



BMJ Open Prospective multicentre Italian pregnancy cohort study (SIMPLE) on the associations of maternal first trimester SIMPLE nutritional score with early placental function markers and pregnancy outcomes

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To cite: Parisi F, Coco C, Cetin I, *et al.* Prospective multicentre Italian pregnancy cohort study (SIMPLE) on the associations of maternal first trimester SIMPLE nutritional score with early placental function markers and pregnancy outcomes. *BMJ Open* 2022;**12**:e062940. doi:10.1136/bmjopen-2022-062940

► Prepublication history for this paper is available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2022-062940>).

Received 16 March 2022
Accepted 10 October 2022



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ABSTRACT

Introduction Currently, the adherence to nutritional guidelines is low, with alarming rates of obesity worldwide and micronutrient deficiencies documented even in industrialised countries. As a consequence, nutritional screening and counselling represent a critical subject in early pregnancy, aiming to improve pregnancy outcomes and population health.

Methods and analysis In this setting, the development of a simple and reproducible nutritional checklist is of utmost importance. The Simple Study is a longitudinal prospective multicentre study aiming to identify the associations between maternal nutritional habits in the first trimester, early markers of placental function and pregnancy outcomes on a large population of singleton pregnancies in Italy.

Ongoing healthy singleton pregnancies will be enrolled at the ultrasound scan of the first trimester combined screening test (11⁺⁰–13⁺⁶ gestational weeks). A nutritional score measuring the adherence to a healthy diet and nutritional deficiencies will be collected at recruitment. Fetal (crown-rump length, nuchal translucency (NT), biparietal diameter, femur length) and utero placental (placental volume, uterine arteries Doppler velocimetry) ultrasound data and biochemical placental markers (pregnancy-associated plasma protein A, free β-human chorionic gonadotropin) will be collected. Second and third trimester ultrasound records and birth outcomes will be recorded from medical registers. This study will set the stage for introducing a reproducible, time-saving and low-cost nutritional screening in pregnancy. The nutritional score will allow the implementation of specific corrective measures with potential large impact on placentation and pregnancy outcomes.

Ethical and dissemination Ethical approval for this study was obtained from the Milano Area 1 Ethics Committee (No 46091, 7 November 2018) prior to the commencement of the research.

The dissemination plan includes the presentation of abstracts and findings at national and international scientific meetings.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The multicentre and longitudinal design of the SIMPLE study will provide the opportunity to investigate maternal nutritional habits and associations with first trimester placental markers and pregnancy outcomes in a large sample of low-risk pregnancies, with high external validity of the study results.
- ⇒ The prospective collection of baseline maternal data, ultrasound and biochemical fetoplacental data, and delivery outcomes will allow to build multivariate models corrected for confounding factors.
- ⇒ The nutritional score is calculated in the late first trimester, thus ignoring potential changes in nutritional habits, exposures and supplementation later in pregnancy.
- ⇒ Energy intake, as a crucial component of nutritional habits, is not included in the nutritional score calculation.

INTRODUCTION

Starting with the Barker's hypothesis in the early 90s', maternal nutrition during pregnancy has been recognised as a crucial determinant of placental function and intrauterine growth, with long-lasting and intergenerational effects on future disease risk profile of the offspring.^{1–4} This long-term 'programming' of future health status has been related to maternal nutritional exposures mainly through epigenetic modifications, which could realise both before conception—by affecting the process of gametogenesis—and during pregnancy.^{2 5–7}

Currently, the adherence to nutritional guidelines is low, with alarming rates of obesity worldwide and micronutrient deficiencies that have been documented even in industrialised countries.^{8–11} Therefore, a universal nutritional counselling and screening

represent a pivotal issue in early pregnancy, requiring proper evaluations in order to improve both individual and population health. In this setting, the development of a simple and reproducible nutritional checklist is of utmost importance.

In this context, a pilot study on 112 healthy women with singleton pregnancies and non-malformed outcome demonstrated that a first trimester nutritional score measuring the adherence to a healthy diet and lifestyle in early pregnancy was significantly associated with first trimester biochemical and ultrasound markers of placental function.¹² In particular, higher maternal nutritional scores were associated with increased serum pregnancy-associated plasma protein-A (PAPP-A) concentrations, lower uterine artery (UA) mean pulsatility index and decreased placental volume at the first trimester screening ultrasound, whereas no associations were detected with free β -human chorionic gonadotropin (free β -HCG). The analysis on birth outcomes additionally showed a significant positive association between first trimester maternal nutritional score and gestational age at birth. These results provided the evidence of a strong association between maternal nutritional habits and pregnancy outcomes, possibly mediated by early impacts on placental function and development. Furthermore, this study possibly provided a simple clinical tool for an early nutritional screening deeply impacting on pregnancy outcomes and clinical practice.

The Simple Study is a longitudinal prospective multi-centre study designed to identify possible associations between first trimester maternal nutritional score, early markers of placental function and pregnancy outcomes on a large population of singleton pregnancies in Italy. In particular, the aims of the study are:

- ▶ To assess first trimester nutritional score and nutritional adequacy in a large population of singleton pregnancies.
- ▶ To investigate the associations between first trimester maternal nutritional score and early markers of placental function and fetal growth.
- ▶ To evaluate the associations between first trimester nutritional score and maternal, fetal and neonatal outcomes, including: birth weight, gestational age at birth, blood loss at delivery, gestational weight gain, adverse maternal (hypertensive disorders, gestational diabetes and caesarean section) and fetoneonatal outcomes (intrauterine growth restriction, preterm delivery).

METHODS AND ANALYSIS

Study design

Multicentre prospective observational cohort study coordinated by 'V. Buzzi' Children Hospital, Milan (Coordination Unit), and involving the following 20 Italian maternity units: 'L. Sacco' University Hospital, Asst-Fbf-Sacco, Milan; 'M.Melloni' University Hospital Asst-Fbf-Sacco, Milan; S.Pio X, Humanitas University Hospital, Milan; 'Careggi' University Hospital, Florence; 'Santa

Maria della Misericordia' University Hospital, Perugia; 'Sant'Anna' University Hospital, Torino; Modena Poly-clinic University Hospital, Modena; '. Martino' University Hospital, Messina; 'San Matteo' Hospital, Pavia; 'Arcispedale Sant'Anna' University Hospital, Ferrara; 'V. Emanuele' University Hospital, Catania; 'isanello' University Hospital, Pisa; 'Gemelli' University Hospital, Rome; 'Ospedali Riuniti' University Hospital, Foggia; Verona Polyclinic University Hospital, Verona; Bari Polyclinic University Hospital, Bari; 'Vanvitelli' University Hospital, Naples; 'Federico II' University Hospital, Naples; San Salvatore University Hospital, L'Aquila.

Each participating centre has access to a database and all patients are prospectively registered by trained operators.

After the study protocol presentation in January 2021, a monthly newsletter with regular update on the research status and recruitment is sent to all centres. The coordination unit will monitor the case reporting and completeness of data collection for all the participating centres on a monthly basis. The final statistical analyses will be performed by the coordination unit.

Study population and sample recruitment

Eligible patients will be enrolled during the ultrasound scan of the first trimester combined screening test for aneuploidies (11–13⁺⁶ weeks), according to the following inclusion criteria: singleton viable pregnancy undergoing prenatal screening, gestational age between 11 and 13⁺⁶ weeks of pregnancy, further confirmed by a crown-rump length (CRL) measurement of 45–84mm, and signed written informed consent. Language barrier, any known maternal disease or required chronic therapy and oocyte donation pregnancy represent the exclusion criteria at enrolment. Later detection of fetal congenital anomalies and aneuploidies confirmed at birth represent additional exclusion criteria from final analyses.

Figure 1 summarises the study step points with maternal, fetal and neonatal data collection.

At enrolment, all women will fill a general questionnaire covering details on age, pregestational body mass index (BMI), ethnicity, mode of conception, lifestyle habits, family and personal history. A modified version of the nutritional checklist developed by the International Federation of Gynecology and Obstetrics (FIGO) in 2015 will be used to provide a 0–10 nutritional score measuring the adherence to a healthy diet and lifestyle.^{13 14} In detail, the FIGO Nutrition Checklist consists of four sections covering: (1) specific dietary requirements (eg, diet or food allergies), (2) BMI calculation, (3) diet quality and (4) specific micronutrients deficiency queries (eg, folic acid), thus giving the healthcare providers the possibility to collect baseline information on maternal nutritional status and to promote conversations about nutrition during pregnancy. A one-point score is calculated in case of affirmative answer for: consumption of meat 2–3 times per week, fruit and vegetables at least five times per day, fish 1–2 times per week, dairy products daily, whole

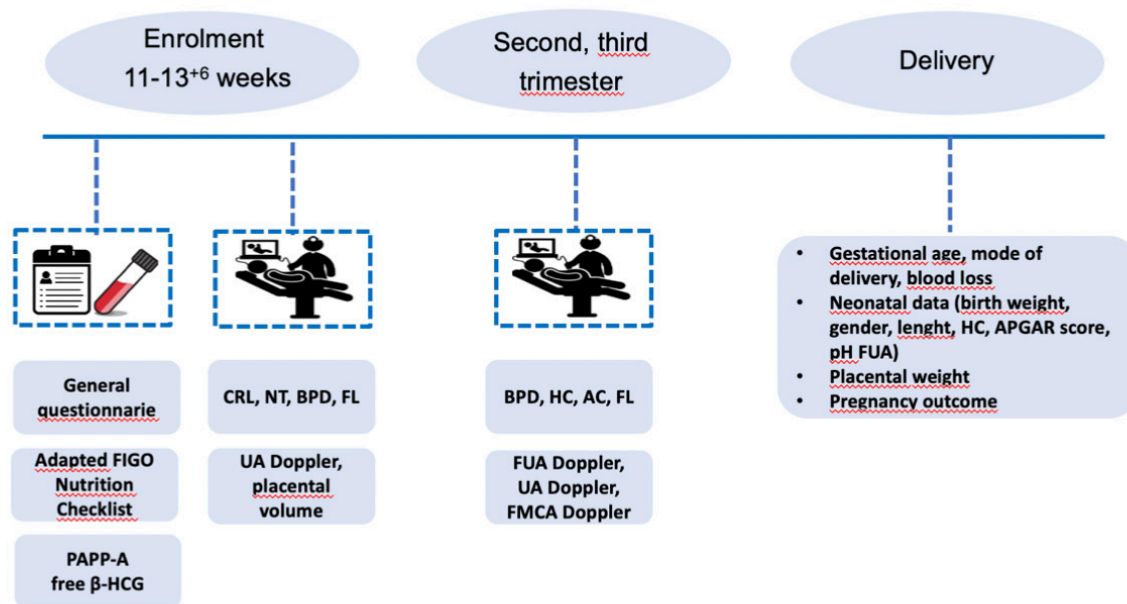


Figure 1 SIMPLE Study step points. Here, the SIMPLE study step points are presented: enrolment at 11-13⁺⁶ weeks, data collection at both second-third trimester and delivery. AC, abdominal circumference; APGAR, Appearance, Pulse, Grimace, Activity and Respiration; BPD, biparietal diameter; CRL, crown rump length; FIGO, International Federation of Gynecology and Obstetrics; FL, femur length; FMCA, fetal middle cerebral artery; free β -HCG, free beta subunit of Human Chorionic Gonadotropin; FUA, fetal umbilical artery; HC, head circumference; NT, nuchal translucency; PAPP-A, pregnancy-associated plasma protein A; pH, potential of hydrogen; UA, uterine arteries.

cereals at least once per day, sweet and snacks less than five times per weeks, first trimester haemoglobin concentrations higher than 110 g/L, folic acid supplementation, use of iodised salt and sun exposure at least 10–15 min per day. Additional adaptations of the checklist are based on the Italian guidelines on maternal nutrition during pregnancy, including one additional question on the consumption of iodised salt and the modified recommended intake of fruit and vegetables to five portions per day. The questionnaire provides a final calculation of a 0–10 score, as the sum of single question scores.

As required by the first trimester combined screening test, biochemical parameters and fetal ultrasound parameters will be collected. Biochemical parameters, including serum PAPP-A and free β -HCG, will be obtained from one venous blood sample collected at 10 weeks of gestation, by using a solid-phase two-site sequential chemiluminescent immunometric assay (BRAHMS Kryptor, Hennigsdorf, Germany). All ultrasound measurements will be performed by a Fetal Medicine Foundation certified sonographer according to the International Society of Ultrasound in Obstetrics and Gynecology guidelines. In addition to parameters required for the combined screening test and including CRL, NT and biparietal diameter (BPD), transabdominal measurements of Doppler velocimetry of UA and two-dimensional placental volume will be performed. Transabdominal UA Doppler velocimetry is achieved identifying the artery along the uterine

body from a midsagittal section and moving laterally to the paracervical vascular plexus.¹⁵ The measurements are taken at the cervicocorporeal junction, before the UA branches into the arcuate arteries, by obtaining three similar consecutive waveform measurements. The two-dimensional estimated placental volume measurement will be performed according to the formula proposed by Sonek *et al*, by acquiring assessment of placental width (measuring the distance among placental edges, perpendicular to surface of placenta), height (as distance from uteroplacental interface to line used to measure width) and thickness (as distance from uteroplacental interface to fetal surface of placenta).¹⁶

As required by national guidelines of low risk pregnancy care, second (20–22 weeks) and third (30–32 weeks) trimester ultrasound data of fetal biometry (BPD, HC, AC, FL) and Doppler velocimetry (UA Doppler, fetal umbilical artery Doppler, fetal middle cerebral artery Doppler) will be obtained from medical records. Data on delivery outcomes, including gestational age, delivery mode, blood loss, neonatal data and placental weight will be recorded from medical registry or phone interview.

The recruitment process and follow-up will last 30 months, in the period of January 2020–June 2023.

Data collection tool

Data will be collected online by using an IT platform named 'Dataereg' and developed in collaboration with the University of Milan.

Sample size calculation

In a cohort of 2300 patients and for a normally distributed continuous outcome (ie, ultrasound and biochemical parameters, birth weight), it is possible to detect with a type I error of 5% and a type II error of 20% (power 80%) a difference of 0.24 SD and 0.16 SD if 10% and 50% of all subjects has the relevant exposure respectively (ie, nutritional score <6).

Statistical analyses

All study variables will be described as median and range or mean and SD for quantitative variables, and absolute and relative frequencies for categorical variables. A first trimester nutritional score representing the adherence to a healthy diet and lifestyle will be calculated as the sum of 10 questions. Bivariate correlations will be performed to investigate the associations between maternal baseline characteristics and the first trimester nutritional score. A multivariate analysis adjusted for confounding factors including pregestational BMI, age, gestational weight gain, smoking habit, alcohol use, education level, ethnicity and fetal sex, will be conducted to assess the associations between maternal nutritional status and study outcomes. The relative risk of adverse outcomes (eg, low birth weight, gestational diabetes, hypertensive disorders and preterm birth) will be calculated in case of low nutritional scores in the nutritional questionnaire, considering a threshold of 6. P values <0.05 will be considered statistically significant. Statistical analyses will be performed using SPSS Statistics for Windows, V.21.0 (IBM) and R V.3.2.1 (The R Foundation for Statistical Computing).

ETHICS AND DISSEMINATION**Ethical considerations**

Developed as a consequence of the Declaration of Helsinki, Ethical Principles regarding the conduct of clinical research involving humans (World Medical Association-WMA, 1964) and of the Oviedo Convention (EU, 1997) are required by the Italian NHS Research Ethics Committee.

Participants involved will be completely informed about the aims of the study and will be asked to sign an individual paper consent form. Women will be free to decline participation or to withdraw any moment. Data will be stored securely on hospital storage and IT platform protected by password (Data Protection Code, 2003; GDPR, 2018).

Ethical approval for this study was obtained from the Milano Area I Ethics Committee (No 46091, 7 November 2018) prior to the commencement of the research. All respondents will be provided with the name, telephone number and email of the principal investigator and the

local review board's contact details, in case of any question about the study.

Dissemination plan

The target audience for this study includes different stakeholders: clinicians, in particular obstetricians and midwives, policy makers, healthcare managers, researchers and the public, especially women in their reproductive age.

The findings from this study would make a significant contribution to both obstetrics recommendations and knowledge, also as regard to public health.

The dissemination plan includes the presentation of abstracts and findings at national and international scientific meetings.

Patient and public involvement

Women were not involved in the design of the study.

Women and their partners will be involved as participants after a detailed explanation of the study by a team researcher and will be fully informed about findings of the study.

Implications for practice

This study will provide findings about the utility of a very easy tool of nutritional screening to evaluate the most relevant nutritional deficiencies in pregnancy, with impacts on the first stages of placentation and pregnancy outcomes, in a large Italian population of singleton pregnancies. A multicentre prospective observational study involving 22 Maternity Units would therefore make a significant contribution to this topic and public health, with a possible impact on future clinical routine care.

Collaborators SIMPLE study group (4)(4) Members of the SIMPLE study group: "L. Sacco" University Hospital, Asst-Fbf-Sacco, Milan (Savasi V.); "M.Melloni" University Hospital Asst-Fbf-Sacco, Milan (Vignali M.); S.Pio X, Humanitas University Hospital, Milan (Di Simone N.); "Careggi" University Hospital, Florence (Petraglia F.); "Santa Maria della Misericordia" University Hospital, Perugia (Di Renzo G.); "Sant'Anna" University Hospital, Torino (Benedetto C.); Polyclinic University Hospital, Modena (Facchinetti F.); "G. Martino" University Hospital, Messina (D'Anna R.); "San Matteo" Hospital, Pavia (Spinillo A.); "Arcispedale Sant'Anna" University Hospital, Ferrara (Greco P.); "Cisanello" University Hospital, Pisa (Simoncini T.); "Gemelli" University Hospital, Rome (Lanzone A.); "Ospedali Riuniti" University Hospital, Foggia (Nappi L.); Verona Polyclinic University Hospital, Verona (Franchi M.); Bari Polyclinic University Hospital, Bari (Cicinelli E.); "Vanvitelli" University Hospital, Naples (Colacurci N.); "Federico II" University Hospital, Naples (Zullo F.); Cagliari Polyclinic University Hospital, Cagliari (Angioni S.); Cagliari University Hospital ART center, Cagliari (Guerriero S.); San Salvatore Hospital, L'Aquila (Guido M.).

Contributors Authors involved in writing the protocol and collecting data. FP: conceived and designed the analysis, data collection, wrote the paper. CC: data collection, wrote the paper. IC: conceived and designed the analysis, wrote the paper SIMPLE study group: data collection.

Funding This work is supported by Bayer Consumer Care, grant number BHC-RD-SOP-038.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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