

**LAHORE PREGNANCY COHORT STUDY;  
ASSOCIATION OF MATERNAL NUTRITIONAL  
STATUS, ENVIRONMENTAL FACTORS AND  
PSYCHOLOGICAL STATUS WITH NEONATAL  
ANTHROPOMETRIC DATA AND PREGNANCY  
OUTCOMES AMONG PAKISTANI PREGNANT  
WOMEN**

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WOMEN**

**by**

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## LIST OF SYMBOLS AND ABBREVIATIONS

AC	Abdominal circumference
ANOVA	Analysis of variance
APGAR	Appearance, Pulse, Grimace, Activity and Respiration
AS	APGAR score
ASA24	Automated Self- Administered 24-h Recall
BM	Blood pressure monitor
BMI	Body Mass Index
BP	Blood pressure
BW	Birth weight
CaC	Calf circumferences
CC	Chest circumference
CDC	Centers for Disease Control and Prevention
CHL	Crown-heel length
COPD	Chronic obstructive pulmonary disease
DASS 21	Depression, anxiety and stress scale
DIP	Diabetes in pregnancy

DNA	Deoxyribonucleic acid
DR	Dietary Recall
EGWG	Excessive Gestational Weight Gain
FBG	Fasting blood glucose level
FFQ	Food Frequency Questionnaire
FIES	Food insecurity experience scale
FMH	Fatima Memorial Hospital
GA	Gestational age
GDM	Gestational diabetes mellitus
GI	Glycemic Index
GL	Glycemic load
GOD	Glucose Oxidase
GWG	Gestational weight gain
H0	Null hypothesis
H1	Alternate hypothesis
HbA1c	Hemoglobin A1C
HB	Hemoglobin



HBW	High birth weight
HC	Head circumference
HCG	human chorionic gonadotropin
HCT	Hematocrit test
HDL-C	High density lipoprotein cholesterol
HFIAS	Household food insecurity access scale
IGF-I	Insulin-like-Growth-Factor-I
IOM	Institute of Medicine
IQR	Interquartile range
IRB	Institutional Review Board
IUGR	Intrauterine growth restriction
JEPeM	Jawatankuasa Etika Penyelidikan Manusia
LBW	Low birth weight
LGA	Large for Gestational Age
LPCS	Lahore pregnancy cohort study
LSD	Least significant difference
MCHC	Mean corpuscular hemoglobin concentration

MCV	Mean corpuscular volume
MDG	Millennium Development Goals
MISC	Mother-Infant Study Cohort
mL	Milliliter
Mm/Hg	Millimeter (s) of mercury
MUAC	Mid-upper arm circumference
n	Total number of samples
NCDs	Non-communicable diseases
OPD	Outpatient Department
p-value	Probability
PAP	Phenol amino phenazone
PIH	Pregnancy induced hypertension
PKR	Pakistani rupees
PSS	Perceived stress scale
PTB	Preterm birth
PTH	Parathyroid hormone
PTHrP	Parathyroid hormone-related peptide

PUFA	Polyunsaturated fatty acid
Q2	Second quarter
$r(\rho)$	Correlation coefficient
RBG	Random blood glucose level
RDA	Recommended dietary allowance
RDW	Red cell distribution width
RNI	Recommended Nutrient Intakes
SC-330ST	Body Composition Analyzer
SD	Standard deviation
SDG	Sustainable Development Goals
SECA	Self-Employed Contributions Act
SEM-1	Scanning Electron Microscopy
SGA	Small-for-gestational-age
SPSS	Statistical Package for Social Sciences
TAC	Total Antioxidant Capacity
TC	Total cholesterol
TG	Triglycerides

TWG	Total weight gain
UAE	United Arab Emirates
UNICEF	United Nations Children's Fund
USDA	U.S. Department of Agriculture
USM	Universiti Sains Malaysia
VLDL-C	Very low-density lipoprotein cholesterol
WAZ	Weight-for-age Z-scores
WBC	White blood cells
WLZ	Weight-for-length Z-scores
WFR's	Weighed food records
WGR	Weight gain rate
WHO	World Health Organization

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Committee of Universiti Sains Malaysia
- Appendix B      Ethical Approval Letter from the Institutional Review Board  
(IRB) of Fatima Memorial Hospital College of Medicine &  
Dentistry, Pakistan
- Appendix C      Informed Consent Form
- Appendix D      Questionnaire

**KAJIAN KOHORT KEHAMILAN LAHORE; PERKAITAN ANTARA  
STATUS PEMAKANAN IBU, FAKTOR PERSEKITARAN DAN STATUS  
PSIKOLOGI DENGAN HASIL KEHAMILAN DAN STATUS  
ANTROPOMETRI NEONATAL DALAM KALANGAN WANITA HAMIL DI  
PAKISTAN**

**ABSTRAK**

Di Pakistan, prevalens kadar kematian ibu berada pada tahap yang lebih tinggi berbanding di negara membangun yang lain. Kajian Kohort Kehamilan Lahore ialah penyiasatan komprehensif yang direka untuk meneroka hubungan kompleks antara status pemakanan ibu, faktor persekitaran, faktor psikologi, dan kesannya terhadap data antropometrik neonatal dan hasil kehamilan dalam kalangan wanita hamil dan kesihatan neonat di Pakistan. LPCS ialah kajian kohort prospektif dua tahun yang dimulakan pada tahun 2019 yang merekrut wanita hamil Pakistan dari Hospital Memorial Fatima Lahore, Pakistan melalui teknik persampelan yang mudah. Seramai 227 peserta kajian berumur antara 19-40 tahun telah ditemu bual pada tiga peringkat. (trimester ke-2, ke-3 dan selepas bersalin). Maklumat ibu dikumpul daripada rekod hospital dan melalui soal selidik berstruktur sendiri. Dengan tumpuan kepada populasi Pakistan, data kajian komprehensif ini mengenai status pemakanan ibu, merangkumi tabiat pemakanan dan indeks jisim badan (BMI). Faktor persekitaran, seperti status sosioekonomi, keselamatan makanan, juga dinilai untuk menentukan potensi pengaruhnya terhadap hasil kehamilan. Status psikologi wanita hamil dinilai, termasuk tekanan, kebimbangan dan kemurungan. Hasil kehamilan seperti pertambahan berat badan semasa mengandung (GWG), diabetes mellitus kehamilan (GDM) dan anemia. Tambahan pula, ia menyiasat faktor yang dikaitkan dengan hasil kelahiran bayi, seperti panjang lahir, berat, lilitan kepala, lilitan perut dan skor APGAR. Hasil ketara

menunjukkan bahawa kebanyakan responden tiada masalah keselamatan makanan (100%) dan masalah kemurungan ringan didapati dalam kalangan ibu. Faktor sosiodemografi, sosioekonomi dan pemakanan didapati berkait dengan anemia. Terdapat perbezaan ketara antara prevalen anemia di pelbagai peringkat kehamilan dan selepas kelahiran dengan min Hb pada  $11.61 \pm 1.05$  (trimester kedua),  $11.11 \pm 1.62$  (trimester ketiga) dan  $10.41 \pm 1.56$  (selepas kelahiran). Perbandingan skor min menunjukkan nilai glukosa berpuasa dan rawak juga berbeza pada setiap kala masa dalam kalangan responden kajian ( $p < 0.05$ ). Kekurangan pengambilan makanan ditemui dengan pergantungan tinggi terhadap suplimen ( $p < 0.05$ ) untuk memenuhi keperluan pemakanan. Tambahan, kecukupan dietari didapati berkait dengan pengukuran antropometri pada item makanan yang tertentu. Tambahan lagi, 44.9% bayi adalah wanita manakala 55.1% adalah bayi lelaki dengan 18.5% bayi mengalami kekurangan berat badan. Kajian ini mengutarakan kesan positif faktor persekitaran dan kesihatan psikologi ibu. Kesimpulannya, kajian ini menonjolkan isu utama berkait kesihatan ibu dan anak di Lahore. Penemuan daripada kajian ini mempunyai potensi untuk memaklumkan inisiatif kesihatan awam, dasar penjagaan kesihatan, dan intervensi yang bertujuan untuk meningkatkan kesihatan ibu dan neonatal di Pakistan. Akhirnya, matlamatnya adalah untuk menyumbang kepada peningkatan penjagaan pranatal dan kesejahteraan keseluruhan ibu mengandung dan anak mereka di rantau ini.

**Kata kunci:** LPCS, Kehamilan, Kohort, Status Pemakanan, Tekanan, Kebimbangan, Kemurungan, Ketidakpastian Makanan, Diabetes Gestational, Pertambahan berat badan semasa mengandung, Anemia, Antropometri Neonat.

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AND PSYCHOLOGICAL STATUS WITH NEONATAL  
ANTHROPOMETRIC DATA AND PREGNANCY OUTCOMES AMONG  
PAKISTANI PREGNANT WOMEN**

**ABSTRACT**

In Pakistan, prevalence of maternal mortality rates is on higher side than in other developing countries. The Lahore Pregnancy Cohort Study is a comprehensive investigation designed to explore the intricate relationship between maternal nutritional status, environmental factors, psychological factors, and their impact on neonatal anthropometric data and pregnancy outcomes among pregnant women and neonate's health in Pakistan. The LPCS was a two-year prospective cohort study started in 2019 that recruits Pakistani pregnant women from Fatima Memorial Hospital Lahore, Pakistan through convenient sampling technique. Participants of the study (approximately 227) between the age of 19-40 years were interviewed in three intervals. (2nd, 3rd trimester and postpartum). The mother's information was collected from the hospital records and via a self-structured questionnaire. With a focus on the Pakistani population, this comprehensive study data on maternal nutritional status, encompassing dietary habits, and body mass index (BMI). Environmental factors, such as socioeconomic status, food insecurity, are also assessed to determine their potential influence on pregnancy outcomes. The psychological status of pregnant women is evaluated, including stress, anxiety and depression. Pregnancy outcomes such as gestational weight gain (GWG), gestational diabetes mellitus (GDM) and anemia. Furthermore, it investigated factors linked to infant's birth outcomes, such as birth length, weight, head circumference,



abdominal circumference and APGAR score. Significant findings highlighted that mostly respondent is food secured (100 %) and mild depression is observed among the mothers. Socio-demographic, socio-economic and dietary variables are associated with the prevalence of anemia. There exists a significant difference between the prevalence of anemia at different points in pregnancy and post-partum with mean Hb levels of  $11.61 \pm 1.05$  (2nd trimester),  $11.11 \pm 1.62$  (3rd trimester) and  $10.41 \pm 1.56$  (post-partum). Mean score comparison showed that fasting and random blood glucose were also significantly different at different time points among study respondents ( $p < 0.05$ ). Insufficient consumption of dietary intake is observed, with a higher reliance on supplements ( $p < 0.01$ ) to meet their nutritional needs. In addition, dietary adequacy was found to be related with anthropometric measurements with different food item effecting differently. Moreover, 44.9% newborns were female while 55.1% were male with 18.5% of neonates having lower birth weight. The study underscored the positive effects of environmental factors and psychological health. In conclusion, this study highlighted key issues related to maternal and infant health in Lahore. The findings from this study hold the potential to inform public health initiatives, healthcare policies, and interventions aimed at improving maternal and neonatal health in Pakistan. Ultimately, the goal is to contribute to the enhancement of prenatal care and the overall well-being of expectant mothers and their offspring in this region.

**Keywords:** LPCS, Pregnancy, Cohort, Nutritional Status, Stress, Anxiety, Depression, Food insecurity, Gestational Diabetes, Gestational weight gain, Anemia, Neonate Anthropometric

# CHAPTER 1

## INTRODUCTION

### 1.1 Background of the study

Nutrition has great effect on health throughout life but it plays a vital role in influencing fetal growth and birth outcomes. It is a modifiable risk factor of public health significance. Maternal nutritional status could be considered as primary predictor for the nutritional status of neonates, however the association between maternal nutrition and birth outcome is complex and is influenced by many physiological, socio economic and demographic factors. The state of maternal nutrition is one of the important factors, which might effect on the period of pregnancy. The fetal growth and dramatical changes include hormonal and the metabolic alterations consequential during pregnancy impose great stress and result in an increase in the expectant mother's nutritional requirements (Tyagi, Toteja and Bhatia, 2019).

Some factors are interrelated, and they can confound the results in addition to modifying the independent estimates of relative risk associated with a risk factor. These risk factors include maternal malnutrition, hypertension (Preeclampsia), gestational diabetes mellitus, poverty, food insecurity, smoking, and depression (Saeed, Humayun and Raana, 2018).

The nutritional status of the pregnant mother and her total weight gain during the period also affect the preterm birth rate. In both pre and post-pregnancy states, nutritional status is relevant because underweight or obese women might increase the risk for preterm birth more than 2 -4 times. Even if the mother has a healthy weight before pregnancy, they must achieve recommended weight gain during gestation. It is also important for the mother to maintain a healthy weight during pregnancy. Excessive weight gain or weight loss during pregnancy can increase the risk of complications, such as gestational diabetes and pre-eclampsia. In addition, a

woman's nutritional status can impact her ability to cope with the physical and emotional changes that occur during pregnancy. A well-nourished mother is more likely to have more energy and be better equipped to handle the physical and emotional demands of pregnancy. The type of food a woman consumes during pregnancy is also important. A balanced diet that includes plenty of fruits, vegetables, whole grains, and lean proteins is recommended. Women should also aim to consume adequate amounts of calcium and iron, as these nutrients are essential for the growth and development of the baby. It is also important to avoid certain foods, such as raw or undercooked meats, unpasteurized dairy products, and fish with high levels of mercury, as these can be harmful to the baby (Xinxo *et al.*, 2013).

In Pakistan, when compared with other areas of the country, Punjab has been declared the least prevalent area concerning the presence of anemic pregnant women. Despite this, prevalence is still higher in the list as far as comparison with other countries is concerned. There were some direct risk factors for anemia, such as maternal age, low socioeconomic background, poor diet: like low consumption of protein, and excessive caffeine intake like coffee and tea. Prevalence of anemia was more prevalent in the 35-40year age group female. Out of 65.4% were anemic females, 39.8% were mild, 19.2% were moderately, and 6.4% were severely anemic. Interestingly, 17.7% of the total fetal mortality rate is associated with pregnant women who have anemia (Hameed *et al.*, 2018).

The impact of being exposed to depression can influence a child throughout childhood and can also lead to developmental issues. Therefore, prenatal depression was considered a factor related to children's development. According to recent surveys for the last 12 months, it is documented that approximately 32.8% of women have gone through various kinds of psychological abuse. Physical violence was reported and experienced by 15.9% of women. Moreover, postnatal abuse was significantly associated with maternal depression and other disorders related to mental well-being (Sikander *et al.* 2019).

From conception until the age of two years, also called the first 1000 days of life, a unique period of remarkable physiological growth and rapid functional development of the body's organs. In this duration, a fetus, infant (<12 months of age), or toddler (1-2 years) is most vulnerable to environmental influences that can profoundly affect critical stages of this development process, with subsequent short or long-term consequences for health and physical performance (Toro Ramos *et al.* 2015).

Many studies show that the survival chances, optimal growth, and development of an infant or young child can be increased by proper feeding, especially in the critical period from birth to 2 years of age. Preferably infants' breastfeeding should be started within one hour of birth. At the 6th month of their age, a semi-solid diet alongside breastfeeding should be introduced to children. The start of tolerable feeding from 6 months onwards can significantly avert undernutrition and the risk of infectious diseases such as diarrhea and pneumonia. Yet regardless of all these potential advantages, more than two-thirds of infants are introduced to solid foods on time (UNICEF, 2018).

Maternal malnutrition (including under and over-nutrition) can have profound distresses on embryonic development & fetal growth, and subsequent infant growth and development during and beyond the breastfeeding period. The first three months of a child are more crucial for normal physical and conceptual development. Even cognitive and emotional potential develop early, as social, intellectual, and emotional competencies might establish during this time. During 3-12 months, poor nutrition leads to perceptible defects such as delayed motor and cognitive development, behavioral problems, lack of social skills, a lesser attention span, learning disabilities, and lower educational attainments (WHO, 2019).

Maternal malnutrition is a major public health concern in Pakistan, contributing to various adverse outcomes for both mothers and their children. Pregnant Pakistani women are more susceptible to specific dietary, environmental, and psychological factors which impact

the course of their pregnancy. The high rates of morbidity and mortality among mothers and newborns highlight the need for focused research that can offer specific insights to enhance mother and newborn health in Pakistan. To summarize, “the Lahore Pregnancy Cohort Study” endeavors to address a noteworthy public health issue by enhancing broader discussions regarding maternal and neonatal health in low- and middle-income communities like Pakistan. In addition, the results of this investigation may spark a more extensive conversation about the region's prenatal care policies and services.

## **1.2 Problem Statement**

The present study will be one of the first birth cohort studies in Lahore, Pakistan. The maternal nutritional status, unavailability of food, depression, and many related factors directly affect neonate health. To protect the health of both the mother and neonate, operational strategies should be adopted, such as policies that might help improve their lifestyles and reduce pregnancy complications.

## **1.3 Rationale of study**

Pakistan faces high fertility rates and maternal mortality, with about 30,000 women dying annually due to pregnancy and childbirth complications. Approximately 1 in 38 Pakistani women is at risk of maternal death, mainly due to issues like inadequate weight gain during pregnancy, gestational diabetes, preeclampsia, food insecurity, and psychological challenges. This situation contrasts sharply with regional averages, which are 1 in 230. Nearly 5 million pregnancies in Pakistan each year, around 15% (0.7 million) are expected to encounter medical and obstetrical problems due to malnutrition. These challenges conflict with Sustainable Development Goals, particularly Goals 2, 3, and 5, which aim to address hunger,

improve health, and promote gender equality, all of which are crucial for maternal health. (Khalid *et al.* 2017).

Pregnancy is a pivotal period in a woman's life, and it can significantly affect the health and well-being of both the mother and her newborn. Maternal nutritional status plays a crucial role in determining the baby's growth, birth weight, and overall health. Early marriages, large family size, extreme fertility rates, no birth spacing, low socioeconomic status, and the lack of awareness about breastfeeding and exclusive breastfeeding were the essential component contributing to malnutrition (Asim and Nawaz, 2018).

The weight of the neonate at birth is a powerful predictor of neonatal growth and survival because of maternal health and nutrition intake during pregnancy. Globally maternal malnutrition is an important determinant of adverse outcomes for mothers and offspring. (Tyagi, Toteja and Bhatia, 2019).

The Lahore Pregnancy Cohort Study is a research initiative designed to investigate the complex interplay between maternal nutritional status, environmental factors, psychological well-being, and their potential impact on neonatal anthropometric data and pregnancy outcomes among pregnant women in Lahore, Pakistan. This study aims to shed light on the various factors that can influence the health and development of both the mother and the child during pregnancy. The rationale for conducting this study lies in the importance of understanding how these factors, when considered together, can influence the growth and health of newborns and the overall well-being of pregnant women.

Understanding the associations between these factors and their impact on neonatal anthropometric data (such as birth weight, length, head circumference and abdominal circumference) and pregnancy outcomes (including preterm birth, gestational diabetes,

preeclampsia, and more) is of significant importance for healthcare professionals, policymakers, and expectant mothers. By examining this association among Pakistani pregnant women, to identify potential areas for intervention and support that can lead to healthier pregnancies and better neonatal outcomes.

#### **1.4 Research Question**

Is there any Association between maternal nutritional status, environmental factors and psychological status with neonatal anthropometric data and pregnancy outcomes among Pakistani pregnant women?

#### **1.5 Research Objectives**

##### **1.5.1 General Objectives**

To investigate the association of maternal nutritional status, environmental factors, and psychological status with neonatal anthropometric data and pregnancy outcomes among Pakistani pregnant women through the Lahore pregnancy cohort study.

##### **1.5.2 Specific Objectives**

###### **a) Mothers**

1. To determine the nutritional status of pregnant women throughout pregnancy.
2. To determine the environmental factors (food insecurity and socioeconomic status) of pregnant women throughout the pregnancy.
3. To determine the psychological status (depression, anxiety and stress) of pregnant women throughout pregnancy.
4. To investigate the factors associated with pregnancy outcomes (GWG, GDM, Anemia).

## **b) Neonates**

1. To investigate the factors associated with birth outcomes (birth length, weight, head circumference, abdominal circumference and APGAR).

### **1.6 Research Hypothesis**

**Alternate hypothesis (H1)** = There is association of maternal nutritional factors, environmental factors and psychological status with neonatal anthropometric measurements and pregnancy outcomes.

**Null hypothesis (H0)** = There is no significant association of maternal nutritional factors, environmental factors and psychological status with neonatal anthropometric measurements and pregnancy outcomes.

### **1.7 Significance of study**

Compared to other emerging nations, Pakistan has a greater frequency of maternal malnutrition. One of the first birth cohort studies to be conducted in Lahore, Pakistan, the current study will serve to give important information on the health of newborns and the outcomes of pregnancies.

The 2018 Pakistan National Nutrition Survey revealed that 41.7% of women in reproductive age are anemic and 44.9% of undernourished women experience doubles the impact of malnutrition. A total of 36.9% of the population is food insecure. Depression as well as anxiety is prevalent overall at 33.62%. Approximately 95 million children under the age of five (14%) are underweight. The prevalence is rising sharply every day and is predicted to surpass 10% by 2025.



Pregnancy-related nutrition and maternal health are key factors in the growth and survival of the fetus. Pregnant women in Pakistan number approximately 5 million annually; of them, 15% (or 0.7 million) are expected to experience medical and obstetrical complications, including GWG, GDM, pre-eclampsia, food insecurity, and psychological problems. As opposed to Goals No. 2, 3, and 5 of the Sustainable Development Goals (SDGs), which center on promoting gender equity, health and wellbeing, and ending hunger in order to improve maternal health status.

This research can help shape health care policies and initiatives pertaining to nutrition, environmental health, mental health assistance for expectant mothers, and maternity care. The findings can be used by policymakers to put plans into place that target the risk factors found and can enhance the health of expectant mothers and newborns in Lahore, Pakistan.

The "Lahore Pregnancy Cohort Study" is important because it has the potential to improve healthcare for expectant mothers and newborns as well as provide information for policies and interventions that could improve the health and wellbeing of Pakistani mothers and their children.

## **1.8 Conceptual Framework**

The conceptual framework (depicted in Figure 1.1) illustrates the significant role of maternal nutritional status in shaping the health and well-being of both the mother and her infant throughout pregnancy and the postpartum period. This framework takes into account various factors that influence maternal nutritional status, psychological, environmental factors and how it, in turn, affects infant outcomes

Anthropometric measurement of mothers involves the assessment of the mother's weight, height, body mass index (BMI) to determine her nutritional status. Blood tests are conducted to evaluate the levels of hemoglobin and blood glucose level (fasting and random) which are crucial for a healthy pregnancy. The mother's dietary intake is analyzed through a 24-hour recall to ensure she receives the necessary dietary requirements for herself and her developing fetus from the second trimester till the postpartum period.

The environmental factors, such as food insecurity, socioeconomic variables like income, education, smoking and access to healthcare is essential. These factors can influence a mother's ability to access food and healthcare facilities, potentially resulting in nutritional deficiencies during pregnancy. The psychological status of the mother, including depression, anxiety, and stress, plays a significant role. Postpartum maternal mental health is also essential, as it affects her ability to care for herself and her infant. Maternal mental health can impact dietary choices, overall nutritional status, and pregnancy outcomes.

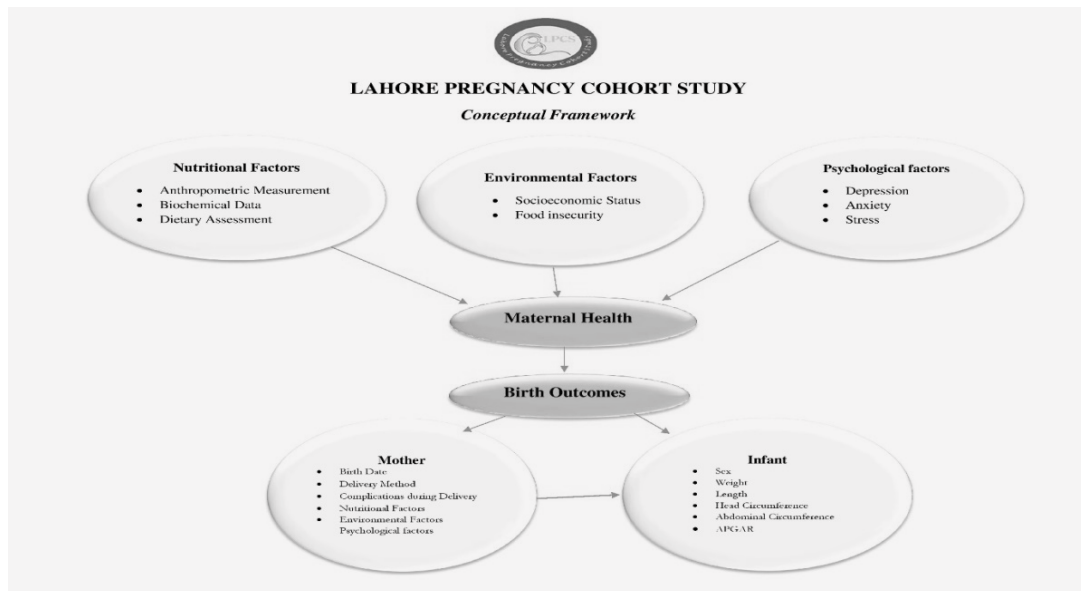
Considering the mother's gestational age when conducting nutritional assessments is crucial, as nutrient requirements change throughout pregnancy. The method of delivery, whether natural or via cesarean section, GWG, pre-eclampsia, anemia and gestational diabetes can influence postpartum recovery and nutritional needs. The presence of complications during delivery, such as excessive bleeding or infection, can have an impact on a mother's nutritional status and her ability to recover

Infant outcomes encompass factors influence various factors such as, Birth weight, a critical indicator of the infant's health and development, often linked to

maternal nutrition during pregnancy. Measurements like length, head circumference, and abdominal circumference, which help assess the infant's growth and development.

APGAR Scores, providing a rapid evaluation of the infant's physical condition at birth, including heart rate, respiration, muscle tone, reflexes, and color, all of which can be influenced by maternal nutrition during pregnancy.

Understanding and comprehensively monitoring these factors play vital for healthcare professionals and researchers. These major three factors associate with pregnancy and neonatal outcomes, emphasizing the significance of adequate nutrition, psychological status and environmental factors impact during both pregnancy and the postpartum period for the health and well-being of both the mother and her child.



**Figure 1.1 Conceptual framework**

## 1.9 Operational Definitions

**Anthropometrics** - Measurement of the physical characteristics of the body, such as height and weight.

**Anxiety** - A feeling of unease, such as worry or fear, that can be mild or severe (Koydemir & Essau, 2018).

**APGAR** - APGAR stands for "Appearance, Pulse, Grimace, Activity, and Respiration." In the test, five things are used to check a baby's health (Rosen & Bateman, 2009).

**DASS 21** - Depression anxiety stress scale 21, it is a set of three self-report scales designed to measure the emotional states of depression, anxiety, and stress. Each of the three DASS-21 scales contains 7 items, divided into subscales with similar content (Al-Kalbani *et al.*, 2022).

**Development** - The process in which someone or something grows or changes and becomes more advanced

**Depression** - Depression (major depressive disorder) is a common and serious medical illness that negatively affects feelings, thinking and action (Klein & Calentino, 2022).

**Family strength** - Number of family members

**Gestational age** – a measure of the age of a pregnancy in weeks, from the first day of the mother's last menstrual cycle to the current date.

**Growth** - The process of increasing in size.

**Gravidity**-the number of pregnancies, including miscarriage and term delivery.

**Healthy pregnancy** – a pregnancy in the absence of pre-existing or currently diagnosed chronic medical condition and pregnancy complications such as gestational diabetes, hypertension or preeclampsia.

**High birth weight (HBW)** – birth weight of more than 4000g.

**Low birth weight (LBW)** – birth weight of less than 2500g.

**Maternal** - Relating to a mother, especially during pregnancy or shortly after childbirth

**Neonates:** Infant in the first 28 days of the birth.

**Normal delivery** – a delivery through the vagina.

**Nutritional Assessment** - A comprehensive analysis of a person's nutrition. The status uses health, socioeconomic, drug, and diet histories; Anthropometric measurements; physical examinations; and laboratory tests (Gurinovic *et al.*, 2017).

**Postpartum/ postnatal period** – a period after delivery or birth (postpartum is the term used for the mothers, while postnatal is the term used for the infants).

**Prenatal period** – a period during pregnancy before delivery or birth.

**Pregnancy** The state of carrying a developing embryo or fetus within the female body

**Preterm (Premature)** Births occurring before 37 weeks of gestation; births occurring at 37 to 38 weeks of gestation are designated early term.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Pregnancy and Maternal Health**

Pregnancy is a period in which women go through several kinds of physiological alterations as a result of fetal growth and development (Soma-Pillay *et al.*, 2016). According to UNICEF, being pregnant is indeed a miracle. There is a living creature inside the women's body that will develop into a special person. There are a lot of changes ahead for the two of you at this exciting time (Mezmur, Assefa *et al.*, 2021).

It is a critical window of humoral, physical and hormonal changes, on which the future of mother and baby depends (Parrettini, Caroli *et al.* 2020). Nearly every organ system, including the endocrine, gastrointestinal, cardiovascular, renal, respiratory, and hematologic system, is impacted by these changes (Kazma, van den Anker *et al.*, 2020).

##### **2.1.1. Understanding the Dynamics of Pregnancy**

Pregnancy is usually separated into three trimesters, each of which has its own set of milestones and physiological changes. Recent research has shed light on the complexities of each trimester:

As stated, during the 9-months of pregnancy, many physical changes and physiological challenges occur. The journey begins with the first trimester, an interval of rapid development and adaptation during which the implantation of the fertilized egg and the development of the placenta are critical events. The first trimester ends at the 13th week while starting from conception. During this trimester, pregnant women might suffer from nausea, vomiting, change in appetite, fatigue,

pica, and numerous physical changes. People assume that pregnancy is a time of mood fluctuations where a woman experiences emotional changes such as mood swings, irritability, and psychiatric problems like anxiety, depression, and borderline personality can be a result (Olander, Smith and Darwin, 2018). Many hormones play vital role in the stability of pregnancy during first semester. To identify the importance of these hormones for maternal health, different researches were studied. One of the recent research projects, such as the work of Napso *et al.* 2018, has emphasized the significance of early prenatal care and the function of placental hormones, such as human chorionic gonadotropin (HCG), and human chorionic somatomammotropin (hCS) in supporting the pregnancy. HCG rises during the first eight to ten weeks of pregnancy at a rate that nearly doubles every three days. The placenta receives sufficient maternal blood supply and optimal embryonic nourishment from HCG during the invasion of the uterine endometrium. This is achieved through the stimulation of angiogenesis and vasculogenesis (Napso, Yong *et al.*, 2018).

The mother-to-be frequently has more energy and less morning sickness during the second trimester. The organs and systems of the growing fetus continue to mature. The final trimester is characterized by rapid growth and preparations for delivery. The baby's posture, which is frequently defined as cephalic or breech, becomes the focus of medical attention. The slightest unfavorable change during these critical months can lead towards maternal mortality or can put adverse effects in neonatal health. Maternal mortality refers to the death of a female during pregnancy or within six weeks after childbirth (Soma-Pillay *et al.*, 2016).

Many of the physiologic changes that occur in these three trimesters are linked to changes in hormones generated by the placenta. Recent research by JM

Kepley *et al.*, has shown that pregnant women have around 2.5 times greater free cortisol levels than non-pregnant women (Kepley, Bates *et al.*, 2023). This 10-fold increase in production of prolactin facilitate in development of breast tissue as well as milk production (Al-Chalabi, Bass *et al.*, 2018).

### **2.1.2 Maternal Health and its Impact on Neonatal Outcomes**

The physical and emotional well-being of a pregnant woman has a significant impact on her unborn child. The changes that occur in women body during pregnancy are vital for the neonatal outcome. As stated above the level of cortisol increases during third trimester, this rise in levels of cortisol is required for optimal fetal brain development. Due to lactotroph hyperplasia, the pituitary gland expands by around 135% during pregnancy, boosting circulating prolactin levels (Chourpiliadi and Papparodis 2019). One observable indicator of the prenatal environment that affects a child's development has been proposed to be the mother's cortisol levels during the third trimester (LeWinn, Stroud *et al.*, 2009).

One more notable variance is the change in cardiac working of pregnant women. The maternal cardiovascular system undergoes major physiologic changes, primarily an increase in cardiac output, stroke volume, heart rate, and a reduction in vascular resistance. The rise in cardiac output leads blood to be pushed towards the uterus, placenta, kidneys, skin, and extremities (Kepley, Bates *et al.*, 2023).

## **2.2 Maternal Nutrition and Dietary Assessment**

Maternal health has a significant impact on the well-being of newborns Maternal health outcomes, optimal birth weight, and higher odds of both mother and newborn survival are linked to a nutrient-rich diet before and during pregnancy (Lowensohn, Stadler *et al.*, 2016)



### **2.2.1 Importance of Maternal Nutrition for Fetal Development**

In earlier and during pregnancy, nutritional status considers crucial for the well-being of pregnant women and the fetus inside her. A normally growing and developing fetus that results from a normal pregnancy is associated with several factors. One of the main factors was the nutritional status which relates to proper metabolic substrate transportation that is important for the supply of the energy required for the growth of the fetus. If this equilibrium is disturbed, the pregnancy outcome effect in different ways (Xinxo *et al.*, 2013). The diet of the mother should contain enough nutrients to prevent the depletion of maternal reserves and to meet the needs of the developing fetus without endangering the mother's health (Maqbool, Dar *et al.*, 2019).

“Comfort eating” practice was commonly seen in pregnant women as their pre-pregnancy BMI is already high >24.9. The reason behind “Comfort eating” might have poor psychological states, but this practice increases the risk of unhealthy pregnancy and infant outcomes connected to maternal weight. Concerning how to decrease poor psychological conditions, current research indicates that omega-3 polyunsaturated fatty acid (PUFA) plays a significant role in optimal brain functioning. It also helps in fetal neuro-development by improving the maternal mental state while providing support to deal with stress, anxiety, and depression. As the requirement for omega-3 PUFA increases during pregnancy. Although, the exact mechanism is still under investigation (Lindsay *et al.*, 2017).

Poor dietary habits are a major risk factor for inadequate nutrition, infant mortality, and non-communicable diseases (NCDs). In addition, it can have adverse effects on birth outcomes like low- birth-weight babies, preterm delivery, and intrauterine growth retardation. Pregnant women should consume a balanced and

nutrient-dense diet to avoid these adverse effects (Pullar, Wickramasinghe *et al.*, 2019).

Dietary diversity was the prime indicator for households to assess their approaches, utilization, and diet quality, as it was considered a proxy indicator for measuring nutrient adequacy among pregnant females. Dietary patterns are associated with socio-demographic characteristics like age, education, occupation, parity, race, and ethnicity. A cross-sectional study of 350 pregnant women in their second and third trimesters was carried out in the outpatient department of the Maternal and Child Health Centre at Pakistan Institute of Medical Sciences (PIMS) Islamabad. A semi-qualitative questionnaire with structured questions about socio-demographic parameters, socioeconomic status, nutritional status, and three-day dietary recall was implemented. A portion with questions about dietary perceptions was also included. Results indicated that increasing age and education were associated with a healthy and diverse dietary intake in pregnant women. On the other hand, females that have less education, are non- working, and have increased parity, are more prone to an unhealthy non-diverse diet. (Ali, Thaver *et al.*, 2014).

Women of childbearing age are especially vulnerable to a variety of illnesses, including viral infections, which can disrupt the course of pregnancy and result in problems and potential complications affecting themselves, the developing fetus, and the baby after birth. Appropriate mother education is essential from preconception to the early postnatal period to support healthy pregnancies in general and to avoid and lessen the burden of viral infections in particular. In particular, an appropriate lifestyle based on correct dietary plans and feeding interventions, whenever possible, may be critical in lowering the risk of virus-related prenatal illnesses and associated issues later in life (Mate, Reyes-Goya *et al.*, 2021).

Parental socioeconomic status directly has no relation to the increased BMI of parents. However, increased parental weight is associated with two major lifestyle factors: eating habits and physical activity, especially for mothers during pregnancy. Although the risk of a child gaining weight and becoming overweight or obese in later stages of life is affected by the BMI of both parents predominantly, the mother's BMI has a significant link with the child's weight for height and body mass index according to age (Zalbahar *et al.*, 2016).

Assessment of pregnant women at Dhaka Medical college hospital revealed that even obese/overweight pregnant women had macro and micronutrient deficiencies which might be the factor of malnourished neonates. Moreover, women do not visit their gynaecologist regularly throughout the pregnancy. Regular visits were reported only in the second trimester, with low follow-up records in the first trimester. Furthermore, another anthropometric measurement factor was considered, such as height. It also declined as their study shows that 60% of women were five feet, and 24% were less than four feet eight inches. Once more, it increases the chance of necessary surgical modifications during delivery (Akther *et al.*, 2015).

Maternal Diet has an extreme effect on fetal anthropometrics such as birth size, birth weight, and head circumference. Consequences of these effects are seen in the long-term health of children. In a research, pregnant women aged 19 to 40 were enrolled in the Universiti Sains Malaysia (USM) Birth Cohort Study. Three 24-hour dietary recalls (DRs) were matched to the Food Frequency Questionnaire (FFQ). The principal component analysis yielded two major eating patterns, which were labelled as Healthy and Less-Healthy. The results showed that high sugar and sodium were proven harmful to fetal health. Similarly, confections and spices/condiments also link with poor fetal growth, especially the low-birth-weight infant. In contrast,

amongst all food groups, a study shows a positive association between mother fruit intake and infant birth weight (Loy and Jan Mohamed, 2013).

The inadequate nutrient intake during pregnancy has been linked to brain defects (diminished cerebral volume, spina bifida, hypothalamic and hippocampal pathway changes), an increased risk of abnormal behaviour, neuropsychiatric disorders (ASD, ADHD, schizophrenia, anxiety, depression), altered cognition, visual impairment, and motor deficits (Cortés-Albornoz, García-Guáqueta *et al.*, 2021).

A year before pregnancy, a considerably higher intake of saturated fat, trans fat, and calcium observe in the dietary pattern of pregnant women in contrast to non-pregnant women living in Alberta. Whereas, if comparing one-year prior dietary practices of non-pregnant women with currently pregnant women, then the results show that their eating habits remain similar concerning the intake of energy and a few essential micronutrients such as iron, folate, vitamin D, B12, and B6 (Ramage *et al.*, 2015).

During the second and third trimesters of pregnancy, parathyroid hormone levels fall, and another hormone similar to parathyroid hormone replaces it. This hormone is called a parathyroid hormone-related peptide (PTHrP). PTHrP mimics the effects of the parathyroid hormone. Parathyroid hormone-related peptide (PTHrP) is secreted from the placenta and elevated to the highest levels in the third trimester. Parathyroid hormone-related peptide (PTHrP) mimics the properties of PTH on the kidney and bones. Vitamin D levels also increase due to the effect of PTHrP. Moreover, it also affects urinary calcium and results in a three-time increase

in the level because of the increased absorption of PTHrP (Teasdale and Morton, 2018).

Maternal vitamin D levels also reflect in breast milk. Poor maternal vitamin D status can alter offspring's health in many ways like as immune, bone, and neural health. Most of the vitamin D levels of breast milk are related to maternal vitamin D status during the second trimester and somewhat during the third trimester. Malaysian research on Malay pregnant women reported that 60% of women in their second trimester and 37% of women in their third trimester are deficient in vitamin D. Even so, this percentage is still comparatively lower than other countries in the Asian region (Jan Mohamed *et al.*, 2014).

Anemia in pregnant women is associated with a considerably low level of hematological and biochemical levels. A study determines the biochemical and hematological profile of pregnant women with and without anemia attending Sanderman Provincial Hospital, Quetta, Pakistan. The prevalence of mild anemia was high than moderate and severe anemia. In addition, a significantly higher proportion of low serum ferritin was also reported in patients with severe anemia. In addition, a significantly higher proportion of low serum ferritin was also reported in patients with severe anemia. Of 357 patients, the mean Hb level was  $10.27 \pm 1.53$  g/dl. Majority of the pregnant were anemic, i.e., 248 (69.5%). Of these 248 anemic patients, mild anemia was found in 135 (54.4%), moderate anemia in 100 (40.3%) and severe anemia in 13 (5.2%) patients. A significantly lower level of Hb, WBC, HCT, MCHC, MCV, and RDW was observed in patients with anemia as compared to non-anemic patients. Moreover, serum ferritin level, serum iron, and total bilirubin level were found to be significantly lower in anemic patients than non-anemic patients (Anwar, 2020).

One of the reports showing malnutrition epidemically affecting Pakistan that can be documented as one of the key hurdles in national development due to its impact on the productive potentials of all ages of individuals. Malnutrition breathes as an unseen crisis in the country and its rates have alarmingly increased in Pakistan during the previous decade. Some of the potential causes are a high incidence of food insecurity, illiteracy, lack of knowledge related to nutrition, and poor hygiene due to low socioeconomic status (Afifa *et al.*, 2015).

A study was done to explore the level of awareness and breastfeeding practices prevalence among the lactating females in most of the areas of Pakistan. The study focused on two aspects of breastfeeding: the current level of awareness among lactating mothers regarding the importance of breastfeeding and whether or not these women practice nursing. It was seen that Pakistani females (especially those who belong to rural cultures) started other liquid items as supporting feed like, rose water, cow/buffalo milk, sweetened water, honey etc., along with them breastfeed to neonates within six months after delivery. Feeding their toddlers was like a routine matter for them and most of the elder relative ladies insisted them for breastfeeding (Ahmed and Chaudhry, 2014).

In Pakistan, nutrition has not been fully integrated into the national health system. There is no nutrition policy at either the federal or the provincial level to deal with malnutrition in emergency and nonemergency situations, and there is no high-level nutrition authority (Ahmed *et al.*, 2014).

### **2.2.2 Methods of Maternal Dietary Assessment: 24-hour Recall and Beyond**

A 24hr dietary recall is a systematic assessment designed to obtain comprehensive information about all the participant's food and drink intake over the

preceding 24 hours, most frequently from midnight to midnight the day before. The fact that the respondent is occasionally prompted for more specific information than what was first supplied is a significant component of the 24HR. For instance, the preparation technique and bread type would be inquired about from a responder who reported having chicken for dinner or a sandwich for lunch. This open-ended response format is intended to compel participants to give a thorough and in-depth account of all ingested meals and beverages. In a research food frequency questionnaire was identified as a reasonably valid tool for assessing dietary patterns of pregnant women. A cohort study was done on pregnant women of Kelantan where researchers compared Food Frequency Questionnaire (FFQ) with three 24-h dietary recalls (DRs). Study sample consist of one hundred and sixty-two pregnant women with age range of 19-40 year old. During their research for assessing the validity of FFQ Two major dietary patterns were identified from the FFQ and DR. They were termed as “Healthy” and “Less-Healthy” patterns. The Healthy pattern was loaded heavily by fish and other seafood, fruit, dairy products, vegetables, nuts and legumes. The Less-Healthy pattern was characterized by high intake of confectioneries, condiments, oils and fats, tea and coffee, cereals, meat (Loy and Jan Mohamed, 2013).

Reliable and accurate data are critical for detecting populations at risk of malnutrition as a result of poor dietary habits, in order to implement appropriate interventions, and assess health progress. A study was conducted to test the concurrent criterion validity of an LLWC-based image-assisted recall (IAR) and 24-hour recall (24HR) for assessing mother and child dietary diversity scores (DDS). It was determined that the 24HR and IAR both provide an accurate measure of the

median dietary diversity for mothers and their young children (Bulungu, Palla *et al.*, 2021).

Tools have been recommended such as 24-h-recall, weighed food records (WFR's) and 3- to 7-d food recalls. Nevertheless, WFR's are preferred over 24-h-recall because they have the least correlation with the possible errors that may be committed in the use of FFQ. For large population 3 to 7-day food recall is preferred over WFR's to use as a reference tool to validate developed food frequency questionnaire (Cabigas, Bongga and Gabriel 2020). The established tool to assess dietary habits of participants especially in epidemiological studies that involve large population. However, The FFQ should reflect the culture and dietary habits of the population being studied and developed FFQ also needs to be validated with appropriate dietary assessment tool as a reference (Shim *et al.*, 2014).

### **2.3 Prevalence of Maternal Malnutrition and Child Health**

A condition of either excessive or insufficient nourishment, malnutrition has grave implications for the health of mothers and their offspring. The main factor contributing to children's death and morbidity is maternal malnutrition. Maternal nutrition has gotten less attention in less developed nations like Pakistan. A mother's nutritional state determines the health of her kid, hence it is currently necessary to assess it in order to identify the root causes of maternal malnutrition in Pakistan (Khalid, Aslam *et al.*, 2017). In Pakistan, the governing elite have not given much attention to nutrition and has made it a low priority. In comparison to other developing countries, Pakistan has been shown to have one of the highest prevalence of malnutrition among women and children, despite several efforts to reduce the condition (Waghmare, Chauhan *et al.*, 2022).



### **2.3.1. Assessing the Global Burden of Maternal Malnutrition**

About half of the world's population suffers from micronutrient deficiencies and undernutrition in mothers and children. These ailments include low birth weight, protein-energy malnutrition, intrauterine growth restriction (IUGR), chronic energy deficit in women, and micronutrient deficiencies. While chronic protein-energy malnutrition and stunting rates are rising in Africa, the absolute number of stunted children is significantly higher in Asia. Iron, iodine, zinc, and vitamin A are the four micronutrient deficits that are most frequently encountered. Over half of all under-5 deaths worldwide are caused, either directly or indirectly, by one of these illnesses (Ahmed, Hossain *et al.*, 2013).

The prevalence of maternal under-nutrition including chronic malnutrition and macronutrient deficiencies are high in many regions of south-central Asia. Nutritional status before and after pregnancy is of key importance for a healthy pregnancy outcome. Worldwide, maternal malnutrition is one of the major influential factors of adverse outcomes for mother as well as for offspring. A range of preventive and therapeutic nutrition- specific interventions can potentially address these risks, ranging from nutrition education to fortification strategies at the population level and targeted supplementation among at risk population (Shenka *et al.*, 2018).<sup>3</sup>

According to Pakistan Nutrition Humanitarian Overview 2022, women of reproductive age (15-49 years) carry a double burden of malnutrition, with one in seven (14.4%) undernourished, 41.7% anemic, and the majority (79.7%) vitamin D deficient (2022).