# A LAHORE BIRTH COHORT STUDY (LBCS): ANALYSIS OF THE GROWTH AND DEVELOPMENT OF PAKISTANI INFANTS IN RELATION TO THE NUTRITIONAL STATUS OF THEIR MOTHER AND ASSOCIATED RISK FACTORS AFTER BIRTH

**SAFEENA AMJAD**

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**by**

**SAFEENA AMJAD**

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May ALLAH Almighty bless them all!!

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# LIST OF SYMBOLS

| | |
|---|---|
| Fe | Iron |
| Hb | Hemoglobin |
| Zn | Zinc |

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AKGs | Alkylglycerols |
| APGAR | Appearance, Pulse, Grimace, Activity, and Respiration |
| BeAT | Beige Adipocytes |
| BMI | Body Mass Index |
| CDC | Center for Disease Control |
| CES-D | Center for Epidemiologic Studies- Depression scale |
| CF | Complementary Feeding |
| COVID19 | Coronavirus Disease-19 |
| DASH | Dietary Approaches to Stop Hypertension |
| DASS-21 | Depression Anxiety Stress Scale-21 |
| DNA | Deoxyribonucleic Acid |
| EPDS | Edinburgh Postnatal Depression Scale |
| FFQ | Food Frequency Questionnaire |
| GDM | Gestational Diabetes Mellitus |
| GI | Glycemic Index |
| GWG | Gestational Weight Gain |
| HREC | Human Research Ethics Committee |
| IU | International Units |
| IYCF | Infant Young Child Feeding |
| KAP | Knowledge, Attitude, Practice |
| LBCS | Lahore Birth Cohort Study |
| LBW | Low Birth Weight |

| | |
|---|---|
| LGA | Large for Gestational Age |
| MDG | Millennium Development Goals |
| MTHF | Methylenetetrahydrofolate |
| MUFA | Monounsaturated Fatty Acid |
| NNS | National Nutrition Survey |
| OGTT | Oral Glucose Tolerance Test |
| P/B-24 Project | Pregnancy and Birth to 24 months Project |
| PMC | Punjab Medical Center |
| PPS | Postpartum Stress |
| PUFA | Polyunsaturated Fatty Acid |
| RBCs | Red Blood Cells |
| SDG | Sustainable Development Goals |
| SGA | Small for Gestational Age |
| SIDS | Sudden Infant Death Syndrome |
| SPSS | Statistical Package for Social Sciences |
| UCP1 | Uncoupling Protein 1 |
| UNICEF | United Nations Children's Fund |
| WAT | White Adipose Tissue |
| WHO | World Health Organization |
| WRA | Women of Reproductive Age |

# LIST OF APPENDICES

**KAJIAN KOHORT KELAHIRAN LAHORE (LBCS): ANALISIS PERTUMBUHAN DAN PERKEMBANGAN BAYI PAKISTAN BERHUBUNG DENGAN STATUS PEMAKANAN IBU DAN FAKTOR RISIKO BERKAITAN SELEPAS KELAHIRAN**

# ABSTRAK

Di Pakistan, prevalens kekurangan zat makanan kanak-kanak adalah lebih tinggi daripada di negara membangun yang lain. Kajian Kohort Kelahiran Lahore (LBCS) telah dijalankan untuk menganalisis hubungan antara kesihatan dan pertumbuhan bayi Pakistan dengan status pemakanan ibu, kemurungan, dan corak pemakanan selepas bersalin. LBCS ialah kajian kohort prospektif dua tahun yang bermula pada 2020 yang merekrut bayi Pakistan selepas kelahiran mereka dari Pusat Perubatan Punjab Lahore, Pakistan. Peserta kajian ditemu bual sebanyak tiga kali iaitu semasa lahir, pada usia 2.5 bulan, dan pada usia 9 bulan. Maklumat ibu selepas bersalin dikumpul daripada rekod hospital dan melalui soal selidik pra-struktur. Data yang dikumpul termasuk ciri sosiodemografi, antropometri bayi baru lahir dan ibu, pengambilan diet ibu semasa mengandung, amalan penyusuan bayi selepas lahir, dan 2.5 bulan bersama-sama dengan amalan penyusuan dan penyusuan susu pada usia 9 bulan. Penemuan kajian menunjukkan bahawa pengambilan susu ibu semasa enam bulan pertama kehidupan melindungi bayi daripada pelbagai bentuk masalah kekurangan zat makanan. Kajian juga mendapati faktor ibu seperti kemurungan selepas bersalin ($P<0.017$) dan pekerjaan ibu ($P<0.04$) mempunyai perkaitan yang signifikan dengan pertumbuhan dan perkembangan bayi. Juga ditemui bahawa penyusuan susu ibu ($P<0.018$), roti dan bijirin ($P<0.00$), tenusu dan produk tenusu ($P<0.015$), susu lain ($P<0.00$), dan pengganti daging dan daging ($P<0.00$) juga mempunyai perkaitan yang signifikan antara pembolehubah pada 9 bulan. Pekali korelasi menunjukkan bahawa terdapat perkaitan positif antara kemurungan selepas bersalin dan BMI selepas bersalin pada berat lahir bayi untuk skor

umur Z, berat lahir (persentil), ketinggian kelahiran untuk skor umur z, dan lilitan kepala kelahiran (persentil). Terdapat korelasi yang signifikan antara penyusuan susu ibu dan ukuran antropometrik bayi pada usia 2.5 dan 9 bulan, termasuk panjang, berat untuk umur, dan persentil lilitan kepala. Kekuatan perkaitan ini meningkat sehingga 9 bulan, menunjukkan bahawa kesan penyusuan susu ibu terhadap parameter pertumbuhan berterusan dan malah semakin meningkat apabila bayi membesar. Kesimpulannya, Kajian Kohort Kelahiran Lahore menyumbang pengetahuan penting tentang pelbagai hubungan antara penyusuan, faktor ibu dan pertumbuhan bayi. Penemuan ini menekankan kesan penyusuan yang berterusan dan intensif, seterusnya memberi panduan kepada ahli kesihatan untuk menggariskan keperluan sokongan holistik untuk kesihatan bayi dalam konteks Pakistan.

Kata kunci: LBCS, Kemurungan Selepas Bersalin, Pertumbuhan Bayi, Kohort, Status Pemakanan, Amalan penyusuan.

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## ABSTRACT

In Pakistan, the prevalence of child malnutrition is higher than in other developing countries. Lahore Birth Cohort Study (LBCS) was conducted to analyze the association between the health and growth of Pakistani infants with maternal nutritional status, depression, and dietary patterns after delivery. The LBCS was a two-year prospective cohort study started in 2020 that recruits Pakistani Infants after their birth from the Punjab Medical Centre Lahore Pakistan. Participants of the study were interviewed three times at birth, at 2.5 months, and at the age of 9 months. The mother's postpartum information was collected from the hospital records and via a pre-structured questionnaire. Collected data included sociodemographic features, anthropometrics of newborns and mothers, dietary intake of mothers during pregnancy, infant feeding practices after birth, and 2.5 months along with breastfeeding and weaning practices at the age of 9 months. Findings indicate that the continuation of maternal breast milk during the first six months of life protects infants from various forms of malnutrition. It was also found that maternal factors such as postpartum depression ($P<0.017$) and mother's occupation ($P<0.04$) have a significant association with the infant's growth and development. It was also determined that breastfeeding ($P<0.018$), bread and cereals ($P<0.00$), dairy and dairy products ($P<0.015$), other milk ($P<0.00$), and meat and meat substitutes ($P<0.00$) also has a potentially significant association between the variables at 9 months. The correlation coefficient revealed that there is a positive association

between postpartum depression and postpartum BMI on infant birth weight for the age Z score, birth weight (percentile), birth height for the age z score, and birth head circumference (percentile). There was a significant correlation between breastfeeding and infant anthropometric measurements at 2.5 and 9 months of age, including length, weight for age, and head circumference percentile. The strength of these associations increased by 9 months, indicating that breastfeeding's effect on growth parameters persists and even intensifies as infant grows. In conclusion, the Lahore Birth Cohort Study contributes crucial insights into the multifaceted relationship between breastfeeding, maternal factors, and infant growth. The findings emphasize the persistent and intensifying impact of breastfeeding, guiding healthcare recommendations and underlining the need for holistic support for infant health in the Pakistani context.

**Keywords**: LBCS, Postpartum depression, Infant Growth, Cohort, Nutritional Status, Feeding practices

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Growth is defined as a numerical increase in the size or mass of a body dimension, and child growth in all of its aspects is of primary importance to all and is regarded as one of the intrinsic qualities of childhood (Soliman et al., 2021). The postnatal development patterns of healthy children are well documented, leading to a number of clinical growth assessment parameters. These parameters include linear growth, weight, growth velocity, growth patterns, body proportions, and head circumference. The growth channel of a child is determined by their genetics. Any deviation in this channel may be resolved by catch-up growth, which happens when a child is free of any condition that has created a divergence from his or her genetic growth channel and is returned to his or her original channel (Cuttler et al., 2016).

From conception until the age of two years, also called the first 1000 days of life, consists of a unique period of remarkable physiological growth and rapid functional development of the organs of the body. It is during this time that 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 cycle, with short- and long-term implications for health and physical performance (Toro Ramos, et al., 2015).

Adequate nutritional intake during the initial two years of life is critical for every human being to reach his or her full potential. This stage is characterized by its quick

growth rate, which necessitates more energy and nutrient intake and puts infants who are subjected to poor feeding methods at nutritional risk (Velarde et al., 2016).

The period comprising the first 1000 days of a child's life is the most sensitive and crucial for establishing a foundation for the child's optimal growth and development. Nutritional supplementation in the first 1000 days of life has been found to ameliorate birth and growth outcomes, as well as infant stunting. Common food-based interventions, such as supplemental nutrition feeding during gestation and the first six months of nursing, followed by complementary feeding for the child until their second birthday, have been found to be more comprehensive and successful in addressing nutrient deficiencies in infants (Soofi et al., 2022).

Malnutrition has an impact on general mother and child survival, health, and economic productivity of people, healthy development & growth of a child. Malnutrition occurs due to a lack of macronutrients specifically protein, and essential micronutrients called various vitamins & minerals; their deficiency results in serious health issues during pregnancy in the mother and stunting in a child after birth (Khalid et al., 2017).

Maternal malnutrition (both over nutrition & undernutrition) can have substantial repercussions for fetal development and growth, as well as subsequent baby growth and development during and after breastfeeding. Normal physical and cognitive development of a kid is crucial during the first three months of life. Because cognitive and emotional capabilities begin to emerge from a young age, the foundation of social, intellectual, and emotional capabilities may have been laid during this period. Poor nutrition during the first three to twelve months of infancy causes perceptual defects such as delayed physical and

mental development, certain behavioral difficulties, a lack of social skills, learning disabilities, a shorter attention span, and worse educational attainment (World Health Organization, 2019).

### 1.2 Problem Statement and Study Rationale

Compared to other emerging countries, Pakistan has the highest frequency of child malnutrition. To investigate the literature on child nutritional status in Pakistan, a narrative review was conducted. This study included some of the most recent and important studies published between 2000 and 2016. This study was based on a total of 28 articles reviews. Most of the articles used the World Health Organization (WHO) growth charts as an assessment tool. The result showed that early marriages, the big size of the family, extreme fertility rates and no birth spacing, low socioeconomic status, the lack of awareness about breastfeeding, and exclusive breastfeeding were the key component contributing to malnutrition (Asim & Nawaz, 2018).

The neonate's birth weight is a significant predictor of neonatal growth and survival, and it is strongly impacted by maternal health and nutrition during pregnancy. Maternal malnutrition is the leading contributing factor to poor outcomes for mothers and their children worldwide. A variety of preventative and therapeutic nutrition-specific interventions, ranging from nutrition education to population-level fortification techniques and targeted supplements among at-risk populations, have the ability to address these hazards (Tyagi, et al., 2017).

The mother is the sole source of sustenance, including brain development for the fetus. As a result, maternal nutritional status (anthropometry, macro-, and micronutrients) prior to and/or during pregnancy may be a predictor of the child's cognitive performance. The association between maternal nutritional intake and infant cognitive function is unknown. There is no conclusive evidence that maternal nutritional state during pregnancy has an effect on child's cognitive ability as determined by BMI, single micronutrient studies, or macronutrient intakes (Veena et al., 2016). Nutrition has not been adequately integrated into Pakistan's national health system. There is no federal or provincial nutrition policy to address malnutrition in emergency and non-emergency conditions, and there is no high-level nutrition authority (Ahmed et al., 2014).

The present study was the first birth cohort study in Lahore, Pakistan. As healthy growth and development of an infant depend on maternal nutritional status and dietary pattern. Effective strategies should be adopted to protect the health of both the mother and neonate. The solicitation of such policies might help in improving the health of infants and mothers. The main emphasis of the study was to provide authentic recommendations to the government of Pakistan for the health of infants and their mothers.

## 1.3 Objectives

### 1.3.1 General Objective

1. To analyze the growth of infants and its association with infant feeding practice, maternal nutritional status, psychological status, and socioeconomic factors.

### 1.3.2 Specific Objectives

1. To determine the nutritional status and growth (through anthropometrics) of infants in the first 9 months.
2. To determine the feeding practice of infants in the first 9 months.
3. To identify factors associated with infant growth in the first 9 months.
4. To determine the postpartum (1 week until 3 months after delivery) nutritional status (Anthropometrics) of mothers.
5. To determine the socioeconomic status (monthly income) of mothers.
6. To determine the postpartum (1 week until 3 months after delivery) psychological status (Postpartum Depression) of mothers.
7. To determine the association between the socioeconomic status, psychological status & nutritional status of the mother and child-feeding practices on infant growth.

## 1.4 Research Questions

1. What is the association between infant feeding practices and the growth and development of infants?
2. What is the association between the nutritional status of mothers and the growth & development of infants?
3. What is the association between socioeconomic status and the growth and development of infants?

4. What is the association between psychological status and the growth and development of infants?

5. What is the association between the socioeconomic status, psychological status & nutritional status of the mother and infant-feeding practices on infant growth?

### 1.5 Hypothesis

**$H_1$** = There is an association between the socioeconomic status, psychological status & nutritional status of the mother and child-feeding practices on infant growth.

**$H_O$** = There is no association between the socioeconomic status, psychological status & nutritional status of the mother and child-feeding practices on infant growth

### 1.6 Significance of the Study

Pakistan is a rapidly growing country with a large population of young people. Cohort studies of Pakistani infants can provide valuable information on the health and well-being of this rapidly growing population. Improving child health requires taking nutritional status into account. Several factors influence the nutritional status of infant's growth. There is a prerequisite for studies to identify factors influencing child health so that appropriate policies and interventions may be developed to assist Pakistan in meeting SDG 3. The current literature on child malnutrition in Pakistan is based on specialized health facilities, a small sample size focused on certain regions, and a few health factors. As a result, Millennium Development Goal 4 aimed to reduce under-five mortality by two-thirds by 2015. Nonetheless, there has been no meaningful development in Pakistan. According to the World Health Organization (2012-2013), the prevalence of stunting, wasting, and

underweight in children under the age of two years in Pakistan was 37.6%, 16.6%, and 32.4%, respectively. The current Lahore Birth Cohort study helped to identify risk factors for poor health outcomes, and these are further to be used to evaluate interventions designed to improve the health of Pakistani children and their mothers.

### 1.7 Conceptual Framework

This framework (Figure 1.1) depicts all of the factors that are correlated with an infant's growth and development. The initial phase of child nutrition is initiated at conception with nutrition-related exposures from the mother and continues through infancy and toddlerhood from birth to 9 months of age. Nutrition during the first 1000 days is quite crucial to the development & growth of an infant, as evidenced by the P/B-24 Project (Stoody, et al., 2019). During this time, the infant's nutrition is influenced by the mother's diet and lifestyle, the family's income and food security, the availability of nutritious food, the infant's own food preferences, and the mother's ability to provide adequate nutrition for the infant. All of these factors combined can have a significant impact on the infant's growth and development. Maternal factors such as nutritional status and intake during pregnancy directly affect neonate health and mortality rates. Complementary feeding practices are expected to bridge the energy and nutrient gaps between infants and young children's daily needs and the amount consumed through breastfeeding. In Pakistan, complementary foods are frequently of poor nutritional quality, or they are given too early or too late, in insufficient quantities, or infrequently enough. Infants are at high risk of malnutrition due to inadequate breastfeeding practices and the use of complementary feeding. Malnutrition can have long-term and far-reaching consequences for a child's

growth, development, and well-being. Since stunting impairs brain development, stunting within the first 1,000 days is connected with low academic achievement. Similarly, postpartum depression has been linked to a variety of early infantile age-related issues, including impaired cognitive, social, and academic functioning.

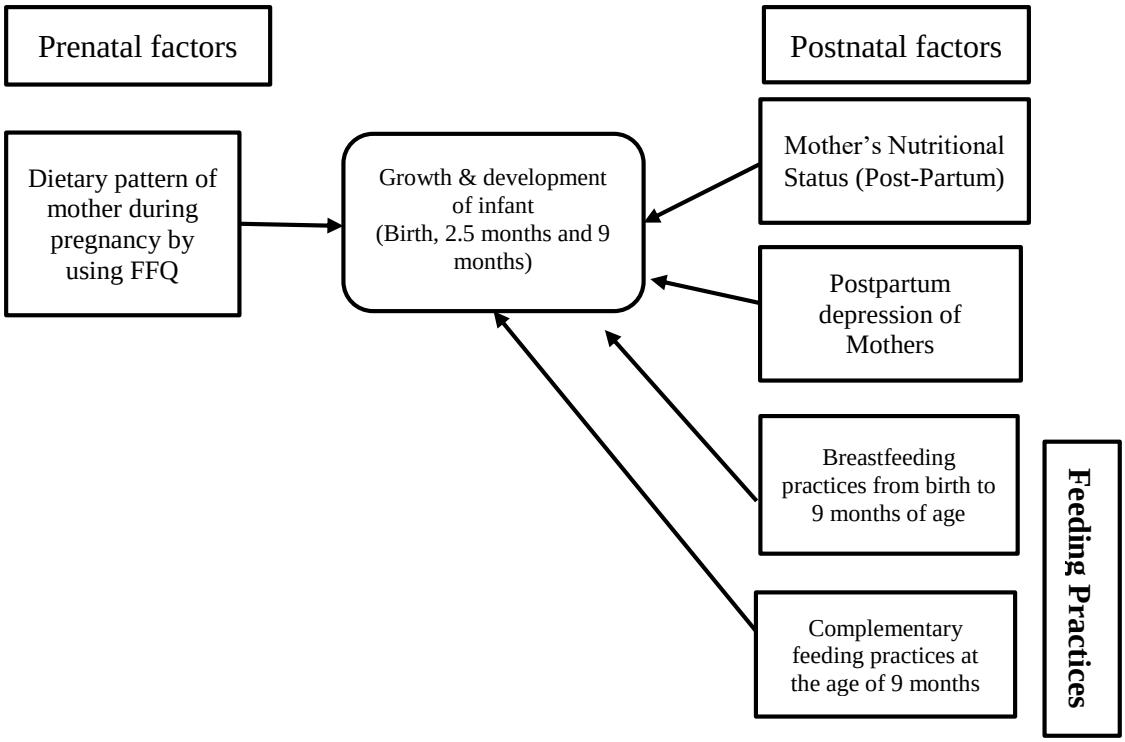


Figure 1.1 Conceptual Framework

## 1.8 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).

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

**Healthy** Without being identified with any pre-existing chronic disease or current pregnancy complication such as gestational diabetes, hypertension or preeclampsia.

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

**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 (Zekovic et al., 2021).

**Neonate** A new born baby, specifically a baby in the first 4 weeks after birth. After a month, a baby is no longer considered a neonate

**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.

**Weaning** Weaning is the progression of introducing soft, semisolid, and/or solid meals by the age of six months while maintaining age-optimal nutritional diversity, meal frequency, and continued breast milk feeding.

# CHAPTER 2

# REVIEW OF LITERATURE

## 2.1 Infant Growth and Development

Child development and growth can be generally characterized as a regular pattern of changes that occur across stage from infancy to puberty to allow children to understand and interact with their surroundings. This development and growth can be seen in a variety of domains, including motor development, physical growth, communication, and social and emotional development. There is a normal pattern but recognized variation in each of these categories depending on the child's innate factors as well as the cultural and social surroundings (Rao et al., 2023).

Child development usually follows a predictable pattern. Surveillance and screening are used to detect deviations from the predicted development trajectory. Child development is a complex conceptual process characterized by periodicity, uneven development of various functions, qualitative transitions of one form into another, or evolution, the intertwining of internal and external variables, and adaptive processes that overcome barriers confronted by the child (White et al., 2023).

The Centers for Disease Control and Prevention defines developmental milestones as tasks that most children can execute by a certain age. Children achieve developmental milestones in their play, speaking, behavior, learning, and movement. (like jumping, crawling, or walking) (Centers for Disease Control and Prevention, 2022). Developmental milestones are monitored to assess growth and development patterns. The ideal technique

of monitoring is to keep a record of the child 's weight and height and, more recently, the body mass index (BMI). In turn, development is broad, referring to a progressive transformation that involves growth, maturation, and learning, as well as psychic and social components. Its monitoring entails activities that examine the steps or milestones of children's psychomotor development at each age group and can detect difficulties and changes in child development (de Almeida et al., 2016).

## 2.2 Factors Affecting the growth and Development of infants

### 2.2.1 Malnutrition

Malnutrition accounts for at least 50% of all infant mortality worldwide. Undernutrition accounts for roughly half of all child deaths worldwide. It also jeopardizes the mental and physical development of youngsters, resulting in low academic achievement. Optimal nourishment is crucial for early childhood immune system development as well as appropriate physical and intellectual development (Asim & Nawaz., 2018). Nutrition plays an important part in maternal and child health (Black et al., 2013). Trends in malnutrition among children recorded in 2020 showed 5.7% overweight, 6.7% wasting, and 22% stunting in children under 5. The numerical values represented that wasting continues to endanger the lives of an estimated 45.4 million children. 38.9 million children were found to be overweight in the world, and 149.2 million children under 5 showed stunted growth. These trends were recorded and analyzed by UNICEF and WHO (UNICEF/WHO/World Bank, 2021).

As stated by the United Nations Children’s Fund (UNICEF), 43.7 percent of the population suffers from stunting and 15.1 percent suffers from wasting (Malik et al., 2022).

Worldwide, malnutrition is one of the fastest-growing concerns. In 2014, UNICEF reported that worldwide, almost 95 million (14%) children under the age of 5 were underweight. Each year, approximately 3 million children die due to malnutrition, which is close to half of all deaths in this age group. There is an increasing number of underweight people residing in Southeast Asia and Africa, but in high-income countries, this prevalence decreases to only 4%. UNICEF published a report in 2014 indicating that worldwide, nearly 41 million children under 5 were overweight. This prevalence is dramatically increasing day by day and is expected to cross 64 million (10%) by 2025 (Rottenstreich et al., 2019).

### 2.2.2 Iron Deficiency Anemia

The management of adequate levels of iron intake is essential for the maintenance of pregnancy and healthy baby weight. Iron deficiency causes anemia, which has side effects on the mother and infant. A study investigating the consequences of anemia on the birth weight of an infant revealed that anemic women had a higher risk factor for delivering weak and LBW infants. Research findings recommend that iron supplementation be initiated in the 1st trimester after checking the complete blood count (Tetik & Coskun, 2018).

According to the National Nutrition Survey (NNS), around 44% of all children were stunted, 15% were wasted, 50% were anemic, and 33% were anemic (iron deficiency). In comparison to other developing countries, Pakistan has seen no decrease in the prevalence of child malnutrition during the last two decades (Asim & Nawaz., 2018).

### 2.2.3 Lack of Social Services

One of the reports on how malnutrition is epidemically affecting Pakistan stated that malnutrition can be documented as one of the key hurdles in national development due to its impact on the productive potential of individuals of all ages. Malnutrition is 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, a lack of knowledge related to nutrition, and poor hygiene due to low socioeconomic status (Tanweer et al., 2015).

Pakistan is a country that is dealing with issues of neonatal infant nutrition and health. These issues are becoming more prevalent as a result of the government's and parents' insufficient checks and balances on nutrient consumption for this age group (Kazmi et al., 2022).

Malnourishment is at its peak in Pakistan among children under 5 years of age. It is because of the economic crisis and the overall abysmal condition of healthcare facilities. In rural areas, it is not convenient to access good hospitals. Lady health workers render their services to cope with this gap. In a survey, it was found that regular visits to the lady health worker can ameliorate the health status of children. A lady health worker provides child nutrition awareness to mothers (Shahid et al., 2022).

According to global statistics, Pakistan has been declared the third country with the highest rate of maternal and infant mortality. The country is widely affected by political conflicts, social issues, and disasters. In such circumstances, tackling common social determinants of health is difficult. That’s why Pakistan has made very slow progress

toward attaining Millennial Development Goal 4 and Millennial Development Goal 5. Goals include satisfactory health services for the promotion of maternal and child health (Bhutta et al., 2013).

### 2.2.4 Infant Feeding Practices

The infant mortality rate is high in Pakistan owing to malnutrition. In this regard, feeding practices and breastfeeding administration can serve as an assessment tool for ascertaining an infant's nutritional status and can predict the infant's growth. A cross-sectional study done in Lahore recorded the exclusive breastfeeding rate, weaning practices, education level of mothers, and their socio-economic status. The results showed that the exclusive feeding rate was 67%. Adequate knowledge of exclusive feeding was observed in 64% of the mothers. 81% of mothers breastfed their infants. However, 19% fed their infants through artificial feed. This feed included cow's milk, dried milk, formula milk, and pasteurized milk (Ijaz et al., 2015).

Knowledge, attitude, and practices (KAP) related to complementary feeding were identified. 130 mothers who visited the OPD of pediatrics in Civil Hospital Karachi were questioned to learn about their infant feeding habits and how different taboos, beliefs, and circumstances have influenced complementary feeding (CF). Results showed that the mothers of 119 babies (86.2%) immediately began to breastfeed. The frequency of breastfeeding was lowered upon administration of bottle feeding. However, the duration of exclusive breastfeeding was observed to be less than 6 months. Results concluded that KAP regarding complement feeding was not satisfactory (Mohsin et al., 2014).

## 2.3 Nutritional Status of the Mother

Poor maternal nutrition has been associated with unfavorable birth outcomes. The association allying maternal nutrition and birth outcome is complex, influenced by a wide range of physiological, socioeconomic, and demographic factors that vary widely among populations. According to the countries by population, Pakistan, a lower-middle-income country, has the world's fifth-largest population and a birth cohort of about 6 million. The most important public health issue is malnutrition (Asghar et al., 2022).

The nutritional status of the mother prior to pregnancy and during pregnancy is very crucial for the well-being and betterment of the life of pregnant women, and the fetus inside her normally growing and developing fetus that results from a normal pregnancy is associated with several factors. One of the major factors is the nutritional status of the mother, which is related to proper metabolic substrate transportation that is important for the supply of the energy required for the proper growth of the fetus. If this equilibrium got disturbed, it could affect the pregnancy outcome in different ways (Xinxo et al., 2013).

There is a notion that hyperglycemic pregnant women lead their children to obesity (Flores & Lin, 2012). A study executed to determine the correlation between hypoglycemia and anthropometry found no relation between raised sugar levels in the mother and the infant’s BMI (Thaware et al., 2015).

The contribution of pregnancy to gaining weight across various BMI categories was examined. Pregnant overweight and obese mothers who put on more weight were at a higher risk of giving birth to macrocosmic children. Macrosomia is defined as a birth weight >8.8 pounds (3.9 kg). Maternal delivery canal damage, shoulder dystocia, and

perinatal hypoxia are only a few of the maternal and fetal issues linked to fetal macrosomia (Araujo Júnior et al., 2017). They are also more likely to undergo Caesarean operations, give birth prematurely, and have hypertension during pregnancy. Moreover, macrosomia raises the infant's risk for injuries to the brachial plexus and clavicle fractures. It also raises the number of admissions to the neonatal critical care unit. Besides this, it can cause infant obesity in later life. This happens when pregnant women have gestational diabetes and are obese (Kc et al., 2015).

Birth outcomes are dependent on many factors, including maternal height, weight, postpartum BMI, prenatal hemoglobin levels, and gestational age. Besides these, birth outcomes are predominantly reliant on dietary intake, which includes total calories, protein, vitamin C, and calcium intake (Chia et al., 2019). Since the nutritional status of the mother and infant is closely related, a plethora of studies are performed to evaluate the association.

A descriptive study was performed to determine the nutritional status, maternal hemoglobin concentration, anthropometric data, and their relationship with newborn anthropometry. It was deduced that women older than 28 had more weight before and after delivery. Also, they had prolonged interpregnancy intervals. Statistical analysis demonstrated that all the evaluated parameters were found to be determinants of the pregnancy outcome. Therefore, it is important to pay attention to adolescent girls' nutrition through good nutrition education and pre-pregnancy counseling, which will aid in a healthier pregnancy outcome (Gala et al., 2016).

Maternal malnutrition leads to low birth weight (LBW), poor fetal growth, and infant morbidity and mortality. A systematic review was done to assess the efficacy of

protein supplementation. Results proved a positive effect on the infant birthweight of the intervention group and decreased the likelihood of LBW to 32%. Secondly, small for gestational age and stillbirth chances were reduced to 34% (Imdad & Bhutta, 2012).

A drop in the level of hemoglobin (Hb) and the amount of healthy red blood cells (RBCs) is known as anemia. This pathological condition leads to low blood pressure, an increased heartbeat, anxiety, nausea, anorexia, and improper food absorption. Besides this, it also induces personality changes and decreases energy competency during physical activity. Anemia is mainly caused by iron, vitamin B12, and a poor intake of vitamin C (Bhadra & Deb, 2020).

Hameed et al. (2018) conducted research in which the prevalence of anemia among expectant women and its relationship to fetal death were examined. Participants were recruited from Punjab, Pakistan. In total, 65.4% of women were anemic. A noteworthy association between the prevalence of anemia and the daily consumption of three or more cups of tea was found. The overall fetal death rate was 17.7% in the severely anemic group. The rate steadily dropped as Hb levels rose in the moderately and mildly anemic groups.

There is a noteworthy association between the occurrence of anemia and tea intake. It was mentioned that the consumption of more than three cups daily halts iron absorption in the body because of the tannins (Hameed et al., 2018). Consuming tea has long been known to impede iron absorption through its iron-binding abilities. Since tea has catechol-containing phenolic compounds that inhibit iron absorption (Fan, 2016). A relationship between tea and anemia was also reported in a research investigation done in Jamshoro,

Karachi. Participants completed blood counts reported increased levels of total iron binding capacity and depleted serum ferritin (Shah et al., 2020).

Maternal death rates are high in Pakistan. The contributing factors include socioeconomic class and ethnicity (Shah et al., 2011); Kiefer, (2017) further assessed this association in a cohort study. Socio-demographic, BMI, and ethnicity data for mothers with gestational diabetes were recorded. The statistical analysis reported that 11.8% of mothers gave birth to infants with macrosomia. Besides this, large for gestational age newborns had considerably greater rates of shoulder dystocia as compared to infants born with normal weight. Results also showed that the risk of giving birth to LBW was 10.7% higher in women who received proper medical care and had medical insurance. However, Hispanic or African Americans had a lower risk of delivering a large for gestational age infant in comparison to Caucasian women (Kiefer, 2017).

Pakistan has a severe maternal health crisis compared to developed countries. 178 fatalities per 100,000 are recorded in Pakistan. However, only 12 deaths occur in developed countries (Tariq et al., 2018). A study performed in South Punjab identified the implications of cultural and social values on maternal healthcare facilities and maternal mortality. According to research findings, the local polyclinics were the second-choice delivery location after being delivered at home. Local Dai, or traditional birth attendants, were the chosen delivery people. They did not even get facilitation from certified midwives. Barriers to accessing healthcare were also explored. It was deduced that a lack of understanding about antenatal care and hygienic delivery services were among the

obstacles. Besides this, travel distances and expensive transportation to the city's medical institutions were problematic (Zaidi et al., 2018).

Omer et al. (2021) conducted a study to investigate socio-cultural factors that cause maternal mortality in South Punjab, Pakistan. The study deduced that the predominant obstacles to receiving antenatal care were low socioeconomic status, less education, and money constraints for the natives of rural areas. Another factor is compromised women's empowerment in the region. Therefore, patriarchal men continued to enforce their orders on women. Another contributing factor to maternal deaths was the recruitment of (Dai) for delivery (Omer et al., 2021).

Maternal dietary intake has a significant effect on birth. A review paper highlighted the dietary patterns that can influence pregnancy outcomes. For instance, high intakes of saturated fatty acids, total carbs, soft drinks, and polyunsaturated fatty acids are suspected to increase the chances of developing gestational diabetes mellitus. The Dietary Approach to Stop Hypertension (DASH) diet has been found to be effective in lowering high cholesterol levels and high blood pressure. It can also lower fasting blood glucose and help pregnant women with Gestational Diabetes Mellitus. DASH and the Mediterranean diet were found effective in decreasing the incidence of Gestational Diabetes Mellitus. Other than Gestational Diabetes Mellitus, women suffer from preeclampsia, which can have adverse effects on the child's health. It can cause prenatal deaths and preterm births. Calcium supplementation has shown efficacy in managing preeclampsia and preventing preterm deliveries (Chen et al., 2016).

Pre-eclampsia is common in pregnant women. In a clinical trial, a high dose of calcium was given to the experimental group. The supplementation dose was greater than 1 g of calcium per day. It was inferred from the comparison of the blood pressure of the control and experimental groups that calcium can lower the chances of pre-eclampsia (Hofmeyr et al., 2019).

A baby's weight, nourishment, and congenital health problems are impacted by maternal dietary patterns, as demonstrated by subsequent research. Dietary patterns of pregnant women were recorded through a food frequency questionnaire, and perinatal outcomes were assessed. These outcomes included preterm birth, low birth weight, and a large gestational age. Pregnant women were found to have three eating patterns that included high-protein and fruit eaters, processed food and high-fat eaters, and vegetarians. High-protein fruit eaters who consumed whole grains, fruit, chicken, fish, and meat reported a lower risk of preterm delivery. Preterm delivery is comparatively more common when a diet is dominated by foods heavy in fat and sugar. It is the primary cause of infant morbidity and mortality and affects 10% of pregnancies worldwide (Grieger et al., 2014).

The dietary intake practices of women before pregnancy were recorded, which revealed that it is crucial to optimize food during the pre-pregnancy period since it can promote and strengthen the health status of the mother and infant (Ramage et al., 2015). Calcium, folate, iron, and vitamin D supplementation are very important if a woman has a low level of these nutrients. Folate supplementation is necessary to prevent neural tube defects, birth defects, pregnancy complications, and congenital anomalies. It is recommended that women of fertile age (12 to 45 years) take adequate amounts of folate.

A 1.0 mg potency dose of folate is advised for women who are trying to conceive (Wilson et al., 2015). Fat is crucial for the brain's development. Besides this, folate is said to be a preventive agent of neural tube defects. That’s why the research was done to ascertain the effects of PUFA, vitamin B9, and Fe on neural growth. Results showed that supplementation couldn’t improve the mental abilities of the infants. However, these are good to stave off neural tube defects (Chmielewska et al., 2019).

A research study was executed to contrast the eating habits of pregnant women and preconception women. The Canadian version of the food frequency questionnaire was employed for analysis. The study covered total calorie intake, macronutrients, and consumption of important nutrients like folic acid, MUFA, PUFA, calcium, vitamin D, vitamin B6, and B12. The results represented familiar dietary patterns in both groups except for saturated and trans fats. Besides this, pregnant women’s dietary intake showed more calcium intake and less intake of alcohol (Ramage et al., 2015).

Likewise, in another trial, iodine supplementation was given to iodine-deficient pregnant women. The neurodevelopment of the children was assessed when they were 5–6 years old. The analysis demonstrated no effect of iodine supplementation on children's mental abilities (Gowachirapant et al., 2017).

In a randomized controlled trial, the outcome of vitamin D supplementation on the immune strength of the neonates was investigated. A 4400 IU/d dose was administered in the 2$^{nd}$ and 3$^{rd}$ trimesters. Cord blood samples were taken from the neonates. Laboratory results showed that neonates had more pro-inflammatory cytokines that can shield them from asthma and other infections in later life (Hornsby et al., 2018).

There are proper guidelines to calculate the energy requirements in each trimester of the gestation period. These are dependent on physical activity, existing BMI, and age. Pregnant women are either performing no activity or are slightly active or moderately active. Physical activity is one of the determinants of the energy requirement calculation. 340 extra calories are added in the 2$^{nd}$ trimester, and 452 calories are added in the 3rd trimester. The rule for protein requirements is 1.1 g/kg in the first 20 weeks, and 25 g is further added for the next 20 weeks (Savard et al., 2018b).

The dietary intake and special nutrient administration to women in each trimester were analyzed. Research findings suggest that awareness of dietary guidelines for pregnant women is necessary. Besides this, pointing out unhealthy eaters in early trimesters can be good as they can be counseled about the importance of the dietary intake guidelines and their implications on the child's health and weight (McGowan & McAuliffe, 2013).

As mentioned earlier, pregnancy demands a proper intake of nutrients as per dietary guidelines. Therefore, the maternal intake of pregnant women was compared with the Australian guidelines in a cross-sectional study. 388 expecting women were sent an online survey form. The computation of the analysis reported that the participants were motivated to eat healthily and were well aware of the criticalness of nutritional guidelines. But their knowledge contradicted their practice, as they had poor dietary habits. Furthermore, their intake did not fall within the recommended quantities of food groups: meat, dairy, grains, vegetables, and fruits (Bookari et al., 2017). This proves that intervention techniques should extend beyond mere knowledge provision.

Starling et al. (2017) performed a cohort study to analyze the patterns of maternal food intake that were related to gestational weight gain (GWG) and fasting blood sugar levels throughout pregnancy. Besides this, the relationship between these patterns and infant adiposity was discussed. Mainly, two eating approaches were observed. The first pattern consisted of an increased intake of poultry, cheese, nuts, fats, and whole grains. The second mainly contained excessive eating of sugary foods, high-GI vegetables, fruits, and refined grains, and decreased consumption of green vegetables. Pattern one induced more weight gain during pregnancy and also resulted in a high-fat mass in the newborn. However, the second dietary pattern represented a larger newborn with more fat mass and a higher likelihood of developing adiposity (Starling et al., 2017).

Failure to meet the exact nutritional needs has adverse effects. In prenatal care, women should be advised not to overindulge blindly. Rather, they should only stay within the range of ideal weight gain during pregnancy. Excessive weight gain can increase the possibility of cesarean delivery and postpartum weight retention. It can also compromise the health status of newborns (Kominiarek & Peaceman, 2017). It is recommended to perform moderate physical activity to maintain well-being. It is found that the risk of gestational diabetes mellitus is reduced by performing 30 minutes of moderate exercise during pregnancy, and maternal weight gain is also reduced. These exercise programs are safe for both mother and child, and there is no constraint on doing physical activity (Sanabria-Martínez et al., 2015).