Gestational Weight Gain Trajectories: A Prospective Cohort Study in Rural Raigarh, Maharashtra, India

Background

Insufficient dietary intake and inadequate weight gain during pregnancy have been linked to low birth weight in newborns, significantly impacting neonatal health outcomes (1-8). Additionally, pre-pregnancy body mass index (BMI) is crucial in determining pregnancy outcomes (9). In India, the high prevalence of child stunting underscores the urgent importance of maternal and pre-pregnancy nutritional status. While global guidelines, such as the Institute of Medicine (IOM) classifications, offer frameworks for gestational weight gain (GWG), it is intriguing to consider how further research is required to assess their relevance to India's diverse population. In rural areas, nutritional deficiencies are often widespread and can affect mothers and their children (10).

Despite recognising the critical role preconception nutrition plays in influencing pregnancy outcomes, existing research in cohort studies remains limited, particularly regarding Gestational Weight Gain (GWG) patterns, especially in resource-constrained settings (11-14). Data limitations hinder comprehensive investigations on the impact of monthly pregnancy measurements in assessing maternal GWG and foetal growth. Previous birth cohort studies have extensively investigated factors associated with gestational weight gain, postpartum weight retention, intrauterine growth restriction (IUGR), and their long-term health consequences (6-7, 14). An evidence-based and culturally sensitive study is essential to address these knowledge gaps on risk factors associated with inadequate GWG and inform effective maternal and infant nutrition strategies in India (15-18).

The intricate relationship between gestational weight gain (GWG) and prevalent maternal conditions like anaemia, gestational diabetes mellitus (GDM), and gestational hypertension is crucial for understanding the holistic impact of nutritional status on maternal health within the context of this study. Maternal overconsumption and overweight during pregnancy can pose various risks to both the mother and the child. Overweight and obese women are at a greater risk for pregnancy-induced hypertension, gestational diabetes mellitus, and other complications such as preterm delivery and foetal mortality (9-10). Managing risks associated with preconception and early pregnancy overweight, gestational weight gain, and high caloric density can have a significant impact on prenatal nutrition and overall health outcomes for offspring. Addressing

these risks through dietary interventions, weight management, and lifestyle modifications can improve maternal and child health outcomes, reduce the risk of complications such as gestational diabetes and hypertension, and promote healthy development for the offspring (12, 15).

Global challenges associated with population growth, food insecurity, and compromised dietary quality have led to a double burden of malnutrition (DBM), characterised by the co-existence of undernutrition and overnutrition within the same population (21-24). India is currently grappling with this DBM, with a substantial portion of the population experiencing both undernutrition and overnutrition. Notably, the prevalence of DBM in Maharashtra has witnessed a significant increase, rising from 12% in 2006 to 22% in 2021, representing an alarming 83% surge. The rise in DBM prevalence was pronounced in rural areas and among low-income households compared to urban areas and wealthier populations (25-26).

Prenatal undernutrition can have long-term effects on offspring, contributing to adult diseases such as obesity, glucose intolerance, and coronary heart disease. Studies have shown that prenatal undernutrition, leading to low birth weight, can result in an increased risk of obesity, glucose intolerance, and coronary heart disease in adulthood. The examination of the profound implications of adverse health and nutritional statuses during pregnancy, including miscarriage, abortion, stillbirth, preterm birth, infant survival, and growth up to 2 years of age, is therefore essential (27-28). Such an investigation will only provide invaluable insights into how maternal well-being shapes the outcomes of infants within our study cohort, paving the way for more effective interventions and strategies tailored to address these pressing concerns.

The prospective cohort study of pregnant women aims to generate crucial insights into the associations among maternal nutrition, health status, and pregnancy outcomes in rural India. Specifically, it aims to evaluate the relationship between pre-pregnancy BMI and the pattern of gestational weight gain (GWG). Further, it finds the association of GWG with maternal diseases (anaemia, gestational diabetes mellitus (GDM), and gestational hypertension).

Data and Methods

Study Design: The study utilised data from the Longitudinal Study of Maternal and Infant Nutrition in Maharashtra (LoSMINM). The LoSMINM is a prospective longitudinal cohort study

involving pregnant women and their birth outcomes in the selected six villages of Karjat Taluk in Maharashtra, India with a duration of five-year observations. It was approved by the Institutional Review Board of IIPS (IRB Certificate no./IIPS/PSC-54/IRB/71/2022) in 2022. A total of 1,180 women aged 15-49 from 1641 households were interviewed in the baseline survey of the Longitudinal Survey of Maternal and Infant Nutrition in Maharashtra (LoSMINM). The cohort was recruited from the pool of currently married women aged 15-49 years (any parity) from the baseline and further updated with the local level support from the Auxiliary Nurse and Midwife (ANM)/ Accredited Social Health Activist (ASHA). The recruited cohort will be followed from conception till their childbirth, and further, till two years post-partum. The recruitment of women will continue till the time the required sample size is reached. The present findings is based on the 138 recruited pregnant women in cohort who were assessed according to the protocol (table-1), consisting of 482 repeated observations.

Recruitment of study participants

A comprehensive baseline census of households and currently married women (aged 15-49 years) was conducted using standardised questionnaires. There is a separate schedule for baseline household surveys, follow-up questionnaires for mothers during pregnancy, and outcome follow-up questionnaires for up to two years postpartum. The target cohort was identified and recruited from the pool of currently married women aged 15-49 years in the preconception stage of any parity during the baseline. The recruited cohort will be followed from conception to childbirth and two years postpartum. The recruitment of women will continue till the expected number of pregnancies as per the birth rates is reached.

The selected women from the census of villages and baseline information are followed up each month (+/- 1 week) to record their date of menstruation. A one-to-one interaction is done with a woman and her husband before following up to explain the objectives of the study. Written informed consent was obtained from all participants. The inclusion of participants is based on whether they are currently married women aged 15-49 years in the preconception stage residing in the community. This list is being updated with the help of an Auxiliary Nurse and Midwife (ANM)/ Accredited Social Health Activist (ASHA) till the expected numbers have been achieved.

Women will be excluded if they had a history of chronic illness, carrying twins or multiple babies, with multi-foetal pregnancies are excluded to avoid the confounding effects of multiple births on gestational weight gain and if the mothers who migrate out of the study, i.e., migration or loss to follow-up in this study is defined as a pregnant woman missing for more than two consecutive follow-up visits at any point during the pregnancy.

All the information was obtained using pre-tested and expert-reviewed interview schedules using Computer Assisted Personal Interview (CAPI). Bilingual interview schedules for the target participants were developed, pre-tested and standardised. A mixed-method approach was used, including quantitative data collection and qualitative investigations. The telephonic interview is conducted if recruited women returned to their parental home or migrated to another place during pregnancy.

Data Collection

The recruitment of study participants began in March 2022 and is ongoing. The respondents are followed over time, and Tables 1 shows the details of the variables assessed at each assessment point for mothers in this study. The study protocol was approved by the Institutional Review Board of IIPS (IRB Certificate no./IIPS/PSC-54/IRB/71/2022) in 2022. The data collection adheres to all applicable ethical standards, ensuring confidentiality and anonymity.

Fig 1: Flow chart of the LoSMINM study

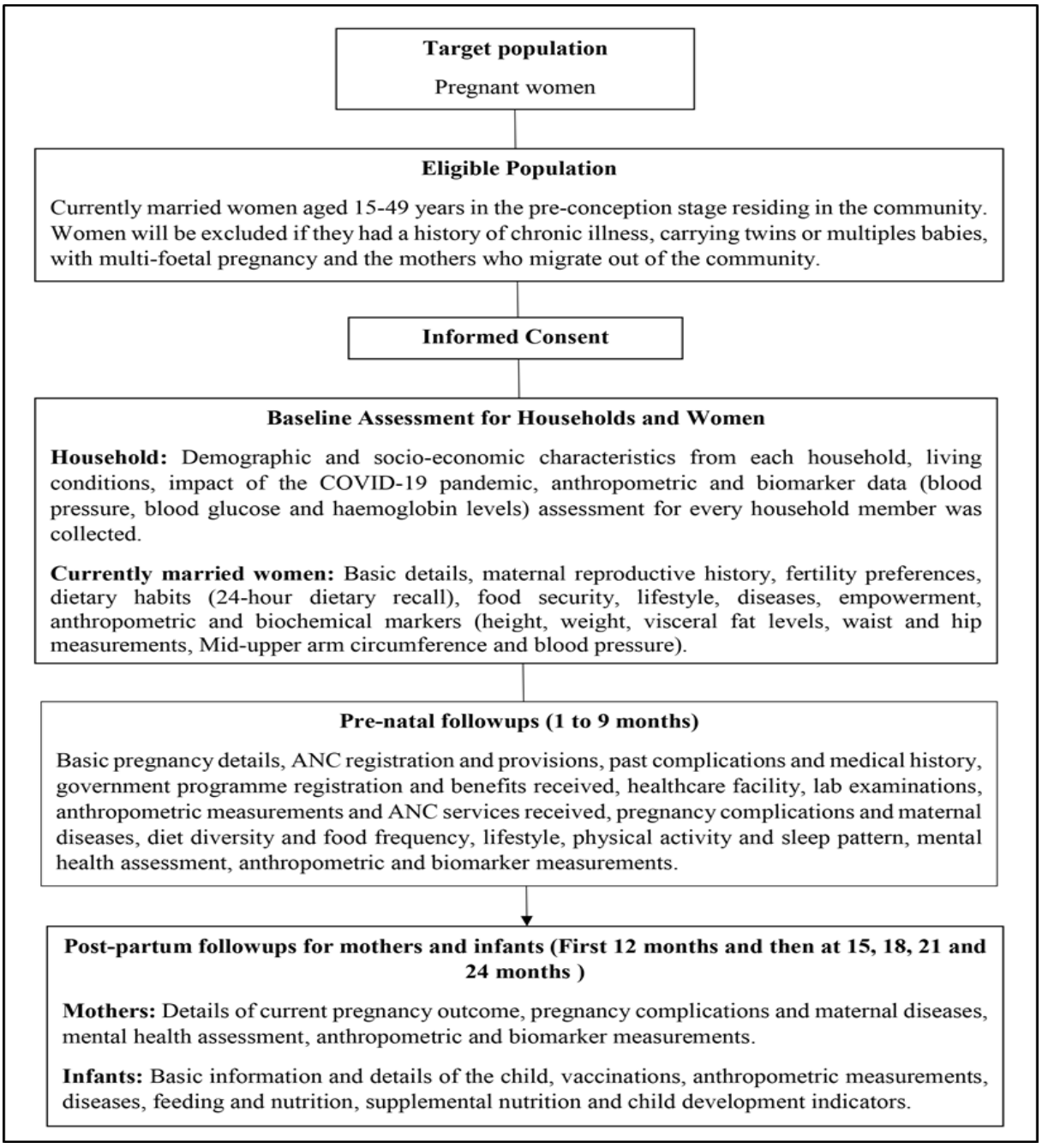

Table 1: Summary of data collection and timeline - Mothers

Variables	Prenatal Follow-ups									
	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10 (After delivery)
Basic pregnancy details	×									
ANC registration	×									
Past complications and medical history	×									
Government programme registration and cash benefits received.									×	
ANC provisions	×	×	×	×	×	×	×	×	×	
Healthcare facility	×	×	×	×	×	×	×	×	×	
Lab examinations, anthropometric measurements and ANC services received	×	×	×	×	×	×	×	×	×	
Pregnancy complications and maternal diseases	×	×	×	×	×	×	×	×	×	×
Diet diversity and food frequency			×			×			×	
Lifestyle, physical activity and sleep pattern	×	×	×	×	×	×	×	×	×	
Mental health assessment			×			×			×	×
Anthropometric and biomarker measurements taken	×	×	×	×	×	×	×	×	×	×
Random blood glucose, anaemia measurement and blood pressure measurement after consent taken	×	×	×	×	×	×	×	×	×	×
Details of current pregnancy outcome										×

Study Instruments: A separate women's questionnaire was administered to currently married women (aged 15-49 years). It covered basic details like age, spouse details, cohabitation status, educational level, occupation, self-help group membership, digital literacy, maternal reproductive history and delivery details of previous pregnancies, reproductive information like menstruation details and health problems, family planning, sterilisation and fertility preferences, food frequency and dietary diversity (24-hour dietary recall), food security, lifestyle, diseases, physical activity and sleep pattern. The anthropometric and biochemical markers like height, weight, visceral fat levels, waist and hip measurements, mid-upper arm circumference (MUAC) and blood pressure measurements are also taken.

Maternal questionnaires

The maternal questionnaires used for the prenatal follow-ups of 9 months include personal identification and information on current pregnancy, lab investigations at ANC visits each month and detailed data from their medical records, past pregnancy complications and medical history, diet diversity and food frequency (72-hour recall), lifestyle, physical activity and sleep pattern, mental health assessment, anthropometric measurements and biomarker measurements like height, weight, visceral fat levels, random blood glucose, anaemia and blood pressure taken by the project staff.

The anthropometric and biomarker measurements are taken using standard calibrated methods and instruments like stadiometers, digital weighing machines, BIA machines, Gulick tapes, digital BP monitors, hemocue photometers and glucometers (43-44). Pre-pregnancy body weight is categorised into four per Institute of Medicine (IOM) guidelines (**¡Error! No se encuentra el origen de la referencia.**). The total gestational weight gain is the difference between the final body weight recorded at the last antenatal care visit or follow-up visit and the pre-pregnancy weight recorded at the first. The maternal GWG is classified and analysed according to the IOM guidelines (**¡Error! No se encuentra el origen de la referencia.**, 45). The details of antenatal care visits of the mother, like anthropometric measurements, medicines and injections provided, are obtained from the Mother and Child Protection (MCP) card (46).

Data Analysis

The relationship between pre-pregnancy BMI and gestational weight gain (GWG) trajectories, gestational age, is assessed using cohort approach. Multilevel regression analysis was used to identify the determining factors of gestational weight. Further, to find the association of GWG

with maternal diseases (anaemia, gestational diabetes mellitus (GDM), and gestational hypertension), appropriate test statists were applied after controlling for potential confounders.

Expected Findings:

Nutrition status of women in study population: Findings summarizes the nutritional status of women based on weight, Body Mass Index (BMI)[1]and Mid-Upper Arm Circumference (MUAC). The average weight of women in the survey is 52.4 kg. The average height of women in the survey is 150.2 cm. A notable finding is that eleven percent of women have a height of less than 145 cm, which may indicate undernutrition earlier in life. Though the data from Raigarh (NFHS-5) shows that twenty-two percent of women are underweight, a similar pattern of around one-fifth (19%) of women are classified as underweight in the study area. Almost half (49%) fall within the normal weight range. While a substantial percentage of women are underweight, over one-fifth (21%) are overweight. These figures highlight the possible double burden of malnutrition in the study population, where undernutrition and overnutrition coexist. It was found that over three-quarters (77%) of the women have a MUAC of 23 cm or above, which is considered normal. A small percentage (8%) fell below 20.9 cm, and four percent in the less than 19 cm category.

The data reveals that remarkably high proportion of women (99%) report consuming pulses (beans, peas, lentils) and nuts/seeds. Additionally, a significant percentage (83%) include dark green leafy vegetables and other Vitamin A-rich fruits and vegetables in their diets. Further, a good proportion of women had healthy eating habits as revealed in the findings. A significant percentage of women reported experiencing some level of food insecurity in the past year. Nearly twenty percent expressed worry about insufficient food, having to eat a limited variety, or being unable to afford healthy food. Despite various programs like the public distribution system aimed at reducing food insecurity, a high prevalence persists among women in the study area.

Average weight was 51 Kg at any time during gestation (variation bweeen:10kg; within 3kg). GWG was at the peak at 1.9 KG (95%CI: 1.45 - 2.36 KG) in 7th and (1.1- 2.77 KG) in 8^{th} month of gestation. GWG varied across social groups and was at lower in women who reported any non-communicable disease. However, there was no linkages between GWG and antenatal check-up (ANC) visits, although ANC visits positively influenced the weight at any time during gestation.

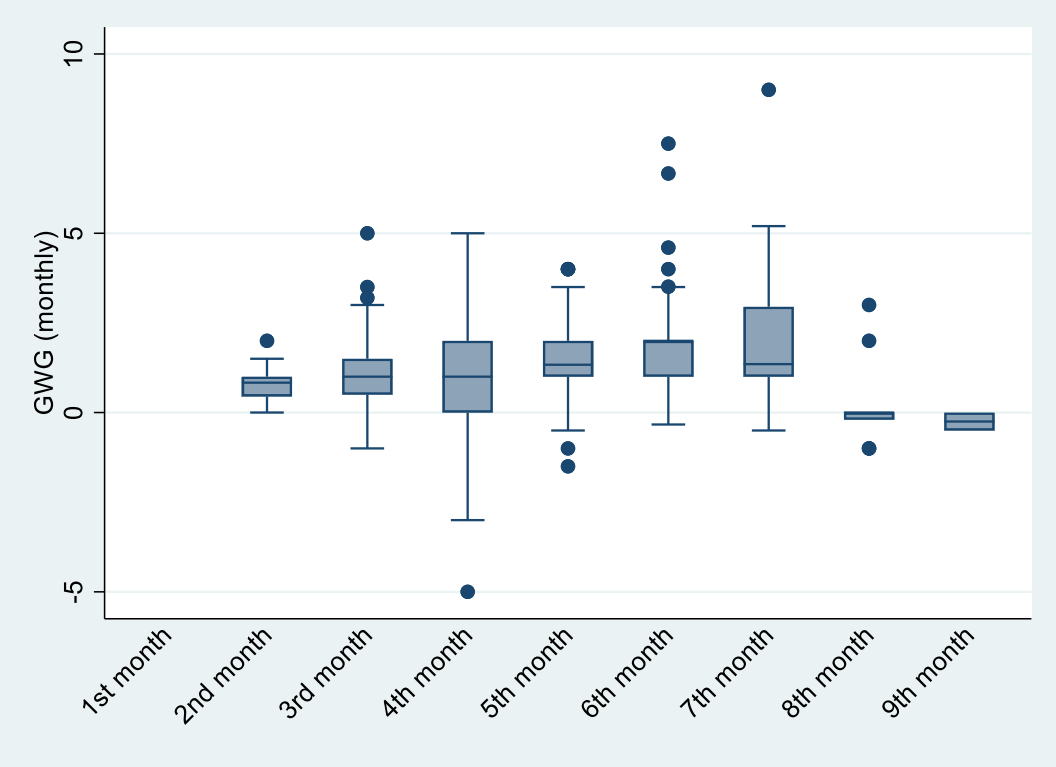

Figure: Gestational weight gain (GWG-monthly) over gestation

Multilevel analysis will be performed on the final recruited sample. The preliminary analysis clearly suggests a significant variation in GWG over period and groups.

This study addresses significant gaps in existing literature, especially in resource-constrained settings where nutritional deficiencies and their impacts on maternal and child health are pervasive. The study underscores the importance of maternal nutritional status before and during pregnancy by focusing on pre-pregnancy BMI and gestational weight gain (GWG) as pivotal determinants of pregnancy outcomes. The assessment of GWG patterns, following the Institute of Medicine (IOM) guidelines, provides a structured framework to evaluate weight gain adequacy and its implications for maternal and foetal health. Investigating the association of GWG with maternal conditions such as anaemia, gestational diabetes mellitus (GDM), and gestational hypertension is particularly significant (5, 7, **¡Error! No se encuentra el origen de la referencia.**-14, **¡Error! No se encuentra el origen de la referencia.**). These conditions, prevalent in the study's rural setting, profoundly affect pregnancy outcomes, highlighting the need for targeted nutritional and healthcare interventions.

Ethical considerations are meticulously addressed, with informed consent obtained from all participants and adherence to cultural and social norms. The involvement of local health workers (ANMs and ASHAs) in the recruitment process ensures community engagement and trust, which are essential for the study's success. The study's ethical framework and rigorous data management practices underscore its commitment to maintaining the highest standards of research integrity. This study also delves into the complexities of maternal and child health, influenced by maternal nutrition, mental health, social support, and environmental stressors. The mixed-methods approach investigates the interplay between maternal nutrition, maternal mental health, and infant health outcomes, focusing on dietary diversity, food security, and postpartum depression. Adequate maternal nutrition during pregnancy is crucial for ensuring optimal foetal growth and development, which has far-reaching implications for the child's long-term health and well-being (51-54). The study aims to strengthen these assertions by revealing associations between maternal dietary diversity and infant growth trajectories, underscoring the importance of promoting a diverse and balanced diet among pregnant women, especially in resource-constrained settings.

Furthermore, the study covers the often-neglected aspect of maternal mental health and its impact on infant health outcomes. In conclusion, this study significantly advances our understanding of the intricate relationships among maternal nutrition, health status, and pregnancy outcomes in rural India. The findings are expected to contribute substantially to the global body of maternal and child health knowledge, with implications for policy and practice in similar settings worldwide.

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