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Adherence to the Healthy Food Pyramid Among Pregnant and Lactating Women and the Impact of Socioeconomic Status in Pakistan: An Analytical Cross-Sectional Study

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ABSTRACT

Background: *Maternal nutrition during pregnancy and lactation is a critical determinant of maternal and neonatal health, yet adherence to balanced dietary patterns remains suboptimal in low- and middle-income settings. In Pakistan, nutritional counseling is frequently supplementation-focused, and the influence of socioeconomic status (SES) on comprehensive dietary adherence during these physiologically demanding periods remains insufficiently characterized.* ***Objective:*** *To assess adherence to the Healthy Food Pyramid (HFP) among pregnant and lactating women attending tertiary care hospitals in Pakistan and to examine its association with socioeconomic indicators and maternal body mass index (BMI).* ***Methods:*** *In this analytical cross-sectional study, 204 women aged 18–42 years (pregnant, lactating, or dual-status) were recruited consecutively from tertiary hospitals. Adherence was measured using a culturally adapted Adherence to Pyramid Questionnaire (AP-Q; 0–10 scale). Sociodemographic data and anthropometric measurements were collected using standardized procedures. Group comparisons were performed using ANOVA, and multivariable linear regression was conducted to adjust for potential confounders.* ***Results:*** *The mean AP-Q score was 5.71 ± 0.96, indicating moderate adherence. No significant differences were observed across reproductive status groups ($p = 0.62$). Higher adherence was associated with normal BMI ($p = 0.003$), higher monthly income ($p = 0.001$), and husband's graduate-level education ($p = 0.004$). In adjusted analysis, high income ($\beta = 0.52$; 95% CI: 0.24–0.80) and obesity ($\beta = -0.61$; 95% CI: −0.94 to −0.28) remained independent predictors.* ***Conclusion:*** *Adherence to HFP principles among pregnant and lactating women in Pakistan is moderate and significantly influenced by socioeconomic gradients and BMI. Integrating culturally tailored, household-oriented dietary interventions into maternal care may improve nutritional quality and mitigate long-term cardiometabolic risk.*

Keywords: *Healthy Food Pyramid; pregnancy; lactation; socioeconomic status; body mass index; dietary adherence; Pakistan*

INTRODUCTION

Maternal nutrition during pregnancy and lactation is a critical determinant of both short- and long-term health outcomes for the mother–infant dyad. These physiological states are characterized by increased metabolic demand, expanded blood volume, progressive fat deposition, fetal growth, and, subsequently, sustained energy expenditure for milk production. To support optimal fetal development and adequate lactogenesis, women require increased intake of high-quality macro- and micronutrients, with lactating mothers requiring approximately 330–400 additional kilocalories per day depending on baseline nutritional status and breastfeeding intensity (1,2). Inadequate or imbalanced dietary intake during these sensitive periods has been associated with adverse maternal outcomes, including gestational hypertension and hyperglycemia, as well as suboptimal neonatal growth and long-term metabolic risk in offspring (3,4). These concerns are particularly relevant in low- and middle-income countries such as Pakistan, where the epidemiological transition toward non-communicable diseases (NCDs) coexists with persistent nutritional inequities (5).

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Globally, dietary pattern–based approaches have gained prominence over single-nutrient frameworks for evaluating nutritional adequacy. The Mediterranean dietary pattern, operationalized through the Healthy Food Pyramid (HFP), emphasizes balanced consumption of whole grains, fruits, vegetables, legumes, nuts, healthy fats, adequate hydration, physical activity, and social eating practices (6). Adherence to this dietary model has been consistently associated with improved cardiometabolic profiles, reduced risk of pregnancy-related hypertensive disorders, and better glycemic regulation during gestation (7,8). Furthermore, maternal dietary quality has been shown to influence fetal programming, with implications extending into childhood and adult health (9). Although the Mediterranean diet originates from specific cultural contexts, its core principles of dietary diversity, plant-forward nutrition, and healthy lifestyle integration are transferable and have been adapted for non-Mediterranean populations through validated assessment tools such as the Adherence to Pyramid Questionnaire (AP-Q) (10).

In Pakistan, however, maternal nutrition is often framed within a biomedical supplementation paradigm rather than a comprehensive dietary pattern approach. Iron, folate, and multivitamin supplementation are widely promoted, yet structured counseling on balanced dietary practices remains inconsistent. Cultural misconceptions, including the notion of "eating for two," may further distort caloric and food-quality choices, potentially contributing to excessive gestational weight gain and postpartum weight retention. Emerging evidence indicates a rising prevalence of overweight and obesity among women of reproductive age in Pakistan, compounding the risk of gestational metabolic complications and intergenerational transmission of NCD risk (11,12). At the same time, socioeconomic disparities—including household income, educational attainment, and urban–rural residence—shape food access, dietary diversity, and health literacy (13). International literature suggests that higher socioeconomic status (SES) is positively associated with adherence to healthy dietary patterns, yet the magnitude and direction of this association vary across sociocultural contexts (14).

Despite the recognized importance of maternal dietary quality, there is limited empirical evidence from Pakistan examining adherence to structured, pattern-based dietary models during pregnancy and lactation. Existing local studies predominantly focus on micronutrient deficiencies, anemia prevalence, or isolated dietary components rather than comprehensive lifestyle-oriented frameworks. Moreover, few investigations have concurrently examined the interplay between socioeconomic determinants, maternal body mass index (BMI), and adherence to a holistic dietary pyramid model in this population. This represents a critical knowledge gap, particularly given that pregnancy and lactation constitute behaviorally receptive periods during which women may be more motivated to adopt health-promoting practices for fetal and infant well-being.

Within a PICO framework, the population of interest comprises pregnant, lactating, and dual-status women of reproductive age attending tertiary healthcare facilities in Pakistan. The exposure variables include socioeconomic indicators (household income, educational status of mother and spouse, residence) and maternal BMI categories, while the primary outcome is adherence to the Healthy Food Pyramid as measured by a culturally adapted AP-Q score. Although no direct intervention or comparison group is implemented in this cross-sectional design, comparisons across socioeconomic strata and BMI categories allow assessment of differential adherence patterns. By situating maternal dietary behavior within a multidimensional lifestyle framework, this study moves beyond nutrient-centric assessments toward evaluating integrated dietary and lifestyle practices.

The present study is therefore justified on both clinical and public health grounds. Clinically, understanding determinants of dietary adherence during pregnancy and lactation may inform targeted counseling strategies within antenatal and postnatal care. From a public health perspective, identifying socioeconomic gradients in adherence can guide policy-level interventions aimed at reducing nutritional inequities and mitigating the growing burden of NCDs in Pakistan. Accordingly, this study aims to assess the level of adherence to the Healthy Food Pyramid among pregnant and lactating women in tertiary care settings in Pakistan and to examine the association between adherence scores and selected socioeconomic factors and maternal BMI. We hypothesize that higher socioeconomic status and normal BMI are independently associated with greater adherence to Healthy Food Pyramid principles in this population.

METHODS

This analytical cross-sectional observational study was conducted to evaluate adherence to the Healthy Food Pyramid (HFP) among pregnant and lactating women and to examine its association with socioeconomic status and maternal body mass index (BMI). A cross-sectional design was selected as it allows estimation of adherence levels and assessment of associations between exposure variables and dietary outcomes within a defined population at a specific point in time, in accordance with established methodological standards for observational research (15). The study was carried out in obstetrics and gynecology outpatient departments of tertiary care teaching hospitals located in Lahore and Multan, Pakistan, between January and June 2024. These centers serve both urban and peri-urban populations and receive referrals from surrounding districts, thereby providing access to women across diverse socioeconomic strata.

Women aged 18–42 years who were currently pregnant (any trimester), lactating (within 12 months postpartum and actively breastfeeding), or simultaneously pregnant while breastfeeding an older infant (dual-status group) were eligible for inclusion. Participants were required to be clinically stable and capable of providing informed consent. Women with previously diagnosed chronic metabolic disorders requiring specialized dietary regimens (e.g., type 1 diabetes mellitus, chronic renal disease), severe pregnancy complications necessitating therapeutic dietary restriction, or inability to complete the interview were excluded to minimize confounding from medically prescribed diets. Participants were selected using purposive consecutive sampling during routine antenatal or postnatal visits. All eligible women attending the clinics during data collection days were approached by trained female research assistants, informed about the study objectives and procedures, and invited to participate. Written informed consent was obtained prior to enrollment in accordance with ethical research principles (16).

Data were collected through structured face-to-face interviews using a culturally adapted version of the Adherence to Pyramid Questionnaire (AP-Q), a validated instrument originally developed to assess adherence to Mediterranean dietary and lifestyle principles (10). The questionnaire was translated into Urdu using forward–backward translation procedures and reviewed by a panel comprising a public health nutritionist, an obstetrician, and a biostatistician to ensure semantic equivalence and contextual appropriateness. Minor modifications were made to reflect locally available foods and customary cooking practices while preserving the conceptual domains of the original tool. A pilot test was conducted on 20 women from a similar population to evaluate clarity and internal consistency; these participants were not included in the final analysis. The adapted instrument demonstrated acceptable internal reliability (Cronbach's alpha >0.70). The final questionnaire consisted of three domains: sociodemographic characteristics, lifestyle practices, and dietary intake

patterns. The average duration of each interview was approximately 20 minutes. Data were recorded electronically using Google Forms with restricted access and real-time validation checks to minimize entry errors.

Sociodemographic variables included maternal age (categorized as 18–25, 26–33, and 34–42 years), residence (urban/rural), maternal educational attainment (illiterate, elementary, undergraduate, graduate), husband's educational attainment (same categories), occupation, parity, gestational age (trimester), and household income. Household income was recorded as average monthly income in Pakistani Rupees (PKR) and categorized into lower (<50,000 PKR), middle (50,000–150,000 PKR), and upper (>150,000 PKR) income groups to reflect locally relevant economic stratification. Maternal anthropometric measurements were obtained on-site using standardized procedures. Body weight was measured to the nearest 0.1 kg using a calibrated digital scale with participants wearing light clothing and no shoes, and height was measured to the nearest 0.1 cm using a wall-mounted stadiometer. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m²) and categorized according to World Health Organization criteria: underweight (<18.5), normal weight (18.5–24.9), overweight (25.0–29.9), and obese (≥30.0) (17).

The primary outcome variable was the total AP-Q adherence score, operationalized as a continuous variable ranging from 0 to 10, with higher scores indicating greater adherence to HFP principles. Each domain score was standardized to a maximum of 10 points, and the overall score was calculated as the arithmetic mean of domain scores. Items reflecting healthy behaviors (e.g., frequent fruit and vegetable intake, adequate hydration, regular physical activity) were positively weighted, whereas items reflecting unhealthy practices (e.g., excessive processed snack consumption, irregular sleep patterns) were reverse-coded. Secondary exposure variables included BMI category, income group, maternal and husband education, residence, and reproductive status (pregnant, lactating, dual-status). Potential confounders identified a priori based on literature included maternal age, parity, and residence (13,14).

To minimize selection bias, all eligible women during the study period were approached consecutively. Information bias was addressed through standardized interviewer training, use of a structured questionnaire, and real-time data validation. Anthropometric measurements were performed using calibrated equipment to reduce measurement error. To mitigate confounding, multivariable statistical models were prespecified to adjust for relevant sociodemographic and reproductive variables. The study adhered to STROBE guidelines for reporting cross-sectional studies (18).

The required sample size was calculated using the Cochrane formula for estimating proportions in cross-sectional studies: $n = Z^2p(1-p)/d^2$ (19). Assuming a 95% confidence level ($Z = 1.96$), an anticipated adherence proportion of 50% to maximize sample variability ($p = 0.5$), and a margin of error of 7% ($d = 0.07$), the minimum required sample size was 196 participants. Accounting for potential non-response and incomplete data, a target sample of 204 participants was achieved.

Data were exported from Google Forms into SPSS version 26 (IBM Corp., Armonk, NY, USA) for analysis. Descriptive statistics were computed as means ± standard deviations (SD) for continuous variables and frequencies with percentages for categorical variables. Normality of continuous variables was assessed using the Shapiro–Wilk test and visual inspection of histograms. Differences in mean AP-Q scores across categorical groups were initially assessed using one-way analysis of variance (ANOVA). Homogeneity of variances was evaluated using Levene's test. When overall ANOVA results were statistically significant, post hoc comparisons were conducted using Tukey's honestly significant difference test.

Effect sizes were reported using partial eta squared (η^2). To account for potential confounding, multiple linear regression analysis was performed with AP-Q score as the dependent variable and BMI category, income group, maternal education, husband education, residence, age group, parity, and reproductive status as independent variables. Adjusted beta coefficients with 95% confidence intervals were reported. Multicollinearity was assessed using variance inflation factors. Missing data were minimal (<5%) and handled using complete case analysis, as patterns were random upon inspection. A two-tailed p-value <0.05 was considered statistically significant.

The study protocol was reviewed and approved by the Institutional Review Board of CMH Lahore Medical College and affiliated centers. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (16). Participant anonymity was ensured by assigning unique identification codes and storing data in password-protected files accessible only to the principal investigators. Data integrity was maintained through double-checking of anthropometric entries, automated range checks in electronic forms, and secure archival of de-identified datasets to permit independent verification and reproducibility of analyses.

RESULTS

Across 204 participants, the cohort was predominantly in the 26–33-year age group (110/204, 53.9%), followed by 18–25 years (61/204, 29.9%) and 34–42 years (33/204, 16.2%), with a mean age of 28.9 ± 5.1 years (Table 1). Nearly two-thirds resided in urban settings (137/204, 67.2%), while one-third were rural (67/204, 32.8%). By reproductive status, pregnant women constituted 92/204 (45.1%), lactating women 78/204 (38.2%), and dual-status women 34/204 (16.7%). The BMI distribution demonstrated a high burden of excess weight: 97/204 (47.5%) were overweight and 30/204 (14.7%) were obese, whereas 72/204 (35.3%) were within the normal BMI range and only 5/204 (2.5%) were underweight. Educational attainment differed by sex of the spouse: maternal education was most commonly elementary (74/204, 36.3%) and graduate level (56/204, 27.5%), while husbands were more frequently graduates (80/204, 39.2%) and undergraduates (60/204, 29.4%). Monthly household income was relatively evenly distributed across the three strata, with 69/204 (33.8%) earning <50,000 PKR, 72/204 (35.3%) earning 50,000–150,000 PKR, and 63/204 (30.9%) earning >150,000 PKR (Table 1).

Adherence to the Healthy Food Pyramid, operationalized as the AP-Q score, showed moderate levels across reproductive groups with minimal separation (Table 2). Pregnant women had a mean AP-Q score of 5.70 ± 1.08 (95% CI: 5.48–5.92), lactating women scored 5.72 ± 0.83 (95% CI: 5.53–5.91), and the dual-status group scored 5.57 ± 1.00 (95% CI: 5.23–5.91). The between-group comparison was not statistically significant (ANOVA $p = 0.62$), and the magnitude of group differences was negligible ($\eta^2 = 0.005$), indicating that pregnancy/lactation status alone did not explain meaningful variation in adherence in this sample (Table 2).

In contrast, adherence differed significantly across BMI categories, with a clear gradient favoring healthier weight status (Table 3). Women with normal BMI demonstrated the highest adherence (mean 6.02 ± 0.81; 95% CI: 5.83–6.21), while overweight participants had lower scores (5.63 ± 0.92; 95% CI: 5.45–5.81), and obese participants had the lowest adherence (5.21 ± 1.03; 95% CI: 4.83–5.59). Underweight women ($n = 5$) had a mean score of 5.88 ± 0.74 (95% CI: 5.03–6.73), though the estimate is imprecise due to the small subgroup size. Overall differences were statistically significant (ANOVA $p = 0.003$) with a moderate effect size ($\eta^2 = 0.084$), suggesting BMI category accounted for approximately 8.4% of the variance in AP-Q scores. Post hoc testing confirmed that normal BMI differed significantly from obesity ($p =$

0.001) and from overweight status (p = 0.02), indicating that the highest adherence clustered in the normal BMI group (Table 3).

Household income showed the strongest bivariate association with adherence among the socioeconomic indicators assessed (Table 4). Women in the lowest income stratum (<50,000 PKR/month) had a mean AP-Q score of 5.34 ± 0.89 (95% CI: 5.13–5.55), rising to 5.73 ± 0.85 (95% CI: 5.53–5.93) in the middle-income group (50,000–150,000 PKR/month) and to 6.09 ± 0.94 (95% CI: 5.85–6.33) in the highest-income group (>150,000 PKR/month). The overall difference across income categories was statistically significant (ANOVA p = 0.001) with a moderate effect size (η^2 = 0.112), implying income explained about 11.2% of the variance in adherence. Post hoc analysis indicated the clearest separation between the lowest and highest income groups (p < 0.001), consistent with the interpretation that economic capacity may facilitate closer alignment with HFP dietary and lifestyle practices (Table 4).

Educational gradients were evident for husbands' education but not for mothers' education (Table 5). Mean adherence increased stepwise with husbands' educational attainment: 5.29 ± 0.91 (95% CI: 4.86–5.72) among illiterate husbands, 5.47 ± 0.88 (95% CI: 5.20–5.74) at elementary level, 5.76 ± 0.85 (95% CI: 5.54–5.98) at undergraduate level, and 6.01 ± 0.92 (95% CI: 5.80–6.22) among graduates. This pattern was statistically significant (ANOVA p = 0.004) with a moderate effect size (η^2 = 0.076). In contrast, mothers' education showed smaller numerical differences—5.41 ± 0.97 (95% CI: 5.01–5.81) in illiterate mothers versus 5.85 ± 0.94 (95% CI: 5.59–6.11) among graduates—and did not reach statistical significance (ANOVA p = 0.18; η^2 = 0.021), indicating limited explanatory value of maternal education alone for adherence variability in this cohort (Table 5).

When socioeconomic and clinical predictors were examined simultaneously, the multivariable regression model supported the independent contribution of income, BMI, and husband's education to adherence, while reproductive status differences remained minimal. Compared with the reference income category, women in the highest income group (>150,000 PKR/month) had higher adjusted AP-Q scores (β = 0.52; 95% CI: 0.24–0.80; p < 0.001). Relative to normal BMI, obesity was independently associated with lower adherence (β = −0.61; 95% CI: −0.94 to −0.28; p = 0.001). Husbands' graduate education also remained a significant predictor (β = 0.37; 95% CI: 0.09–0.65; p = 0.01), whereas maternal education did not demonstrate an independent association after adjustment (p = 0.14).

Table 1. Sociodemographic and Clinical Characteristics of Participants (N = 204)

Variable	Category	n (%) or Mean ± SD
Maternal Age (years)	18–25	61 (29.9%)
	26–33	110 (53.9%)
	34–42	33 (16.2%)
Age (continuous)	—	28.9 ± 5.1
Reproductive Status	Pregnant	92 (45.1%)
	Lactating	78 (38.2%)
	Dual-status	34 (16.7%)
BMI Category	Underweight (<18.5)	5 (2.5%)
	Normal (18.5–24.9)	72 (35.3%)
	Overweight (25–29.9)	97 (47.5%)

Variable	Category	n (%) or Mean ± SD
	Obese (≥30)	30 (14.7%)
Residence	Urban	137 (67.2%)
	Rural	67 (32.8%)
Mother's Education	Illiterate	26 (12.7%)
	Elementary	74 (36.3%)
	Undergraduate	48 (23.5%)
	Graduate	56 (27.5%)
Husband's Education	Illiterate	20 (9.8%)
	Elementary	44 (21.6%)
	Undergraduate	60 (29.4%)
	Graduate	80 (39.2%)
Monthly Income (PKR)	<50,000	69 (33.8%)
	50,000–150,000	72 (35.3%)
	>150,000	63 (30.9%)

Table 2. Comparison of Mean AP-Q Scores by Reproductive Status

Reproductive Status	n	Mean AP-Q ± SD	95% CI	p-value (ANOVA)	Effect Size (η^2)
Pregnant	92	5.70 ± 1.08	5.48–5.92		
Lactating	78	5.72 ± 0.83	5.53–5.91		
Dual-status	34	5.57 ± 1.00	5.23–5.91	0.62	0.005

Table 3. Association Between BMI Category and AP-Q Score

BMI Category	n	Mean AP-Q ± SD	95% CI	p-value (ANOVA)	Effect Size (η^2)
Underweight	5	5.88 ± 0.74	5.03–6.73		
Normal	72	6.02 ± 0.81	5.83–6.21		
Overweight	97	5.63 ± 0.92	5.45–5.81		
Obese	30	5.21 ± 1.03	4.83–5.59	0.003	0.084

Table 4. Association Between Monthly Household Income and AP-Q Score

Monthly Income (PKR)	n	Mean AP-Q ± SD	95% CI	p-value (ANOVA)	Effect Size (η^2)
<50,000	69	5.34 ± 0.89	5.13–5.55		
50,000–150,000	72	5.73 ± 0.85	5.53–5.93		
>150,000	63	6.09 ± 0.94	5.85–6.33	0.001	0.112

Table 5. Association Between Parental Education and AP-Q Score

Variable	Category	n	Mean AP-Q ± SD	95% CI	p-value (ANOVA)	Effect Size (η^2)
Husband's Education	Illiterate	20	5.29 ± 0.91	4.86–5.72		

Variable	Category	n	Mean AP-Q ± SD	95% CI	p-value (ANOVA)	Effect Size (η^2)
	Elementary	44	5.47 ± 0.88	5.20–5.74		
	Undergraduate	60	5.76 ± 0.85	5.54–5.98		
	Graduate	80	6.01 ± 0.92	5.80–6.22	0.004	0.076
Mother's Education	Illiterate	26	5.41 ± 0.97	5.01–5.81		
	Elementary	74	5.62 ± 0.90	5.41–5.83		
	Undergraduate	48	5.79 ± 0.88	5.53–6.05		
	Graduate	56	5.85 ± 0.94	5.59–6.11	0.18	0.021

The overall model explained 21% of the variability in adherence (adjusted $R^2 = 0.21$; model $p < 0.001$), indicating that socioeconomic and BMI-related factors collectively contributed meaningfully—though not exhaustively—to differences in HFP adherence in this maternal population.

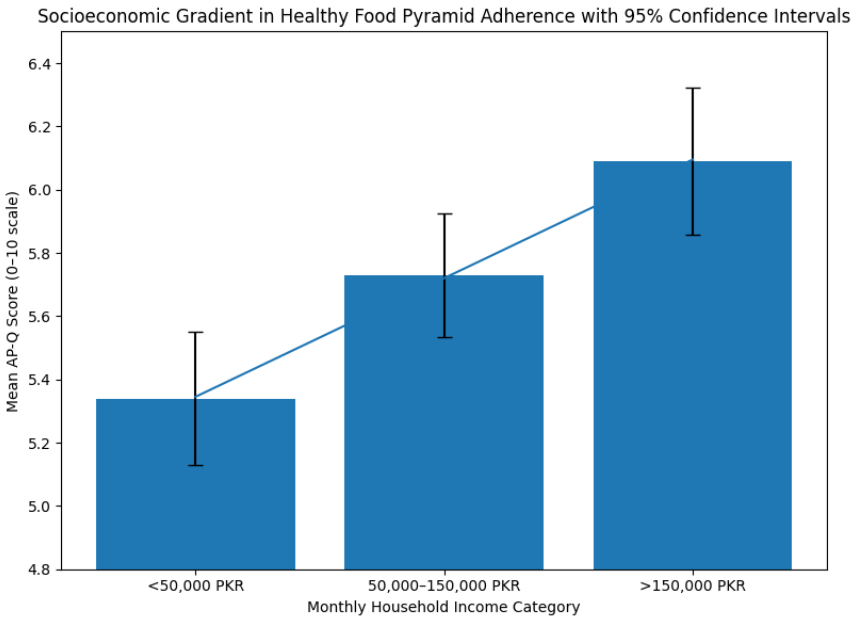

Figure 1 Socioeconomic Gradient in Healthy Food Pyramid Adherence With 95% Confidence Intervals

The figure demonstrates a clear positive socioeconomic gradient in adherence to the Healthy Food Pyramid across monthly income categories. Mean AP-Q scores increased progressively from 5.34 (95% CI: 5.13–5.55) in the lowest income group (<50,000 PKR) to 5.73 (95% CI: 5.53–5.93) in the middle-income group and 6.09 (95% CI: 5.85–6.33) in the highest income group (>150,000 PKR). The confidence intervals show minimal overlap between the lowest and highest income strata, supporting the statistically significant overall difference (ANOVA $p = 0.001$; $\eta^2 = 0.112$). The superimposed regression layer illustrates a consistent linear upward trajectory in adherence with increasing income category, reflecting a mean absolute difference of 0.75 points (approximately 14% of the 0–10 scale range) between the lowest and highest income groups. Clinically, this gradient indicates that economic capacity is associated

with materially higher adherence to balanced dietary and lifestyle practices during pregnancy and lactation, reinforcing income as an independent determinant of maternal dietary quality.

DISCUSSION

This analytical cross-sectional study evaluated adherence to the Healthy Food Pyramid among pregnant and lactating women attending tertiary care hospitals in Pakistan and examined its association with socioeconomic status and maternal BMI. The overall mean AP-Q score of 5.71 ± 0.96 on a 0–10 scale indicates moderate adherence to structured dietary and lifestyle principles. Importantly, adherence did not significantly differ across reproductive status groups (pregnant, lactating, dual-status; $p = 0.62$), suggesting that physiological state alone does not appear to drive meaningful variation in dietary pattern adherence in this cohort. Rather, socioeconomic and anthropometric factors demonstrated stronger explanatory value. These findings align with prior evidence indicating that dietary behaviors during pregnancy and lactation are shaped more by contextual determinants than by biological state per se (20).

A key finding of this study is the significant inverse association between BMI category and adherence score. Women with normal BMI exhibited the highest mean adherence (6.02 ± 0.81), while obese women had the lowest (5.21 ± 1.03), with BMI category explaining approximately 8.4% of the variance in AP-Q scores ($\eta^2 = 0.084$). After multivariable adjustment, obesity remained independently associated with lower adherence ($\beta = -0.61$; 95% CI: −0.94 to −0.28; $p = 0.001$). This pattern is clinically meaningful, as dietary quality and weight status are bidirectionally related. Lower adherence to balanced dietary patterns may contribute to excessive gestational weight gain and postpartum weight retention; while pre-existing overweight and obesity may reflect longstanding suboptimal dietary behaviors (21). In populations undergoing nutritional transition, such as Pakistan, rising rates of maternal overweight and obesity have been linked to increased risk of gestational diabetes, hypertensive disorders, and adverse neonatal outcomes (22). Our findings suggest that structured dietary pattern adherence may represent a modifiable pathway to address this escalating risk.

Socioeconomic status emerged as the strongest determinant of adherence. A clear income gradient was observed, with mean AP-Q scores rising from 5.34 in the lowest income group to 6.09 in the highest income group ($p = 0.001$; $\eta^2 = 0.112$), and higher income remaining independently associated with better adherence in adjusted analyses ($\beta = 0.52$; 95% CI: 0.24–0.80; $p < 0.001$). This gradient likely reflects differences in food affordability, access to dietary diversity, and exposure to health-promoting information. Economic constraints in low-income households may prioritize calorically dense but nutritionally limited food options, thereby reducing alignment with plant-forward and lifestyle-integrated dietary frameworks (23). Similar socioeconomic gradients in adherence to healthy dietary patterns have been documented internationally, where income and educational resources facilitate access to fruits, vegetables, whole grains, and healthier cooking oils (24). In the Pakistani context, where food inflation and income instability disproportionately affect vulnerable households, the observed gradient underscores structural determinants of maternal dietary quality.

Interestingly, husband's educational attainment demonstrated a significant positive association with adherence, whereas maternal education did not retain statistical significance after adjustment. Women whose husbands were graduates had higher mean adherence scores (6.01 ± 0.92) compared with those whose husbands were illiterate (5.29 ± 0.91; $p = 0.004$). In multivariable analysis, husband's graduate education remained an independent

predictor (β = 0.37; 95% CI: 0.09–0.65; p = 0.01). This finding may reflect sociocultural household dynamics in which financial decision-making and food purchasing authority are influenced by male partners, particularly in South Asian settings (25). The absence of a significant independent association with maternal education, despite a directional increase in mean scores across categories, suggests that knowledge alone may be insufficient without corresponding economic and structural support. This aligns with behavioral models indicating that capability must be complemented by opportunity and enabling environment to translate into sustained dietary behavior change (26).

The lack of statistically significant differences in adherence across pregnancy and lactation categories suggests that healthcare contact during these phases may not uniformly translate into improved dietary practices. Although antenatal and postnatal visits offer opportunities for counseling, structured dietary pattern education may not be systematically integrated into routine care. Existing maternal health programs in Pakistan primarily emphasize micronutrient supplementation rather than comprehensive dietary frameworks (27). Given that pregnancy and lactation represent heightened periods of health motivation, structured counseling grounded in culturally adapted dietary models could potentially yield greater behavioral uptake (28). Our data support the need to shift from nutrient-centric to pattern-based dietary counseling within maternal health services.

From a public health perspective, the moderate overall adherence level (mean 5.71/10) indicates substantial room for improvement. The adjusted model explained 21% of the variance in adherence, implying that additional unmeasured factors—such as food environment, cultural dietary norms, parity-related workload, and psychosocial stress—likely contribute to dietary behavior variability. Future research employing longitudinal designs could better elucidate temporal relationships and potential causal pathways between socioeconomic mobility, weight trajectory, and dietary adherence during and after pregnancy (29). Additionally, qualitative investigations may help clarify barriers to implementing healthy dietary patterns in lower-income households.

Several methodological considerations merit attention. The cross-sectional design precludes causal inference, and although multivariable modeling was applied, residual confounding cannot be excluded. Recruitment from tertiary care centers may limit generalizability to women receiving care at primary or community-level facilities. Nonetheless, the study contributes novel evidence by applying a culturally adapted, pattern-based adherence tool within a maternal population in Pakistan and by simultaneously examining BMI and multiple socioeconomic dimensions. The use of standardized anthropometric measurement and multivariable regression strengthens internal validity.

In summary, adherence to the Healthy Food Pyramid among pregnant and lactating women in this tertiary-care cohort was moderate, with significant gradients across BMI and socioeconomic strata. Higher household income, normal BMI, and husband's higher educational attainment were independently associated with better adherence, whereas maternal education alone was not. These findings highlight the interplay between structural socioeconomic determinants and maternal dietary behaviors, emphasizing the need for integrated, household-level nutritional interventions that address economic access, gender dynamics, and weight-specific guidance. Targeted strategies embedded within antenatal and postnatal care may represent a feasible entry point to improve maternal dietary quality and mitigate long-term cardiometabolic risk for both mothers and offspring.

CONCLUSION

In conclusion, this study demonstrates that adherence to the Healthy Food Pyramid among pregnant and lactating women attending tertiary care hospitals in Pakistan is moderate overall and is significantly influenced by socioeconomic and anthropometric factors rather than reproductive status alone. Higher household income, normal BMI, and greater husband educational attainment were independently associated with better adherence, while maternal education did not show an independent effect after adjustment. These findings underscore the importance of addressing structural determinants—particularly economic capacity and household decision-making dynamics—when designing maternal nutrition interventions. Integrating culturally adapted, pattern-based dietary counseling into routine antenatal and postnatal care, with attention to weight-specific guidance and socioeconomic constraints, may represent a strategic approach to improving maternal dietary quality and mitigating intergenerational cardiometabolic risk in this population.

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DECLARATIONS

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Informed Consent: Informed Consent was taken from participants.

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