# Nutritional Status, Dietary Patterns, and the Impact of Structured Lifestyle Education on Knowledge, Attitudes, and Practices Among Urban and Rural Women with Polycystic Ovary Syndrome: A Comparative Interventional Study from Uttar Pradesh, India

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***ABSTRACT***

**Background**

Polycystic Ovary Syndrome (PCOS) is among the most prevalent endocrine disorders in women of reproductive age, with significant metabolic and nutritional implications. Urban-rural disparities in nutritional status and health literacy remain poorly characterised in Uttar Pradesh (U.P.), India.

**Objectives**

To assess nutritional status, dietary patterns, and clinical profile of urban and rural PCOS women in U.P., and to evaluate the effectiveness of a structured nutritional education and lifestyle intervention on Knowledge, Attitudes, and Practices (KAP).

**Methods**

A comparative pre-post interventional study enrolled 300 women (urban n=150; rural n=150) diagnosed with PCOS. Anthropometric, biochemical, dietary, and KAP assessments were conducted before and after a structured 6-month intervention.

**Results**

Fifty percent of participants were overweight or obese (BMI ≥25 kg/m²). Critical micronutrient deficiencies were identified, particularly calcium (<40% RDA), vitamin D (<25% RDA), and dietary fiber (mean 18 g/day vs. recommended 25 g/day). The intervention produced dramatic improvements across all KAP domains (overall total KAP score: 63.85 to 97.36; p<0.001). Rural participants exhibited greater receptivity to the educational programme.

**Conclusion**

PCOS women in U.P. — both urban and rural — carry a substantial nutritional burden. Structured nutritional education is a high-impact, scalable intervention for improving health behaviours in this population, particularly in underserved rural communities.

**Keywords:** Polycystic Ovary Syndrome, Nutritional Status, Dietary Diversity, Knowledge Attitude Practice, Urban-Rural, Uttar Pradesh, India, Nutritional Intervention.

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## 1. Introduction

Polycystic Ovary Syndrome (PCOS) is the most common endocrine disorder in women of reproductive age, affecting 6–21% of women globally depending on diagnostic criteria and population studied.[1,2] Characterised by hyperandrogenism, oligo/anovulation, and polycystic ovarian morphology, PCOS extends well beyond reproductive consequences to encompass a profound metabolic syndrome, including insulin resistance, type 2 diabetes mellitus, dyslipidaemia, and cardiovascular disease risk.[3,4] In India, the estimated prevalence ranges from 9.13% to 36%, with disparities documented between urban and rural populations due to differences in lifestyle, dietary exposure, healthcare access, and health literacy.[8,9]

Nutrition plays a central, modifiable role in PCOS pathophysiology. High-carbohydrate, low-fibre diets exacerbate insulin resistance, the cardinal driver of the

PCOS metabolic cascade.[10,11] Specific micronutrient deficiencies — notably vitamin D, calcium, iron, and omega-3 fatty acids — are disproportionately prevalent in PCOS and independently compound hormonal dysregulation, menstrual dysfunction, and fertility impairment.[12,13,14] Despite this, dietary assessment data specific to Indian PCOS populations, and comparative urban-rural data in particular, remain sparse.

Evidence from structured nutritional education interventions demonstrates significant improvements in dietary quality, physical activity, and metabolic parameters in PCOS women.[25,27] Knowledge, Attitude, and Practice (KAP) frameworks offer a validated approach to measuring the translational impact of health education on behaviour change.[27] However, no study from Uttar Pradesh has comprehensively assessed nutritional status alongside KAP outcomes in a comparative urban-rural design.

The present study therefore aimed to: (i) characterise the socio-demographic, anthropometric, dietary, and biochemical profiles of urban and rural PCOS women in U.P.; (ii) identify prevalent nutritional deficiencies; and (iii) evaluate the effectiveness of a structured 6-month nutritional education and lifestyle counselling programme on KAP scores and anthropometric outcomes across both settings.

## 2. Materials and Methods

### 2.1 Study Design and Setting

A comparative, pre-post interventional study was conducted at SMMH Government Medical College, Saharanpur, Uttar Pradesh (Ref. No. 64/05/01/2024, dated 05/01/2024), India, from January 2024 to June 2025. Ethical clearance was obtained from the Institutional Ethics Committee, and written informed consent was secured from all participants prior to enrolment.

### 2.2 Participants

A total of 300 women diagnosed with PCOS were recruited: 150 from urban settings and 150 from rural settings. Diagnosis was based on the revised 2003 Rotterdam criteria (at least two of three: oligo/anovulation, clinical or biochemical hyperandrogenism, and polycystic ovarian morphology on ultrasound).[5] Inclusion criteria were: female sex, age 18–45 years, confirmed PCOS diagnosis, and willingness to participate in the full programme. Exclusion criteria included pregnancy, lactation, use of hormonal contraceptives or lipid-lowering drugs, known thyroid disease at enrolment, and other systemic endocrine disorders.

### 2.3 Assessments

Socio-demographic data were collected via structured interview-administered questionnaires. Anthropometric measurements — height, weight, waist and hip circumference — were recorded using standardised protocols.[33,34] BMI (kg/m²) was computed and classified per WHO Asian-specific cutoffs. Waist-to-Hip Ratio (WHR) and Waist-to-Height Ratio (WHtR) were calculated as validated central adiposity indices. Body fat percentage was estimated using skinfold thickness.[35]

Dietary assessment was conducted using a 24-hour dietary recall combined with a validated semi-quantitative Food Frequency Questionnaire (FFQ). Dietary Diversity Score (DDS) was computed across nine food groups per international methodology.[35] Macronutrient and micronutrient intakes were compared against Indian Council of Medical Research (ICMR) Recommended Dietary Allowances (RDA).

Biochemical assessment (n=70 sub-sample, 35 urban and 35 rural) included haemoglobin, fasting blood glucose, lipid profile (total cholesterol, LDL, HDL, triglycerides, VLDL), thyroid-stimulating hormone (TSH), free thyroxine (fT4), and reproductive hormones (LH, FSH, testosterone).

Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ v2).[23] KAP assessment was performed using a structured, validated tool covering 10 knowledge items, 10 attitude statements, and 10 practice indicators, producing maximum scores of 10, 50, and 50 respectively (total KAP score: 110).

### 2.4 Intervention

A structured 6-month nutritional education and lifestyle counselling programme was delivered to all participants. The programme included: individualised dietary counselling based on ICMR guidelines contextualised for PCOS; group education sessions on macronutrient and micronutrient requirements; guidance on meal timing, physical activity enhancement, stress management, and sleep hygiene. Urban participants received hospital-based sessions; rural participants received community health centre and home-based sessions.

### 2.5 Statistical Analysis

Data were analysed using SPSS version 26.0. Descriptive statistics are expressed as mean ± SD for continuous variables and frequencies with percentages for categorical variables. Independent samples t-test and chi-square tests were used for between-group comparisons. Paired t-test was applied for pre-post comparisons within groups. Pearson correlation coefficients assessed KAP domain inter-relationships. Cohen's d was computed as a standardised effect size. Statistical significance was set at $p<0.05$.

## 3. Results

### 3.1 Socio-Demographic Characteristics

The study recruited 300 PCOS women from U.P. with a mean age of 26.59 ± 6.20 years (range: 18–40 years). The predominant age group was 26–35 years (48.3% overall). Key socio-demographic differences between groups are presented in Table 1.

**Table 1. Socio-Demographic Characteristics of PCOS Women by Urban-Rural Setting**

| Characteristic | Urban (n=150) | Rural (n=150) | Overall (n=300) |
|---|---|---|---|
| Age – Mean ± SD (years) | 26.45 ± 6.15 | 26.73 ± 6.25 | 26.59 ± 6.20 |
| Marital Status – Married | 92 (61.3%) | 103 (68.7%) | 195 (65.0%) |
| Education – Undergraduate/PG | 80 (53.3%) | 55 (36.7%) | 135 (45.0%) |
| Occupation – Homemaker | 60 (40.0%) | 75 (50.0%) | 135 (45.0%) |
| Occupation – Professional | 45 (30.0%) | 30 (20.0%) | 75 (25.0%) |

Urban participants demonstrated significantly higher educational attainment, with 53.3% completing undergraduate or postgraduate degrees compared to 36.7% in rural areas. Homemakers were the most common occupational category overall (45%), with higher representation in rural areas (50% vs. 40% urban).

### 3.2 Anthropometric Assessment

Anthropometric measurements are summarised in Table 2. The overall mean BMI was 26.07 ± 4.49 kg/m², placing the majority in the overweight category. Exactly 50% of participants had a BMI ≥25 kg/m².[6] Rural women showed marginally higher mean BMI (26.40 vs. 25.73 kg/m²), though this difference was non-significant ($p>0.05$).

**Table 2. Anthropometric Measurements of Urban and Rural PCOS Women (Mean ± SD)**

| Parameter | Urban (n=150) | Rural (n=150) | Overall (n=300) |
|---|---|---|---|
| Height – Mean ± SD (cm) | 160.45 ± 5.92 | 159.21 ± 5.79 | 159.82 ± 5.87 |
| Weight – Mean ± SD (kg) | 66.16 ± 12.45 | 67.11 ± 13.22 | 66.64 ± 12.84 |
| BMI – Mean ± SD (kg/m²) | 25.73 ± 4.34 | 26.40 ± 4.62 | 26.07 ± 4.49 |
| Waist Circumference (cm) | 84.56 ± 11.45 | 85.89 ± 12.09 | 85.23 ± 11.78 |
| WHR – Mean ± SD | 0.84 ± 0.08 | 0.84 ± 0.08 | 0.84 ± 0.08 |
| WHtR – Mean ± SD | 0.53 ± 0.07 | 0.54 ± 0.08 | 0.53 ± 0.07 |
| Body Fat % – Mean ± SD | 31.85 ± 7.08 | 32.50 ± 7.41 | 32.18 ± 7.25 |

Mean waist circumference (85.23 ± 11.78 cm) exceeded the 80 cm threshold recommended for Asian women,[33] indicating widespread central obesity. The mean WHR of 0.84 confirmed android fat distribution. Seventy percent of participants exceeded a WHtR of 0.50, the recognised cardiometabolic risk threshold. Figure 1 illustrates BMI category distribution by setting.

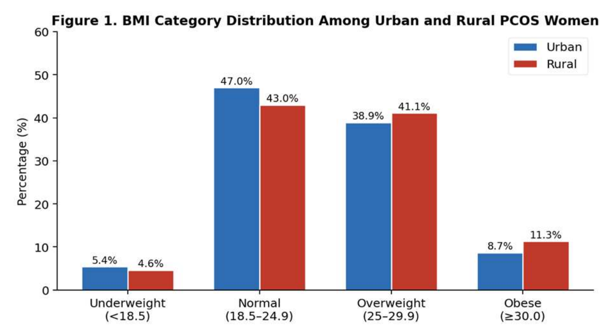


*Figure 1. BMI Category Distribution Among Urban and Rural PCOS Women*

### 3.3 Dietary Assessment

The mean Dietary Diversity Score was 4.2 ± 1.8 overall (urban: 4.5 ± 1.7; rural: 3.9 ± 1.9), below the recommended threshold of ≥5 food groups per day. Sixty percent of participants followed a vegetarian diet. Urban participants showed significantly better dietary diversity ($p=0.005$), with 52% achieving a DDS ≥5 versus 44.7% in rural areas.

#### 3.3.1 Macronutrient Intake

Significant urban-rural differences were identified across several macronutrients (Table 3). Dietary fibre intake was the most critical deficiency, with a mean of only 18 g/day against the recommended 25 g/day. Omega-3 fatty acid intake was severely inadequate in both groups (0.7 g/day overall vs. recommended >1.1 g/day). Only 14.7% of urban and 8% of rural participants met omega-3 recommendations ($p<0.001$).

**Table 3. Macronutrient Intake Assessment with Urban-Rural Comparison**

| Nutrient | Urban Mean ± SD | Rural Mean ± SD | Recommended | p-value |
|---|---|---|---|---|
| Energy (kcal/day) | 1892 ± 438 | 1798 ± 411 | 1800–2000 | 0.048* |
| Carbohydrate (g/day) | 251 ± 72 | 239 ± 64 | 225–325 | 0.125 |
| Protein (g/day) | 51 ± 16 | 45 ± 14 | 46–56 | 0.001** |
| Total Fat (g/day) | 68 ± 24 | 62 ± 20 | 44–78 | 0.019* |
| Omega-3 Fatty Acids (g/day) | 0.8 ± 0.4 | 0.6 ± 0.3 | >1.1 | <0.001** |
| Dietary Fiber (g/day) | 19 ± 8 | 17 ± 8 | 25 | 0.032* |

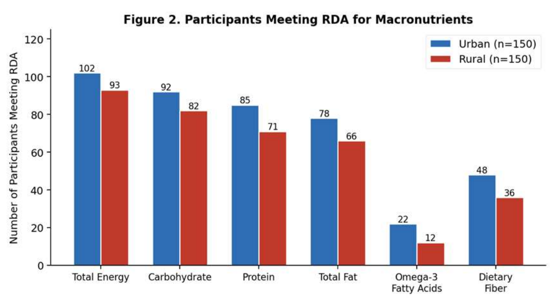


*Figure 2. Number of Participants Meeting RDA for Macronutrients*

**3.3.2 Micronutrient Intake**

Widespread and clinically significant micronutrient deficiencies were identified across both settings (Figure 3). Calcium intake averaged only 385 ± 125 mg/day — less than 40% of the 1000 mg RDA — with urban intake significantly higher (408 mg vs. 362 mg; p=0.002). Vitamin D intake was severely deficient (mean 3.2 μg/day vs. recommended 15 μg/day; <25% RDA), with only 8.0% of urban and 5.3% of rural participants meeting requirements (p<0.001). Iron intake was inadequate in 65% of participants overall. Rural women demonstrated significantly lower intake for calcium (Cohen's d=0.37), iron (d=0.50), and vitamin C (d=0.44).

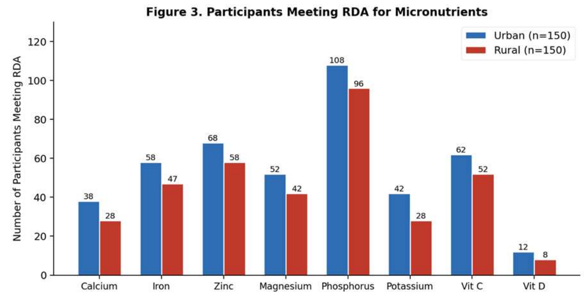


*Figure 3. Number of Participants Meeting RDA for Micronutrients*

**3.4 Clinical and Biochemical Assessment**

Clinical symptom prevalence was comparable between settings. Hirsutism (Ferriman-Gallwey score ≥8) was identified in 72% of urban and 78% of rural participants (p=0.24). Irregular menstrual cycles were reported by 58% and 62% of urban and rural women respectively (p=0.49). Severe PCOS symptom burden (>8 concurrent manifestations) was present in 38% of urban and 48.7% of rural participants.

In the biochemical subsample (n=70), rural participants showed significantly lower haemoglobin (10.8 ± 1.6 g/dL vs. 11.6 ± 1.4 g/dL; p=0.047), with 71.4% demonstrating iron deficiency indication vs. 48.6% urban (p=0.049). Endocrine dysregulation was widespread: elevated LH in 68.6%, abnormal LH:FSH ratio (>2:1) in 72.9%, and hyperandrogenemia in 35.7% of the subsample. Subclinical hypothyroidism (TSH >4.20 μIU/mL) was present in 31.4% of participants overall, with higher prevalence in rural women (37.1% vs. 25.7%).

**3.5 Physical Activity and Lifestyle**

Rural participants exhibited significantly higher physical activity levels (p<0.001), with 34.7% in the high-activity category (≥1500 MET-min/week) versus only 12.7% of urban participants. Conversely, 38.7% of urban participants fell in the low-activity category versus 19.3% rural. Irregular meal timing was prevalent in both settings (56.7% urban, 66.7% rural). Excessive screen time (>4 hours/day) was noted in 61.3% of urban and 48.7% of rural participants.

**3.6 Pre-Post Intervention KAP Outcomes**

The structured 6-month nutritional education intervention produced highly significant improvements across all three KAP domains (p<0.001 for all; Table 4). The overall total KAP score rose from 63.85 ± 8.74 to 97.36 ± 6.48 (mean improvement: +33.51; p<0.001). Knowledge scores nearly tripled (3.25 to 9.33 out of 10). Rural participants demonstrated slightly greater improvements in all domains, particularly attitude scores (rural improvement: +12.91 vs. urban: +10.66; p<0.001), reflecting higher baseline educational receptivity among the rural cohort.

**Table 4. Pre- and Post-Intervention KAP Scores (Overall and Urban-Rural, N=300)**

| Domain (Max Score) | Pre-Intervention Mean ± SD | Post-Intervention Mean ± SD | Mean Change ± SD | p-value |
|---|---|---|---|---|
| Knowledge (/10) | 3.25 ± 1.82 | 9.33 ± 1.45 | +6.08 ± 1.50 | <0.001 |
| Knowledge – Urban | 3.45 ± 1.75 | 9.42 ± 1.38 | +5.97 ± 1.48 | <0.001 |
| Knowledge – Rural | 3.05 ± 1.88 | 9.24 ± 1.52 | +6.19 ± 1.52 | <0.001 |
| Attitude (/50) | 32.15 ± 4.25 | 45.85 ± 3.78 | +13.70 ± 2.95 | <0.001 |
| Practice (/50) | 28.45 ± 5.67 | 42.18 ± 4.25 | +13.73 ± 4.18 | <0.001 |
| Total KAP (/110) | 63.85 ± 8.74 | 97.36 ± 6.48 | +33.51 ± 5.63 | <0.001 |

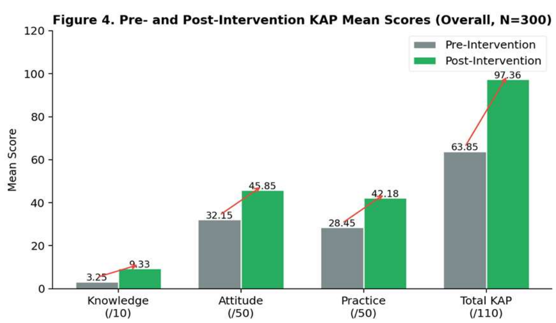


*Figure 4. Pre- and Post-Intervention KAP Mean Scores*

Post-intervention KAP inter-correlation analysis revealed the strongest relationship between post-intervention Knowledge and Practice scores (r=0.618; p<0.01), demonstrating that knowledge gain was the primary driver of behavioural change. The knowledge-practice correlation was marginally stronger in rural participants (r=0.631 vs. 0.605 urban).

Physical activity improved substantially: mean total MET-min/week increased from 485 ± 285 to 1,245 ± 385 (+760 MET-min/week; p<0.001), and the proportion meeting WHO physical activity recommendations rose from 28.3% to 81.7%. BMI category distribution shifted significantly toward the normal range following the 6-month programme (p<0.001; Figure 5).

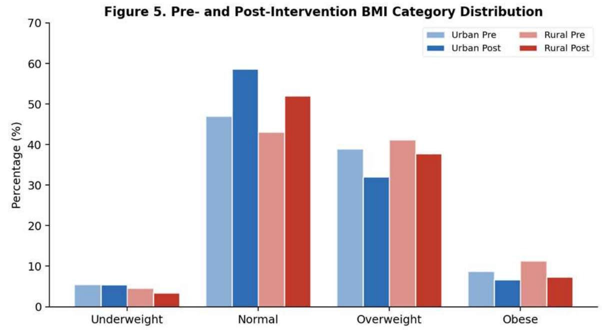


*Figure 5. Pre- and Post-Intervention BMI Category Distribution by Setting*

## 4. Discussion

This study provides a comprehensive characterisation of nutritional status and the effectiveness of structured lifestyle education in 300 PCOS women across urban and rural Uttar Pradesh (U.P.), India. The findings reveal a dual burden: widespread metabolic and nutritional inadequacies on one hand, and significant potential for improvement through structured education on the other.

The mean age of 26.59 years is consistent with the documented peak PCOS prevalence in the 20–30 year age bracket,[1] and the equal urban-rural distribution enables meaningful comparative analysis. The 50% overweight/obesity prevalence aligns with the international meta-analytic range of 38–88% documented by Lim et al.[6] and underscores the central role of obesity in amplifying insulin resistance and hyperandrogenism in PCOS.[7] The slightly higher BMI in rural women, despite their significantly greater physical activity, likely reflects poorer dietary quality rather than sedentary behaviour — an important distinction for designing targeted interventions.[10]

The mean waist circumference of 85.23 cm exceeding the 80 cm Asian-specific threshold[33] and a mean WHR of 0.84 confirming android fat distribution in both groups are clinically significant. Central obesity preferentially contributes to insulin resistance through visceral adipose tissue-mediated dysregulation of free fatty acids and adipokines, directly worsening the PCOS metabolic axis.[7,18] The finding that 70% of participants exceeded a WHtR of 0.50 — a predictor of cardiometabolic risk more sensitive than BMI[33] — suggests that conventional BMI-based screening underestimates the true metabolic risk burden in this population.

The macronutrient profile — high refined carbohydrate, inadequate fibre, and severely deficient omega-3 intake — is characteristic of diets that worsen insulin resistance in PCOS.[10,11] The dietary fibre deficit (mean 18 g/day vs. recommended 25 g/day) is particularly concerning given robust evidence from Kazemi et al.[11] that fibre supplementation significantly improves glycaemic control, hormonal profiles, and inflammatory markers in PCOS women. The stronger inverse correlation between fibre intake and BMI in rural participants ($r=-0.222$) suggests that fibre-focused dietary counselling may yield particularly high returns in rural settings.

The omega-3 deficiency (0.7 g/day overall vs. >1.1 g/day recommended) has direct relevance for the chronic low-grade inflammation characteristic of PCOS. Randomised evidence from Mohammadi et al.[14] and Cussons et al.[30] demonstrates that omega-3 supplementation reduces serum triglycerides, VLDL, and inflammatory markers, and may improve menstrual regularity in PCOS. The primarily vegetarian dietary pattern of our cohort (60%) and the near-absence of oily fish consumption largely explains this deficit.

The micronutrient deficiencies identified represent a severe public health concern. Calcium intake below 40% of the RDA, combined with inadequate vitamin D (less than 25% RDA), has compounded implications: beyond skeletal health, both nutrients play roles in insulin secretion, ovarian folliculogenesis, and sex hormone synthesis.[12,13] Thomson et al.[12] documented vitamin D insufficiency in 67–85% of PCOS women, with deficiency correlating with insulin resistance, hyperandrogenism, and menstrual irregularity — all of which were highly prevalent in our cohort. The consistently lower micronutrient intakes in rural women likely reflect limited access to diverse food sources, lower purchasing power, and greater dietary monotony,[9] as evidenced by their significantly lower Dietary Diversity Scores (3.9 vs. 4.5 urban; $p=0.005$).

Despite rural women's nutritional disadvantages, two findings challenge simplistic urban-versus-rural framing. First, rural women showed significantly higher physical activity (34.7% high-activity vs. 12.7% urban; $p<0.001$), which likely provides partial metabolic protection. Second, and most notably, rural participants demonstrated greater receptivity to the educational intervention across all KAP domains — particularly attitude (improvement +12.91 vs. +10.66; $p<0.001$). This may reflect lower baseline health literacy creating larger margins for improvement,[27] stronger community engagement when contextually appropriate materials are delivered, and the motivational effect of receiving targeted health information. This finding resonates with Nguyen et al.[27] who reported that communities with lower baseline health literacy benefited most from structured nutrition education programmes.

The dramatic improvement in total KAP scores from 63.85 to 97.36 ($p<0.001$), with near-universal post-intervention knowledge (93–100% across all items), demonstrates that structured 6-month education is not merely incrementally effective but transformatively so. The strong post-intervention Knowledge-Practice correlation ($r=0.618$; $p<0.01$) confirms knowledge acquisition as the key driver of behavioural change — a critical finding for designing cost-effective community health programmes in resource-constrained settings.[22,27] The significant increase in physical activity (28.3% to 81.7% meeting WHO recommendations) and the favourable BMI shift ($p<0.001$) further validate the holistic impact of the intervention.

The biochemical findings — subclinical hypothyroidism in 31.4% and reproductive hormone dysregulation (elevated LH:FSH in 72.9%) — underscore the need for comprehensive clinical screening in PCOS, rather than limiting assessment to ovarian morphology alone.[22] The higher thyroid abnormality prevalence in rural women (37.1% vs. 25.7%) may reflect diagnostic gaps rather than true differences in disease burden,[31] and argues for integration of thyroid screening into rural PCOS management protocols.

## 5. Conclusion

This study demonstrates that PCOS women in Uttar Pradesh (U.P.) — both urban and rural — carry a substantial nutritional burden characterised by widespread deficiencies in calcium, vitamin D, dietary fibre, iron, and omega-3 fatty acids, superimposed on a high prevalence of overweight, central obesity, and cardiometabolic risk. While urban-rural disparities in dietary diversity, micronutrient intake, and diagnostic access are evident, the metabolic and clinical burden of PCOS itself transcends geographical boundaries.

Critically, a structured 6-month nutritional education and lifestyle counselling programme produced highly significant, near-universal improvements in knowledge, attitudes, and health practices across both settings (total KAP improvement: +33.51 points; $p<0.001$), with rural participants demonstrating greater attitudinal receptivity. Knowledge gain was the strongest predictor of positive behaviour change ($r=0.618$). These findings establish structured nutritional education as a scalable, high-impact, and low-cost public health intervention for PCOS management in U.P. and across India. Future studies should evaluate sustained long-term outcomes, the role of community health workers in programme delivery, and the integration of targeted micronutrient supplementation protocols alongside educational components.

**Conflicts of Interest**

The authors declare no conflict of interest.

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