

# Maternal Anemia Prevalence and Associated Risk Factors During Pregnancy in Pakistan: A Mixed-Methods Study

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## ABSTRACT

**Background:** Maternal anemia remains a major public health concern in Pakistan and is shaped by nutritional deficiency, poverty, reproductive burden, cultural dietary practices, and limitations in antenatal healthcare access. **Objective:** To determine the prevalence pattern of maternal anemia during pregnancy and explore the biological, socioeconomic, behavioral, cultural, and health-system factors associated with anemia among pregnant women attending antenatal services in urban and semi-urban Pakistani settings. **Methods:** A mixed-methods study was conducted using a quantitative cross-sectional assessment and qualitative interviews and focus group discussions. Pregnant women attending antenatal care were assessed for hemoglobin status and completed structured questionnaires addressing sociodemographic characteristics, dietary practices, obstetric history, antenatal attendance, and iron and folic acid supplementation. Qualitative data were collected from pregnant women and healthcare providers to explore anemia awareness, dietary beliefs, supplement adherence, healthcare access, and service-delivery barriers. Quantitative findings were summarized descriptively, and qualitative data were analyzed thematically, followed by integrated mixed-methods interpretation. **Results:** Maternal anemia was highly prevalent, with most affected women having mild-to-moderate anemia and a greater burden observed in semi-urban settings. Reported risk factors included poor dietary diversity, low socioeconomic status, high parity, short interpregnancy intervals, inadequate antenatal attendance, and poor supplement adherence. Qualitative themes included limited awareness of anemia, cultural food restrictions, barriers to healthcare access, provider-related constraints, and systemic limitations. **Conclusion:** Maternal anemia during pregnancy in Pakistan is a multifactorial condition requiring integrated nutritional, behavioral, reproductive, community-based, and health-system interventions. **Keywords:** Maternal anemia; pregnancy; Pakistan; mixed-methods study; antenatal care; iron supplementation; dietary diversity.

## INTRODUCTION

Maternal anemia remains one of the most persistent nutritional and hematological disorders affecting pregnant women, particularly in low- and middle-income countries where nutritional insecurity, recurrent pregnancies, infections, limited antenatal coverage, and socioeconomic deprivation intersect to increase maternal vulnerability. During pregnancy, expansion of plasma volume, fetal iron requirements, placental development, and increased maternal erythropoietic demand substantially raise

the need for iron and other micronutrients (1-3). When these physiological requirements are not matched by adequate dietary intake, supplementation, and timely clinical screening, pregnant women are at increased risk of anemia, which may contribute to fatigue, reduced physical functioning, impaired immunity, poor obstetric tolerance, preterm birth, low birth weight, and increased maternal and neonatal morbidity. The World Health Organization has consistently identified anemia among women and children as a major public health priority, emphasizing the need for context-specific prevention and control strategies in high-burden settings (4-7).

The burden of maternal anemia is not explained by biological deficiency alone. Global evidence indicates that maternal and child undernutrition is shaped by a wider network of poverty, poor dietary diversity, limited access to animal-source foods, food insecurity, low educational attainment, and unequal access to preventive healthcare services (8-13). In low-income settings, anemia is commonly driven by multiple overlapping determinants, including iron deficiency, folate deficiency, parasitic and infectious disease burden, repeated pregnancies, short interpregnancy intervals, and delayed or inadequate use of antenatal services (3). Pakistan represents a setting where these determinants remain particularly relevant because nutritional vulnerability in pregnancy is embedded within broader social and health-system constraints. National nutrition evidence has shown that anemia among women and children continues to be a major public health concern, despite ongoing supplementation and maternal-health programs (4). Global prevalence analyses have similarly demonstrated that anemia remains disproportionately concentrated in regions where maternal nutrition, poverty, and healthcare access remain structurally constrained (14-16).

Within Pakistan, the prevention and management of maternal anemia are complicated by interacting biological, socioeconomic, behavioral, and cultural factors. Pregnant women from low-income households may have limited access to iron-rich foods such as meat, legumes, green leafy vegetables, and fortified products. Women with high parity or short birth intervals may enter pregnancy with depleted iron reserves, while those with inadequate antenatal attendance may miss opportunities for hemoglobin screening, iron and folic acid supplementation, dietary counseling, and early referral. In addition, cultural dietary restrictions during pregnancy, misconceptions regarding supplement safety, fear of gastrointestinal side effects, low awareness of anemia symptoms, and limited household decision-making autonomy may reduce preventive behavior even when services are available. Community-based health workers may play a critical role in maternal and child health education, supplementation support, and linkage with antenatal services; however, their effectiveness can be limited by workload, inconsistent supplies, and gaps in counseling resources (6). Broader health-system barriers, including transportation costs, distance to facilities, overcrowded clinics, and inconsistent availability of essential supplements, further restrict equitable access to anemia prevention and treatment (7).

Although previous studies and national surveys have helped quantify the burden of anemia among pregnant women, prevalence estimates alone do not fully explain why anemia persists despite established preventive interventions. A purely quantitative approach can identify associations between anemia and factors such as diet, parity, birth interval, antenatal attendance, and supplement adherence, but it may not adequately capture women's perceptions, cultural beliefs, household constraints, or service-level barriers that influence health behavior. Similarly, qualitative inquiry can explain lived experiences and contextual barriers but cannot estimate the magnitude of anemia or statistically examine risk-factor patterns. A mixed-methods approach is therefore appropriate for this research problem because it permits estimation of anemia prevalence and associated risk factors while also exploring the social, cultural, and healthcare-related mechanisms that shape maternal anemia prevention and care.

This study was designed to assess maternal anemia among pregnant women attending antenatal services in urban and semi-urban Pakistani settings through an integrated mixed-methods approach. The quantitative component aimed to determine the prevalence and severity pattern of anemia and examine

its association with sociodemographic, dietary, obstetric, antenatal-care, and supplementation-related factors. The qualitative component aimed to explore pregnant women's and healthcare providers' perspectives regarding anemia awareness, dietary beliefs, supplement adherence, access to antenatal care, and health-system barriers. The study objective was to determine the prevalence of maternal anemia during pregnancy and to identify the biological, socioeconomic, behavioral, cultural, and healthcare-related factors associated with anemia in the Pakistani maternal-health context (13-18).

## MATERIALS AND METHODS

A mixed-methods study design was used to examine maternal anemia during pregnancy by integrating a quantitative cross-sectional assessment with qualitative interviews and focus group discussions. The quantitative component was designed to estimate the prevalence and severity of anemia and to assess associations between anemia status and selected sociodemographic, dietary, obstetric, antenatal-care, and supplementation-related factors. The qualitative component was designed to explore contextual explanations for the quantitative findings, including women's awareness of anemia, cultural and household dietary practices, perceived barriers to iron and folic acid supplementation, access to antenatal services, and healthcare-provider perspectives on anemia prevention and management. The study was conducted in antenatal clinics and community settings located in urban and semi-urban areas of Pakistan, allowing inclusion of pregnant women with different levels of healthcare access and socioeconomic exposure.

The study population for the quantitative component consisted of pregnant women attending antenatal care services during the study period. Eligible participants were pregnant women in any trimester who attended the selected antenatal clinics or were identified through community-based maternal-health contact points and who provided informed consent for participation. Women were excluded if they were unable to provide consent or if hemoglobin assessment and questionnaire data could not be completed. The qualitative component included pregnant women and healthcare providers involved in maternal-health services, including doctors, nurses, and Lady Health Workers. Pregnant women were selected to capture variation in antenatal attendance, dietary practices, parity, supplement use, and residential context, while healthcare providers were selected because of their direct role in screening, counseling, supplementation, and referral for maternal anemia.

Sampling was separated according to the requirements of the two study strands. For the quantitative component, pregnant women attending antenatal services were recruited using a systematic clinic-based approach to minimize arbitrary selection and improve representativeness within the available service population. For the qualitative component, purposive sampling was used to include participants with relevant experience of anemia prevention, pregnancy-related dietary practices, antenatal service use, supplementation counseling, or community maternal-health delivery. Recruitment continued until the qualitative data provided sufficient depth and recurrence of themes related to anemia awareness, dietary restrictions, supplement adherence, healthcare access, and service-delivery constraints. All participants were informed about the purpose of the study, the voluntary nature of participation, confidentiality of responses, and their right to withdraw at any stage without any effect on their healthcare access.

Quantitative data were collected through hemoglobin assessment and a structured questionnaire administered to pregnant women. Hemoglobin concentration was measured using standard clinical procedures available at the study sites, and anemia status was classified according to accepted pregnancy-specific hemoglobin thresholds. Where severity classification was applied, anemia was categorized into mild, moderate, and severe groups according to hemoglobin concentration. The questionnaire collected information on age, residential background, education, household socioeconomic status, dietary diversity, intake of iron-rich foods, antenatal-care attendance, receipt and use of iron and folic acid supplementation, side effects or concerns related to supplementation, parity, birth interval, trimester of pregnancy, and relevant obstetric history. Dietary assessment focused on usual consumption patterns

and access to iron-rich foods, including meat, legumes, green leafy vegetables, and other nutrient-dense food items. Antenatal-care variables included attendance pattern, hemoglobin screening, counseling exposure, supplement receipt, and perceived barriers to service use.

The primary outcome variable was maternal anemia status during pregnancy based on hemoglobin concentration. Secondary outcome variables included anemia severity and patterns of supplement adherence. Independent variables included sociodemographic characteristics, dietary intake indicators, socioeconomic status, education, parity, birth interval, antenatal-care attendance, supplement use, and reported barriers to nutrition and healthcare access. For analytic purposes, antenatal-care attendance was treated as a healthcare-access variable, while supplement adherence was treated as a behavioral and service-linked variable. High parity, short birth interval, low dietary diversity, low socioeconomic status, and limited antenatal attendance were considered potential risk factors based on their biological and contextual relevance to maternal anemia.

Qualitative data were collected through semi-structured interviews and focus group discussions with pregnant women and healthcare providers. Interview topics included understanding of anemia, perceived causes and symptoms, pregnancy-related food beliefs, household decision-making around diet and clinic visits, reasons for using or not using iron and folic acid supplements, experiences of antenatal care, distance and transportation barriers, cost-related constraints, availability of supplements, and provider-level challenges in anemia counseling and follow-up. Interviews and discussions were conducted in a setting that allowed privacy and participant comfort. Responses were documented, transcribed, and reviewed for thematic content. Thematic analysis was used to identify recurrent patterns across participant accounts, including limited awareness of anemia, cultural and dietary restrictions, barriers to healthcare access, the role of community health workers, and systemic constraints affecting prevention and treatment.

Bias and confounding were addressed at the design, data-collection, and analysis stages. Systematic recruitment in the quantitative strand was used to reduce selection bias among antenatal attendees, while standardized questionnaire domains and hemoglobin assessment procedures were used to improve measurement consistency. Questions were framed in neutral language to reduce response bias, particularly for supplement adherence and dietary practices. Potential confounding by socioeconomic status, education, parity, birth interval, dietary diversity, and antenatal-care attendance was considered during statistical analysis because these factors may be associated both with anemia status and with healthcare-seeking or nutrition-related behavior. In the qualitative strand, inclusion of both pregnant women and healthcare providers allowed triangulation of community-level, patient-level, and service-delivery perspectives. The analytic process emphasized consistency between participant quotations, coded categories, and final themes.

Quantitative data were entered, cleaned, and checked for completeness before analysis. Descriptive statistics were used to summarize participant characteristics, anemia prevalence, severity categories, dietary indicators, obstetric variables, antenatal-care attendance, and supplement use. Categorical variables were summarized as frequencies and percentages, while continuous variables were summarized using appropriate measures of central tendency and dispersion according to distributional characteristics. Associations between anemia status and categorical risk factors were assessed using chi-square tests or appropriate alternatives where cell counts were insufficient. Continuous variables were compared between anemia groups using suitable parametric or non-parametric tests depending on distribution. Regression analysis was planned to identify independent factors associated with anemia while adjusting for relevant sociodemographic, dietary, obstetric, and healthcare-access variables. Missing data were assessed before analysis, and analyses were conducted using available valid observations for each variable. Statistical significance was interpreted alongside clinical and public-health relevance rather than by p-values alone.

The integration of quantitative and qualitative findings was performed at the interpretation stage. Quantitative results were used to identify the magnitude of anemia and its association with nutritional, reproductive, socioeconomic, and antenatal-care factors, while qualitative findings were used to explain how knowledge gaps, cultural food restrictions, household constraints, supplement side effects, access barriers, and service-level limitations contributed to these observed patterns. This approach allowed the study to move beyond prevalence estimation and provide a contextual explanation of why maternal anemia persists in the study population.

Ethical approval was obtained before data collection, and informed consent was secured from all participants. Participation was voluntary, and confidentiality was maintained throughout data collection, analysis, and reporting. Personal identifiers were removed from analytic records, and qualitative quotations were presented without information that could identify individual participants. Data integrity was supported through standardized data-collection procedures, review of completed questionnaires, secure handling of study records, and consistency checks during data entry and analysis.

## RESULTS

The results are presented according to the mixed-methods structure of the study, beginning with quantitative findings on the prevalence and distribution of maternal anemia, followed by qualitative findings on participant and provider perspectives, and ending with an integrated interpretation of how the two strands explain the multifactorial nature of anemia during pregnancy.

### *Quantitative Findings*

The quantitative component showed a high burden of maternal anemia among pregnant women receiving antenatal care in the study settings. Most anemic women had mild-to-moderate anemia, while severe anemia was also observed among a smaller proportion of participants. Anemia was identified in both urban and semi-urban settings, with a comparatively greater burden among women from semi-urban areas. This pattern indicates that maternal anemia was not confined to one geographic subgroup but was more pronounced where access to diverse nutrition and regular healthcare services appeared more limited.

*Table 1. Quantitative Summary of Maternal Anemia Patterns*

<b>Finding Domain</b>	<b>Observed Pattern</b>
<b>Overall anemia burden</b>	High prevalence among pregnant women attending antenatal care
<b>Severity pattern</b>	Predominantly mild-to-moderate anemia
<b>Severe anemia</b>	Present among a smaller subgroup
<b>Urban and semi-urban distribution</b>	Higher burden in semi-urban settings
<b>Antenatal detection</b>	Cases were commonly identified during antenatal contact

The observed anemia pattern suggests that routine hemoglobin screening during antenatal visits remains essential, particularly because most cases were mild to moderate and therefore potentially manageable through early detection, dietary counseling, and iron and folic acid supplementation. The higher anemia burden among women from semi-urban settings may reflect differences in household income, food diversity, transportation access, and continuity of antenatal care.

Nutritional deficiency emerged as the most prominent quantitative risk-factor domain. Women with poor dietary intake, low dietary diversity, and limited consumption of iron-rich foods were more likely to have lower hemoglobin levels. Diets were frequently described as being dominated by roti and vegetables, with limited regular intake of meat, legumes, and green leafy vegetables. Economic limitations were a major contributor to this dietary pattern, indicating that anemia risk was closely related to household food affordability and access to nutrient-dense foods.

Socioeconomic disadvantage was also associated with anemia. Women from low-income households experienced greater vulnerability because financial constraints affected both nutrition and healthcare access. Lower female education was linked with reduced awareness of anemia prevention and lower

adherence to iron supplementation. Obstetric factors, particularly high parity and short interpregnancy intervals, were also associated with anemia, suggesting that repeated pregnancies without adequate nutritional recovery contributed to depletion of maternal iron reserves.

Antenatal-care utilization was another important factor. Women with irregular antenatal attendance were more likely to remain undiagnosed or untreated because they had fewer opportunities for hemoglobin testing, supplement provision, and anemia counseling. Poor adherence to iron and folic acid supplementation further contributed to anemia risk. The main barriers to supplement adherence included nausea, constipation, fear of possible harm to the fetus or infant, and limited understanding of the purpose of supplementation.

*Table 2. Quantitative Risk-Factor Domains Associated with Maternal Anemia*

Risk-Factor Domain	Specific Factor	Relationship With Maternal Anemia
<b>Dietary intake</b>	Low dietary diversity	Associated with lower hemoglobin levels
	Limited intake of meat, legumes, and green leafy vegetables	Associated with increased nutritional vulnerability
<b>Socioeconomic status</b>	Low household income	Associated with restricted access to nutritious food and healthcare
<b>Education</b>	Lower female educational attainment	Associated with reduced anemia awareness and supplement adherence
<b>Obstetric history</b>	High parity	Associated with cumulative depletion of maternal iron stores
<b>Obstetric history</b>	Short interpregnancy interval	Associated with inadequate nutritional recovery between pregnancies
<b>Antenatal care</b>	Irregular antenatal attendance	Associated with missed screening, counseling, and supplementation opportunities
<b>Supplementation</b>	Poor adherence to iron and folic acid	Associated with persistence of anemia risk
<b>Supplementation barriers</b>	Gastrointestinal side effects and fear of harm	Associated with reduced supplement continuation

Overall, the quantitative findings indicate that anemia during pregnancy was associated with interrelated nutritional, socioeconomic, reproductive, healthcare-access, and behavioral factors. These findings support the interpretation that maternal anemia in this population was not only a biomedical condition but also a marker of broader social and health-system vulnerability.

### *Qualitative Findings*

The qualitative component provided contextual insight into why anemia remained common despite the availability of antenatal services and iron supplementation. Five major themes were identified: limited awareness of anemia, cultural and dietary practices, barriers to healthcare access, the role of healthcare providers, and systemic constraints in anemia prevention and treatment.

Limited awareness of anemia was a recurring theme among pregnant women. Many participants had little understanding of what anemia was, how it developed, or how it could affect maternal and fetal health. Symptoms such as fatigue, weakness, and pallor were often viewed as normal experiences of pregnancy rather than warning signs requiring clinical attention. This limited awareness delayed care-seeking and reduced the perceived importance of routine hemoglobin testing and supplement use.

Cultural and dietary practices also shaped anemia risk. Some women avoided nutrient-rich foods such as eggs, meat, selected fruits, and other iron-containing foods because of beliefs that these foods could harm the fetus, increase pregnancy complications, or make delivery difficult. These restrictions reduced dietary diversity during a period of increased nutritional requirement. When cultural avoidance was combined with poverty and food insecurity, the likelihood of inadequate iron intake increased further.

Barriers to healthcare access were prominent, particularly among women from peri-urban and semi-urban communities. Distance from health facilities, transportation costs, household responsibilities, and the need for permission from male family members limited regular antenatal attendance. These barriers reduced opportunities for anemia screening, follow-up, supplementation, and counseling. Some women

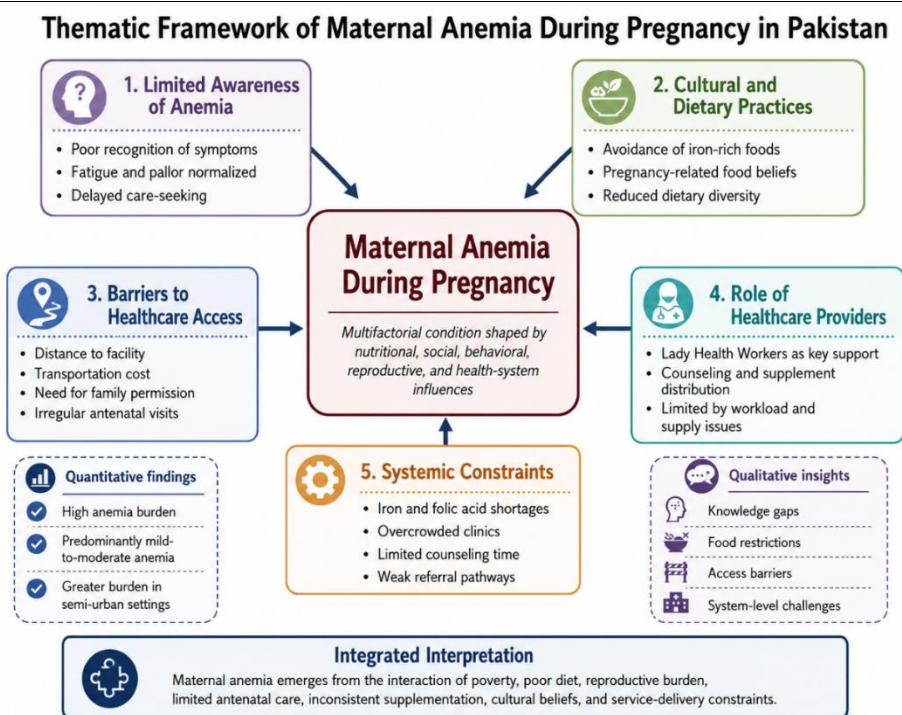
became aware of their anemia only after attending a clinic irregularly or when symptoms became more noticeable.

Healthcare providers, especially Lady Health Workers, were recognized as important community-level resources for anemia prevention. They contributed to awareness raising, supplement distribution, and encouragement of antenatal attendance. However, their effectiveness was constrained by heavy caseloads, inconsistent supply of iron and folic acid supplements, and limited opportunities for detailed counseling. Providers also reported that overcrowded clinics reduced the time available for individualized dietary and adherence counseling.

Systemic constraints further limited anemia prevention and management. Recurrent shortages of iron and folic acid supplements, overcrowded antenatal clinics, insufficient counseling time, and weak referral pathways for severe cases reduced continuity of care. These barriers indicated that anemia management required more than individual-level education; it also required strengthening of supply chains, community follow-up, and facility-level service delivery.

**Table 3. Qualitative Themes and Interpretive Meaning**

Theme	Key Finding
Limited awareness of anemia	Fatigue and pallor were often normalized during pregnancy
Cultural and dietary practices	Iron-rich foods were sometimes avoided because of pregnancy-related beliefs
Barriers to healthcare access	Distance, cost, and family permission affected clinic attendance
Role of healthcare providers	Lady Health Workers supported awareness and supplement distribution
Systemic constraints	Supplement shortages and overcrowded clinics affected care quality



**Figure 1 Thematic Framework of Maternal Anemia during Pregnancy in Pakistan**

The integrated findings demonstrate that maternal anemia during pregnancy was produced by overlapping nutritional, reproductive, socioeconomic, behavioral, cultural, and health-system pathways. Poor diet and low income contributed directly to inadequate iron intake, while high parity and short birth intervals increased physiological vulnerability. Irregular antenatal attendance and poor supplement adherence reduced opportunities for prevention and early treatment. Cultural beliefs and limited awareness further weakened dietary and supplementation practices, while systemic issues such as supplement shortages and overcrowded clinics constrained effective service delivery. Together, these findings indicate that maternal anemia prevention in Pakistan requires a combined strategy involving

routine hemoglobin screening, reliable iron and folic acid supply, culturally sensitive nutrition counseling, reproductive-health education, community-based follow-up, and improved access to antenatal services in semi-urban and underserved populations.

The qualitative findings showed that women's anemia-related behaviors were shaped by knowledge, beliefs, household decision-making, economic limitations, and service availability. These findings helped explain why some women did not attend antenatal care regularly, why supplement adherence was inconsistent, and why dietary recommendations were difficult to follow in routine household life.

*Table 4. Integrated Mixed-Methods Interpretation of Maternal Anemia Determinants*

Quantitative Finding	Qualitative Explanation
Poor dietary intake	Nutritious foods were limited by cost and cultural restrictions
Low socioeconomic status	Financial constraints affected food choices and clinic attendance
High parity and short birth interval	Repeated pregnancies limited maternal nutritional recovery
Inadequate antenatal care	Distance, transportation cost, and household permission restricted visits
Poor supplement adherence	Side effects, fear of harm, and limited understanding reduced use
Higher burden in semi-urban settings	Service access and nutritional diversity were more constrained

Integration of the quantitative and qualitative findings showed convergence across the major determinants of maternal anemia. Quantitative findings identified poor diet, low socioeconomic status, high parity, short birth interval, inadequate antenatal care, and poor supplement adherence as important anemia-related domains. Qualitative findings explained these patterns by showing how food affordability, cultural restrictions, limited awareness, household decision-making, transportation barriers, supplement side effects, and service-delivery limitations shaped women's actual behavior and access to care.

## DISCUSSION

The present mixed-methods study found that maternal anemia during pregnancy was a common and multifactorial antenatal health problem among women attending care in urban and semi-urban Pakistani settings. The quantitative findings indicated a high anemia burden, with most affected women having mild-to-moderate anemia and a smaller subgroup presenting with severe anemia. The observed pattern is clinically important because mild-to-moderate anemia may remain under-recognized without routine hemoglobin screening, yet it can progress or contribute to maternal fatigue, reduced functional capacity, poor pregnancy tolerance, and adverse perinatal outcomes when left untreated. The greater burden observed among women from semi-urban settings suggests that geographic and service-access differences may influence anemia risk through reduced dietary diversity, irregular antenatal attendance, inconsistent screening, and limited continuity of supplementation. These findings are consistent with global and regional evidence that anemia in pregnancy remains concentrated in populations exposed to nutritional deprivation, poverty, repeated pregnancies, and limited access to preventive maternal healthcare (16-19).

The quantitative risk-factor pattern showed that poor dietary intake, low dietary diversity, limited intake of iron-rich foods, low socioeconomic status, high parity, short interpregnancy intervals, inadequate antenatal care, and poor adherence to iron and folic acid supplementation were central contributors to maternal anemia. These findings support the understanding that anemia in pregnancy is not merely a laboratory abnormality but a marker of cumulative nutritional, reproductive, and social vulnerability. Diets dominated by staple foods with limited intake of meat, legumes, and green leafy vegetables reduce the availability of bioavailable iron and other micronutrients required during pregnancy. Socioeconomic disadvantage further intensifies this risk by limiting household purchasing power, access to nutrient-dense foods, and ability to attend health facilities. The association of anemia with high parity and short birth intervals is biologically plausible because repeated pregnancies without adequate nutritional recovery can deplete maternal iron reserves and increase vulnerability in subsequent pregnancies. These patterns align with established evidence that maternal undernutrition and anemia in low- and middle-

income settings are shaped by overlapping deficiencies, poverty, reproductive burden, and unequal access to care (2,3).

The qualitative findings expanded the interpretation of these quantitative associations by showing how women's knowledge, beliefs, household circumstances, and health-system experiences shaped anemia-related behavior. Limited awareness of anemia was a major theme, with many women normalizing fatigue, weakness, and pallor as expected features of pregnancy rather than recognizing them as possible warning signs. This finding helps explain delayed care-seeking and low perceived urgency for hemoglobin testing or supplementation. Cultural and dietary beliefs further influenced nutritional behavior, as some women avoided eggs, meat, selected fruits, or other nutrient-rich foods because of concerns about fetal harm, difficult delivery, or pregnancy complications. These beliefs may reduce dietary diversity at precisely the stage when maternal iron and micronutrient requirements are increased. The qualitative strand therefore clarified that poor dietary intake was not only an economic issue but also a culturally mediated behavior influenced by household norms, pregnancy-related beliefs, and limited counseling (7, 11).

Barriers to healthcare access also emerged as a major explanatory pathway. Women from semi-urban and peri-urban communities faced distance-related barriers, transportation costs, household responsibilities, and the need for permission from male family members before attending antenatal services. These barriers reduced opportunities for routine hemoglobin screening, supplement provision, dietary counseling, follow-up, and timely referral. The qualitative findings therefore contextualized the quantitative observation that inadequate antenatal attendance was linked with anemia risk. Irregular antenatal contact can delay diagnosis and reduce the likelihood that women receive and continue iron and folic acid supplementation. Even when supplementation is available, adherence may be reduced by gastrointestinal side effects, fear of harm to the fetus or infant, and lack of understanding regarding the preventive and therapeutic purpose of supplements. This indicates that supplementation programs are unlikely to succeed through distribution alone unless accompanied by culturally sensitive counseling, side-effect management, and repeated reinforcement during antenatal visits.

The role of healthcare providers, particularly Lady Health Workers, was another important mixed-methods finding. Healthcare providers were identified as key resources for community education, anemia awareness, supplement distribution, and linkage to antenatal services. This finding supports the broader importance of community-based health workers in maternal and child health service delivery in Pakistan (6). However, the qualitative findings also revealed that heavy caseloads, limited counseling time, inconsistent supply of iron and folic acid, and service overcrowding reduced the effectiveness of provider-led anemia prevention. These systemic constraints are important because they show that maternal anemia cannot be addressed solely through individual-level behavior change. Even motivated women may remain at risk if supplements are unavailable, clinics are overcrowded, counseling is brief, and referral systems for severe anemia are weak. This interpretation is consistent with health-system perspectives emphasizing that barriers to maternal and preventive care in Pakistan arise from structural limitations as well as patient-level factors (7).

Integration of the quantitative and qualitative strands indicates convergence across nutritional, socioeconomic, reproductive, behavioral, cultural, and health-system determinants. Quantitative findings identified the main domains associated with anemia, while qualitative findings explained the mechanisms through which these domains operated in daily life. Poor dietary intake was explained by poverty, affordability constraints, and cultural food restrictions. Low antenatal attendance was explained by transportation costs, distance, household permission, and service inconvenience. Poor supplement adherence was explained by side effects, fear, and inadequate understanding. Higher semi-urban burden was explained by reduced access to diverse nutrition, screening, counseling, and consistent supplementation. This integration strengthens the interpretation that maternal anemia in the Pakistani

pregnancy context is a syndemic-like public health problem produced by interacting biological and structural vulnerabilities rather than by isolated iron deficiency alone (19-24).

The findings have important implications for antenatal care and public health programming. Routine hemoglobin screening should remain a core component of antenatal visits, especially in semi-urban and underserved communities where women may present late or attend irregularly. Iron and folic acid supplementation must be accompanied by practical counseling on side effects, adherence strategies, dietary sources of iron, and correction of pregnancy-related food misconceptions. Community-level interventions should involve Lady Health Workers and other frontline providers, but these providers require reliable supplement supply, updated counseling tools, manageable workloads, and referral support. Nutrition education should be culturally sensitive and should address both affordability and beliefs about iron-rich foods. Reproductive counseling regarding birth spacing may also be important because high parity and short interpregnancy intervals increase maternal nutritional depletion. Facility-level improvements, including shorter waiting times, consistent screening, supplement availability, and strengthened referral pathways for severe anemia, are necessary to translate awareness into effective prevention and treatment (20-23).

This study has several limitations that should be considered when interpreting the findings. The cross-sectional quantitative component can identify associations but cannot establish causality between reported risk factors and anemia. Recruitment from antenatal care and community settings may underrepresent women with no access to care or those who seek care only in emergencies. Dietary practices, supplement adherence, and barriers to care may be affected by recall or social desirability bias. The qualitative component provides important contextual insight but may reflect the experiences of women and providers within the selected settings rather than all pregnant women in Pakistan. Despite these limitations, the mixed-methods design is a strength because it combines estimation of anemia patterns with contextual explanation of why anemia persists despite known preventive interventions. The integration of both strands provides a more complete understanding of maternal anemia and supports the need for combined nutritional, behavioral, reproductive, community-based, and health-system interventions (25, 26).

## CONCLUSION

Maternal anemia during pregnancy was identified as a prevalent and multifactorial health issue among women attending antenatal services in urban and semi-urban Pakistani settings, with the burden shaped by poor dietary diversity, socioeconomic disadvantage, high parity, short birth intervals, irregular antenatal attendance, and inconsistent adherence to iron and folic acid supplementation. The qualitative findings showed that these quantitative risk domains were reinforced by limited awareness of anemia, cultural restrictions on iron-rich foods, household and transport barriers to antenatal care, fear of supplement-related harm, side effects, and systemic constraints such as supplement shortages, overcrowded clinics, and limited counseling time. The integrated mixed-methods interpretation demonstrates that effective anemia prevention requires more than supplementation alone; it requires routine hemoglobin screening, reliable iron and folic acid availability, culturally sensitive nutrition counseling, improved antenatal access, reproductive-health counseling, strengthened Lady Health Worker support, and health-system improvements targeting semi-urban and underserved communities.

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