portion
☐	1 Portion
☐	2 Portionen
☐	3 Portionen (oder mehr)
	Mit einer Portion sind etwa 1 Hähnchenschenkel oder 8 Nuggets gemeint.

28b	Wie oft war das **Geflügel** paniert oder frittiert (z. B. Nuggets)?
☐	(Fast) nie
☐	Etwa ¼ des Verzehrs
☐	Etwa ½ des Verzehrs
☐	Etwa ¾ des Verzehrs
☐	(Fast) immer

29	Wie oft haben Sie **Hamburger oder Döner Kebab** gegessen?	
☐	**Nie → Bitte weiter mit Frage 30**	
☐	1 Mal im Monat	☐ 1 Mal am Tag
☐	2–3 Mal im Monat	☐ 2 Mal am Tag
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag

29a	Wenn Sie **Hamburger oder Döner Kebab** essen, wie viel essen Sie davon meistens?
☐	½ Stück (oder weniger)
☐	1 Stück
☐	2 Stück
☐	3 Stück
☐	4 Stück (oder mehr)

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30 Wie oft haben Sie **Bratwurst** oder **Currywurst** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 31**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

30a Wenn Sie **Bratwurst** oder **Currywurst** essen, wie viel essen Sie davon meistens?

- ☐ ½ Stück (oder weniger)
- ☐ 1 Stück
- ☐ 2 Stück
- ☐ 3 Stück
- ☐ 4 Stück (oder mehr)

31 Wie oft haben Sie **Fleisch** (z. B. Schweinefleisch, Rindfleisch, Wildfleisch) gegessen? Nicht gemeint sind Wurst oder Geflügel.

- ☐ **Nie → Bitte weiter mit Frage 32**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

31a Wenn Sie **Fleisch** essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Mit einer Portion ist etwa 1 Kotelett, 1 Steak oder 1 Schnitzel gemeint.

31b Wie oft war das **Fleisch** paniert (z. B. Wiener Schnitzel)?

- ☐ (Fast) nie
- ☐ Etwa ¼ des Verzehrs
- ☐ Etwa ½ des Verzehrs
- ☐ Etwa ¾ des Verzehrs
- ☐ (Fast) immer

32 Wie oft haben Sie **Wurst** (z. B. Salami, Leberwurst) gegessen? Nicht gemeint ist Schinken.

- ☐ **Nie → Bitte weiter mit Frage 33**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

32a Wenn Sie **Wurst** essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe
- ☐ 1 Scheibe
- ☐ 2 Scheiben
- ☐ 3 Scheiben
- ☐ 4 Scheiben (oder mehr)

32b Essen Sie **fettarme Wurst**?

- ☐ Selten oder nie
- ☐ Etwa zur Hälfte
- ☐ Überwiegend
- ☐ Weiß ich nicht

33 Wie oft haben Sie **Schinken** gegessen?

- ☐ **Nie → Bitte weiter mit Frage 34**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

33a Wenn Sie **Schinken** essen, wie viel essen Sie davon meistens?

- ☐ ½ Scheibe
- ☐ 1 Scheibe
- ☐ 2 Scheiben
- ☐ 3 Scheiben
- ☐ 4 Scheiben (oder mehr)

34 Wie oft haben Sie **kalten Fisch** (z. B. Räucherlachs, Matjes, Thunfisch) gegessen?

- ☐ **Nie → Bitte weiter mit Frage 35**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

34a Wenn Sie **kalten Fisch** essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Mit einer Portion ist etwa die Menge eines Brotbelages gemeint.

35 Wie oft haben Sie **Fisch als warme Mahlzeit** (z. B. Seelachs, Forelle) gegessen?

- ☐ **Nie → Bitte weiter mit Frage 36**
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

35a Wenn Sie **Fisch als warme Mahlzeit** essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Mit einer Portion sind 1 Fischfilet oder 4 Fischstäbchen gemeint.

35b Wie oft war der **Fisch** paniert oder frittiert?

- ☐ (Fast) nie
- ☐ Etwa ¼ des Verzehrs
- ☐ Etwa ½ des Verzehrs
- ☐ Etwa ¾ des Verzehrs
- ☐ (Fast) immer

GeliS Gesund leben in der Schwangerschaft

36	Wie oft haben Sie **frisches Obst** (z. B. Apfel, Banane) gegessen?		36a	Wenn Sie **frisches Obst** essen, wie viel essen Sie davon meistens?
	☐ **Nie → Bitte weiter mit Frage 37**			☐ ½ Stück oder ½ Schale (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ 1 Stück oder 1 Schale
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 2 Stück oder 2 Schalen
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 3 Stück oder 3 Schalen
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 4 Stück oder 4 Schalen (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		1 Stück ist z. B. 1 Apfel oder 1 Banane. Mit Schale ist eine kleine Dessertschale von 150 ml mit z. B. Erdbeeren oder Kirschen gemeint.

37	Wie oft haben Sie **gegartes Obst** (z. B. Kompott, Konservenobst) gegessen?		37a	Wenn Sie **gegartes Obst** essen, wie viel essen Sie davon meistens?
	☐ **Nie → Bitte weiter mit Frage 38**			☐ ¼ Schale (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ ½ Schale
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 1 Schale
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 2 Schalen
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 3 Schalen (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Dessertschale von 150 ml.

38	Wie oft haben Sie **rohes Gemüse** (z. B. Kopfsalat, Rohkost) gegessen?		38a	Wenn Sie **rohes Gemüse** essen, wie viel essen Sie davon meistens?
	☐ **Nie → Bitte weiter mit Frage 39**			☐ ¼ Portion (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ ½ Portion
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 1 Portion
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 2 Portionen
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 3 Portionen (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Beilagenportion von etwa 150 g.

39	Wie oft haben Sie **Hülsenfrüchte** (z. B. Bohnen, Erbsen, Linsen) gegessen?		39a	Wenn Sie **Hülsenfrüchte** essen, wie viel essen Sie davon meistens?
	☐ **Nie → Bitte weiter mit Frage 40**			☐ ¼ Portion (oder weniger)
	☐ 1 Mal im Monat	☐ 1 Mal am Tag		☐ ½ Portion
	☐ 2–3 Mal im Monat	☐ 2 Mal am Tag		☐ 1 Portion
	☐ 1–2 Mal pro Woche	☐ 3 Mal am Tag		☐ 2 Portionen
	☐ 3–4 Mal pro Woche	☐ 4–5 Mal am Tag		☐ 3 Portionen (oder mehr)
	☐ 5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Beilagenportion von etwa 150 g.

Gesund leben in der Schwangerschaft GeliS

40 Wie oft haben Sie gegartes Gemüse gegessen?

- ☐ Nie → Bitte weiter mit Frage 41
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

40a Wenn Sie gegartes Gemüse essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Gemeint ist eine Beilagenportion von etwa 150 g.

40b Wenn Sie gegartes Gemüse essen, dann ist das üblicherweise:

- ☐ Frisch (roh) eingekauft
- ☐ Tiefkühlgemüse
- ☐ Konservengemüse
- ☐ Weiß ich nicht

41 Wie oft haben Sie Nudeln (z. B. Spaghetti, Spätzle, Ravioli, Lasagne) gegessen?

- ☐ Nie → Bitte weiter mit Frage 42
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

41a Wenn Sie Nudeln essen, wie viel essen Sie davon meistens?

- ☐ ¼ Teller (oder weniger)
- ☐ ½ Teller
- ☐ 1 Teller
- ☐ 2 Teller
- ☐ 3 Teller (oder mehr)

42 Wie oft haben Sie Reis (auch Couscous, Bulgur) gegessen?

- ☐ Nie → Bitte weiter mit Frage 43
- ☐ 1 Mal im Monat
- ☐ 2–3 Mal im Monat
- ☐ 1–2 Mal pro Woche
- ☐ 3–4 Mal pro Woche
- ☐ 5–6 Mal pro Woche
- ☐ 1 Mal am Tag
- ☐ 2 Mal am Tag
- ☐ 3 Mal am Tag
- ☐ 4–5 Mal am Tag
- ☐ Öfter als 5 Mal am Tag

42a Wenn Sie Reis (auch Couscous, Bulgur) essen, wie viel essen Sie davon meistens?

- ☐ ¼ Portion (oder weniger)
- ☐ ½ Portion
- ☐ 1 Portion
- ☐ 2 Portionen
- ☐ 3 Portionen (oder mehr)

Gemeint ist eine Beilagenportion von etwa 150 g.

GeliS Gesund leben in der Schwangerschaft

43	Wie oft haben Sie **gekochte Kartoffeln** (z. B. Salzkartoffeln, Pellkartoffeln, Kartoffelklöße) gegessen?
	☐ **Nie → Bitte weiter mit Frage 44**
	☐ 1 Mal im Monat
	☐ 2–3 Mal im Monat
	☐ 1–2 Mal pro Woche
	☐ 3–4 Mal pro Woche
	☐ 5–6 Mal pro Woche
	☐ 1 Mal am Tag
	☐ 2 Mal am Tag
	☐ 3 Mal am Tag
	☐ 4–5 Mal am Tag
	☐ Öfter als 5 Mal am Tag

43a	Wenn Sie **gekochte Kartoffeln** essen, wie viel essen Sie davon meistens?
	☐ ½ Portion oder 1 Kartoffel (oder weniger)
	☐ 1 Portion oder 2 Kartoffeln
	☐ 1 ½ Portionen oder 3 Kartoffeln
	☐ 2 Portionen oder 4 Kartoffeln
	☐ 2 ½ Portionen oder 5 Kartoffeln (oder mehr)
	Gemeint sind mittelgroße Kartoffeln.

44	Wie oft haben Sie **gebratene Kartoffeln** (auch Kroketten oder Kartoffelpuffer) gegessen? Nicht gemeint sind Pommes.
	☐ **Nie → Bitte weiter mit Frage 45**
	☐ 1 Mal im Monat
	☐ 2–3 Mal im Monat
	☐ 1–2 Mal pro Woche
	☐ 3–4 Mal pro Woche
	☐ 5–6 Mal pro Woche
	☐ 1 Mal am Tag
	☐ 2 Mal am Tag
	☐ 3 Mal am Tag
	☐ 4–5 Mal am Tag
	☐ Öfter als 5 Mal am Tag

44a	Wenn Sie **gebratene Kartoffeln** essen, wie viel essen Sie davon meistens?
	☐ ¼ Teller (oder weniger)
	☐ ½ Teller
	☐ 1 Teller
	☐ 2 Teller
	☐ 3 Teller (oder mehr)

45	Wie oft haben Sie **Pommes Frites** gegessen?
	☐ **Nie → Bitte weiter mit Frage 46**
	☐ 1 Mal im Monat
	☐ 2–3 Mal im Monat
	☐ 1–2 Mal pro Woche
	☐ 3–4 Mal pro Woche
	☐ 5–6 Mal pro Woche
	☐ 1 Mal am Tag
	☐ 2 Mal am Tag
	☐ 3 Mal am Tag
	☐ 4–5 Mal am Tag
	☐ Öfter als 5 Mal am Tag

45a	Wenn Sie **Pommes Frites** essen, wie viel essen Sie davon meistens?
	☐ ¼ Portion (oder weniger)
	☐ ½ Portion
	☐ 1 Portion
	☐ 2 Portionen
	☐ 3 Portionen (oder mehr)
	Gemeint ist eine mittlere Portion am Imbissstand.

46	Wie oft haben Sie **Pizza** gegessen?
	☐ **Nie → Bitte weiter mit Frage 47**
	☐ 1 Mal im Monat
	☐ 2–3 Mal im Monat
	☐ 1–2 Mal pro Woche
	☐ 3–4 Mal pro Woche
	☐ 5–6 Mal pro Woche
	☐ 1 Mal am Tag
	☐ 2 Mal am Tag
	☐ 3 Mal am Tag
	☐ 4–5 Mal am Tag
	☐ Öfter als 5 Mal am Tag

46a	Wenn Sie **Pizza** essen, wie viel essen Sie davon meistens?
	☐ ¼ Portion (oder weniger)
	☐ ½ Portion
	☐ 1 Portion
	☐ 2 Portionen
	☐ 3 Portionen (oder mehr)
	Mit einer Portion ist eine Tiefkühlpizza von etwa 350 g gemeint.

47	Wie oft haben Sie **Kuchen, Torten oder süße Backwaren** (auch Muffins, Apfeltaschen, Baklava) gegessen?		47a	Wenn Sie **Kuchen, Torten oder süße Backwaren** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 48**		☐	½ Stück (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Stück
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Stück
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Stück
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Stück (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

48	Wie oft haben Sie **Kekse** (z. B. Butterkekse, Plätzchen) gegessen?		48a	Wenn Sie **Kekse** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 49**		☐	2 Kekse (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	3 Kekse
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	4 Kekse
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	5 Kekse
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	6 Kekse (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

49	Wie oft haben Sie **Schokolade oder Schokoriegel** (auch Pralinen) gegessen?		49a	Wenn Sie **Schokolade oder Schokoriegel** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 50**		☐	½ kleinen Schokoriegel (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	¼ Tafel oder 1 kleinen Schokoriegel
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	½ Tafel oder 1 großen Schokoriegel
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	1 Tafel oder 2 große Schokoriegel
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	2 Tafeln (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Tafel von 100 g.

50	Wie oft haben Sie **Süßigkeiten** (z. B. Bonbons, Fruchtgummi, Hustenbonbons, Lakritz) gegessen?		50a	Wenn Sie **Süßigkeiten** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 51**		☐	1 Stück
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	2–5 Stück
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	6–10 Stück
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	11–20 Stück
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	21 Stück (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

GeliS Gesund leben in der Schwangerschaft

51	Wie oft haben Sie **Eis** gegessen?		51a	Wenn Sie **Eis** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 52**		☐	½ Kugel (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	1 Kugel
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	2 Kugeln oder 1 Eis am Stiel
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	3 Kugeln
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	4 Kugeln (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		

52	Wie oft haben Sie **Kartoffelchips** gegessen?		52a	Wenn Sie **Kartoffelchips** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 53**		☐	¼ Schale (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	½ Schale
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 Schale
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Schalen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	3 Schalen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Dessertschale von 150 ml.

53	Wie oft haben Sie **Salzgebäck** oder **Cracker** (z. B. Salzstangen) gegessen?		53a	Wenn Sie **Salzgebäck** oder **Cracker** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 54**		☐	¼ Schale (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	½ Schale
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 Schale
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Schalen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	3 Schalen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Gemeint ist eine Dessertschale von 150 ml.

54	Wie oft haben Sie **Nüsse** (z. B. Erdnüsse, Walnüsse, Haselnüsse) gegessen?		54a	Wenn Sie **Nüsse** essen, wie viel essen Sie davon meistens?
☐	**Nie → Bitte weiter mit Frage 55**		☐	¼ Portion (oder weniger)
☐	1 Mal im Monat	☐ 1 Mal am Tag	☐	½ Portion
☐	2–3 Mal im Monat	☐ 2 Mal am Tag	☐	1 Portion
☐	1–2 Mal pro Woche	☐ 3 Mal am Tag	☐	2 Portionen
☐	3–4 Mal pro Woche	☐ 4–5 Mal am Tag	☐	3 Portionen (oder mehr)
☐	5–6 Mal pro Woche	☐ Öfter als 5 Mal am Tag		Mit einer Portion ist eine Handvoll von ca. 25 g gemeint.

Gesund leben in der Schwangerschaft GeliS

55	Welches **Fett** verwenden Sie bei der Zubereitung von **Fleisch** oder **Fisch** hauptsächlich?
☐	Butter, Margarine
☐	Olivenöl
☐	Rapsöl
☐	Pflanzliches Kochfett (z. B. Biskin, Palmin)
☐	Tierisches Kochfett (z. B. Schmalz)
☐	Sonnenblumen-, Distel-, Keimöl etc.
☐	Weiß ich nicht
☐	Kein

56	Welches **Fett** verwenden Sie bei der Zubereitung von **Gemüse** hauptsächlich?
☐	Butter, Margarine
☐	Olivenöl
☐	Rapsöl
☐	Pflanzliches Kochfett (z. B. Biskin, Palmin)
☐	Tierisches Kochfett (z. B. Schmalz)
☐	Sonnenblumen-, Distel-, Keimöl etc.
☐	Weiß ich nicht
☐	Kein

57	Essen Sie üblicherweise **vegetarisch**?
☐	**Nein → Bitte weiter mit Frage 58**
☐	Ja

57a	Welche der folgenden Lebensmitteln essen Sie **nicht**? Mehrfachangaben möglich.
☐	Fleisch, Geflügel und Wurst
☐	Fisch
☐	Milch und Milchprodukte
☐	Eier

58	Wie häufig in der Woche bereiten Sie aus Grundzutaten/ frischen Lebensmitteln eine warme Mahlzeit (Mittag- oder Abendessen) selbst zu?
☐	Täglich
☐	5–6 Mal pro Woche
☐	3–4 Mal pro Woche
☐	1–2 Mal pro Woche
☐	Nie

59	Rauchen Sie zurzeit?
☐	Ja, regelmäßig
☐	Ja, gelegentlich (< 1 Zigarette pro Tag)
☐	Nein, nicht mehr
☐	Habe noch nie geraucht

59a	Wenn Sie rauchen, wie viele Zigaretten rauchen Sie pro Tag?
	_____ Zigaretten

Quelle: modifiziert nach Ernährungsfragebogen der Studie zur Gesundheit Erwachsener in Deutschland (DEGS) des Robert Koch Instituts, Berlin, 2008

Appendix 4 – Questionnaire applied for assessment of dietary supplement intake behavior during pregnancy in the GeliS trial.

GeliS Gesund leben in der Schwangerschaft

Teilnehmer ID – Praxis ID –

Fragebogen zu Nahrungsergänzungsmitteln in der Schwangerschaft

- Sie werden gefragt, ob Sie Nahrungsergänzungsmittel vor oder während der Schwangerschaft eingenommen haben oder einnehmen. Bitte geben Sie an welche.
- Gemeint sind zum Beispiel einzelne Vitamine, Mineralstoffe oder Multivitaminprodukte.
- Bitte geben Sie die **genauen Bezeichnungen** der jeweiligen Produkte mit Zusätzen und deren Hersteller in **Druckbuchstaben** an, damit wir die Inhaltsstoffe selbst ermitteln können.

1 Haben Sie vor oder während der Schwangerschaft regelmäßig Nahrungsergänzungsmittel eingenommen?

☐ Ja ☐ Nein → bitte weiter mit Seite 34

2 Wenn ja: (bei mehreren Produkten bitte unter a-f entsprechend auflisten)

a) was (genauer Produktname, Hersteller):

wann:
☐ nur vor der Schwangerschaft
☐ vor der Schwangerschaft und bis zur ____ Schwangerschaftswoche
☐ von der ____ bis zur ____ Schwangerschaftswoche

wie oft:
☐ täglich mehrmals
☐ täglich einmal
☐ alle ____ Tage
☐ wöchentlich

b) was (genauer Produktname, Hersteller):

wann:
☐ nur vor der Schwangerschaft
☐ vor der Schwangerschaft und bis zur ____ Schwangerschaftswoche
☐ von der ____ bis zur ____ Schwangerschaftswoche

wie oft:
☐ täglich mehrmals
☐ täglich einmal
☐ alle ____ Tage
☐ wöchentlich

Gesund leben in der Schwangerschaft GeliS

c)	**was (genauer Produktname, Hersteller):**				
	wann:	☐	nur vor der Schwangerschaft		
		☐	vor der Schwangerschaft und bis zur	_____	Schwangerschaftswoche
		☐	von der _____	bis zur _____	Schwangerschaftswoche
	wie oft:	☐	täglich mehrmals		
		☐	täglich einmal		
		☐	alle _____	Tage	
		☐	wöchentlich		
d)	**was (genauer Produktname, Hersteller):**				
	wann:	☐	nur vor der Schwangerschaft		
		☐	vor der Schwangerschaft und bis zur	_____	Schwangerschaftswoche
		☐	von der _____	bis zur _____	Schwangerschaftswoche
	wie oft:	☐	täglich mehrmals		
		☐	täglich einmal		
		☐	alle _____	Tage	
		☐	wöchentlich		
e)	**was (genauer Produktname, Hersteller):**				
	wann:	☐	nur vor der Schwangerschaft		
		☐	vor der Schwangerschaft und bis zur	_____	Schwangerschaftswoche
		☐	von der _____	bis zur _____	Schwangerschaftswoche
	wie oft:	☐	täglich mehrmals		
		☐	täglich einmal		
		☐	alle _____	Tage	
		☐	wöchentlich		
f)	**weitere:**				

Appendix 5 – Questionnaire applied for assessment of dietary supplement intake behavior during breastfeeding in the GeliS trial.

GeliS Gesund leben in der Schwangerschaft

Teilnehmer ID – Praxis ID –

Fragebogen zu Nahrungsergänzungsmitteln in der Stillzeit

- Sie werden gefragt, ob Sie stillen und welche Nahrungsergänzungsmittel Sie seit der Geburt einnehmen oder eingenommen haben.
- Gemeint sind zum Beispiel einzelne Vitamine, Mineralstoffe oder Multivitaminprodukte.
- Bitte geben Sie die **genauen Bezeichnungen** der jeweiligen Produkte mit Zusätzen und deren Hersteller in **Druckbuchstaben** an, damit wir die Inhaltsstoffe selbst ermitteln können.

1 Haben Sie Ihr Kind eine Zeit lang voll gestillt (nur Muttermilch, keine Säuglingsmilchnahrung)?

- ☐ seit der Geburt und immer noch
- ☐ von der _____ bis zur _____ Lebenswoche
- ☐ ich habe nie voll gestillt

2 Haben Sie Ihr Kind eine Zeit lang teilweise gestillt (Muttermilch und Säuglingsmilchnahrung)?

- ☐ seit der Geburt und immer noch
- ☐ von der _____ bis zur _____ Lebenswoche
- ☐ ich habe nie gestillt

3 Haben Sie nach der Geburt regelmäßig Nahrungsergänzungsmittel eingenommen?

- ☐ **Ja**
- ☐ **Nein → bitte weiter mit Seite 32**

4 Wenn ja: (bei mehreren Produkten bitte unter a-f entsprechend auflisten)

a) was (genauer Produktname, Hersteller):

wann:
- ☐ seit der Geburt und bis zur _____ Woche nach der Geburt
- ☐ von der _____ bis zur _____ Woche nach der Geburt

wie oft:
- ☐ täglich mehrmals
- ☐ täglich einmal
- ☐ alle _____ Tage
- ☐ wöchentlich

b)	was (genauer Produktname, Hersteller):					
	wann:	☐	seit der Geburt und bis zur			Woche nach der Geburt
		☐	von der		bis zur	Woche nach der Geburt
	wie oft:	☐	täglich mehrmals			
		☐	täglich einmal			
		☐	alle		Tage	
		☐	wöchentlich			
c)	was (genauer Produktname, Hersteller):					
	wann:	☐	seit der Geburt und bis zur			Woche nach der Geburt
		☐	von der		bis zur	Woche nach der Geburt
	wie oft:	☐	täglich mehrmals			
		☐	täglich einmal			
		☐	alle		Tage	
		☐	wöchentlich			
d)	was (genauer Produktname, Hersteller):					
	wann:	☐	seit der Geburt und bis zur			Woche nach der Geburt
		☐	von der		bis zur	Woche nach der Geburt
	wie oft:	☐	täglich mehrmals			
		☐	täglich einmal			
		☐	alle		Tage	
		☐	wöchentlich			
e)	was (genauer Produktname, Hersteller):					
	wann:	☐	seit der Geburt und bis zur			Woche nach der Geburt
		☐	von der		bis zur	Woche nach der Geburt
	wie oft:	☐	täglich mehrmals			
		☐	täglich einmal			
		☐	alle		Tage	
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Acknowledgement

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