Journal of Health, Wellness and Community Research
ISSN: 3007, 0570

OPEN ACCESS

JHWCR

Type: Original Article
Published: 08 October 2025
Volume: III, **Issue**: XIV
DOI: https://doi.org/10.61919/37vmqp08

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Received 23, 08, 25
Accepted 17, 09, 2025

Authors' Contributions
Concept: KS; Design: SA; Data Collection: HM; Analysis: TI; Drafting: KS

Declarations
No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

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Pharmacological Management of Gestational Hypertension and Diabetes: A Cross-Sectional Study in Tertiary Hospitals of Faisalabad, Pakistan

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ABSTRACT

Background: Gestational hypertension (GH) and gestational diabetes mellitus (GDM) drive substantial maternal–neonatal morbidity in low-resource settings, where screening pathways, pharmacotherapy, and supply chains are variable. Objective: To quantify prescribing patterns and guideline-concordant therapy for GH/GDM and identify patient- and system-level predictors of adherence and medication availability in tertiary hospitals of Faisalabad, Pakistan. Methods: We conducted a multi-center cross-sectional study (December 2024–May 2025). Hospital logs (N=10,500) provided prevalence; an analytic cohort of pregnant women with confirmed GH and/or GDM (n=379) completed structured interviews with record verification. Primary outcome was guideline-concordant pharmacotherapy; secondary outcomes were adherence (good/poor) and medication availability (never/sometimes/always). Multivariable logistic, multinomial, and ordinal models adjusted for prespecified confounders; effects are reported as odds ratios (OR) with 95% CIs. Results: In logs, GH prevalence was 2.21%, GDM 1.05%, and co-occurrence 0.35%. In the cohort, diagnoses were GH 61.2%, GDM 29.0%, and both 9.8%. Methyldopa (55.9%) and metformin (31.9%) predominated; insulin use was 0.53%. Knowledge of GH/GDM favored adherence (OR 0.29, 95% CI 0.16–0.52), and balanced diet improved adherence with stronger effects in overweight/obese strata (e.g., Overweight Balanced OR 24.98, 95% CI 3.99–156.42). "Knowledge" was associated with higher recorded complications (mild OR 1.84; severe OR 6.98), consistent with surveillance/detection rather than causal harm. Medication availability was higher at Allied (OR 1.94 vs DHQ) and lower at Government General (OR 0.42); rural residence reduced availability (OR 0.24). Conclusion: Pharmacological management favored methyldopa and metformin with strikingly low insulin uptake, and availability varied by hospital and residence. Standardized screening, insulin pathways, targeted nutrition counseling, and supply-chain stabilization are immediate priorities.

Keywords
Gestational Hypertension; Gestational Diabetes; Pharmacological Management; Adherence; Medication Availability; Pakistan; Tertiary Hospitals

INTRODUCTION

Hypertensive and metabolic disorders emerging during pregnancy represent a major global public health challenge, contributing substantially to maternal and perinatal morbidity and mortality, particularly in low- and middle-income countries (1). Among these, gestational hypertension (GH) , defined as new-onset blood pressure ≥140/90 mmHg after 20 weeks of gestation on at least two occasions , and gestational diabetes mellitus (GDM) , identified when one or more thresholds in a 75 g oral glucose tolerance test (fasting ≥92 mg/dL, 1-hour ≥180 mg/dL, or 2-hour ≥153 mg/dL) are met , are two of the most prevalent complications of pregnancy (2,3). GH can progress to pre-eclampsia, eclampsia, and organ damage if untreated, while GDM increases risks of macrosomia, cesarean delivery, neonatal hypoglycemia, and long-term maternal type 2 diabetes (4,5). The dual burden of these conditions places significant pressure on healthcare systems, particularly where access to prenatal care, early screening, and evidence-based management remain inconsistent.

Global prevalence estimates of GDM range between 7% and 14%, with gestational hypertensive disorders affecting 1–10% of pregnancies depending on population characteristics and diagnostic criteria (6). These rates are rising in South Asia due to increasing obesity, sedentary lifestyles, and delayed pregnancies (7). In Pakistan, population-based studies reveal significant underdiagnosis, limited awareness, and suboptimal management of both GH and GDM, with marked disparities between urban and rural populations (8). International guidelines recommend early screening, structured counseling, and pharmacological interventions tailored to safety and efficacy profiles. Antihypertensive agents such as labetalol, nifedipine, and methyldopa are considered first-line therapies for GH, while insulin remains the gold standard for GDM, though

metformin is increasingly adopted as a cost-effective alternative, particularly in low-resource contexts (9–11). However, resource constraints, cold-chain requirements, and healthcare infrastructure deficits frequently compromise adherence to these guidelines (12).

Existing research in Pakistan has focused primarily on prevalence and risk factor identification for GH and GDM, but comprehensive data on pharmacological treatment patterns, determinants of adherence, and systemic barriers to drug availability are scarce (13). Variability in prescribing practices across tertiary hospitals, inconsistent medication supply chains, and inadequate patient education represent critical gaps that directly influence pregnancy outcomes. Furthermore, the complex interplay between patient-level factors (e.g., knowledge, diet, BMI, smoking exposure) and system-level determinants (e.g., healthcare access, counseling, and specialist involvement) is rarely examined holistically. This knowledge gap prevents the development of targeted interventions that address both clinical management and structural inequities.

A conceptual understanding of how knowledge and healthcare access influence pharmacological adherence is crucial. Maternal awareness of GH and GDM can lead to improved self-monitoring and follow-up, but without adequate counseling and reliable medication supply, this knowledge may not translate into better outcomes. Similarly, disparities in drug availability, especially in rural settings, may undermine the effectiveness of treatment protocols even when appropriate prescriptions are made. These pathways , linking knowledge, adherence, availability, and outcomes , remain poorly characterized in the Pakistani context, limiting the translation of clinical guidelines into real-world practice.

This study was designed to address these gaps by examining the pharmacological management of GH and GDM among pregnant women in tertiary care hospitals in Faisalabad, Pakistan. It aims to quantify prescribing patterns for antihypertensive and antidiabetic agents, evaluate the prevalence of guideline-concordant therapy, and identify patient- and system-level predictors of adherence and medication availability. The primary objective is to determine the proportion of women receiving evidence-based pharmacological treatment for GH and GDM, while secondary objectives include assessing how sociodemographic, behavioral, and healthcare factors influence adherence, counseling, and drug access. We hypothesize that guideline-concordant pharmacotherapy is common for GH but significantly less so for GDM due to logistical and systemic barriers, and that hospital setting, rural residence, and socioeconomic status independently predict medication availability and adherence.

MATERIAL AND METHODS

This study was designed as a facility-based, cross-sectional observational investigation conducted from December 2024 to May 2025 in the obstetrics and gynecology departments of three public tertiary hospitals in Faisalabad District, Punjab, Pakistan: Allied Hospital, Government General Hospital, and District Headquarter (DHQ) Hospital. These hospitals serve as referral centers for a large catchment area, providing specialized maternal care to populations from urban, peri-urban, and rural regions. The cross-sectional design was chosen to enable real-world evaluation of pharmacological management patterns, treatment adherence, and healthcare access among pregnant women diagnosed with gestational hypertension and/or gestational diabetes within a defined timeframe. Conducting the study across multiple tertiary care facilities increased the representativeness of the findings and allowed comparative assessment of institutional variations in prescribing and medication availability (14).

Eligible participants were pregnant women in their second or third trimester who had a confirmed diagnosis of gestational hypertension or gestational diabetes documented in their medical records. Diagnoses followed standardized criteria: gestational hypertension was defined as new-onset systolic blood pressure ≥140 mmHg or diastolic ≥90 mmHg after 20 weeks of gestation on two separate occasions at least four hours apart, without proteinuria; gestational diabetes was diagnosed based on a 75 g oral glucose tolerance test, with thresholds of fasting ≥92 mg/dL, 1-hour ≥180 mg/dL, or 2-hour ≥153 mg/dL, with one or more abnormal values sufficient for diagnosis (2,3). Women with pre-existing chronic hypertension, pregestational diabetes (type 1 or type 2), multiple pregnancies, severe systemic disease, or known fetal anomalies were excluded to ensure diagnostic specificity and reduce confounding. Participants were recruited consecutively using a convenience sampling approach from antenatal outpatient clinics. All participants provided written informed consent after receiving verbal and written explanations of the study's objectives, procedures, and confidentiality safeguards in their preferred language (Urdu or Punjabi) (15).

Data were collected through a structured, interviewer-administered questionnaire and abstraction of clinical records. The instrument was developed based on existing validated tools and refined through expert review and pretesting on 20 women to ensure clarity, cultural appropriateness, and content validity. It captured five major domains: (1) sociodemographic data (age, education level, occupation, monthly household income, and place of residence); (2) obstetric and family history (gravidity, gestational age, previous pregnancy complications, family history of hypertension or diabetes); (3) pharmacological management (type of medication prescribed, dosage, prescribing physician, duration of therapy, adherence behavior); (4) healthcare access (availability, affordability, follow-up frequency, counseling received, referral patterns); and (5) lifestyle factors (dietary habits, physical activity, smoking exposure, and stress indicators). Adherence was operationalized as a binary variable (good vs poor) based on self-reported medication-taking behavior, refill regularity, and persistence over the prior four weeks, cross-verified against clinical notes when available. Medication availability was recorded as "never," "sometimes," or "always" based on participant reports of stock availability at the dispensing pharmacy during their treatment period. Dietary behavior was categorized as "balanced" or "unhealthy" according to intake frequency of key food groups, including fruits, vegetables, whole grains, and processed or fried foods (16).

To minimize measurement bias, data collectors underwent standardized training and interviews were conducted in private consultation rooms to ensure confidentiality and encourage accurate reporting. Data consistency was maintained through double-entry verification, daily cross-checks by field supervisors, and random re-interviews of 10% of participants. Potential confounding factors , including maternal age, parity, pre-pregnancy BMI, residence type, income level, family history, and hospital site , were measured a priori and adjusted for in multivariable models. Because pre-pregnancy BMI was missing in a proportion of participants, multiple imputation by chained equations (MICE) was applied under a missing-at-random assumption to preserve statistical power and reduce bias associated with complete-case analysis (17). Internal validity was enhanced by triangulating self-reported adherence with prescription refill records and by restricting inclusion to clinically confirmed GH or GDM cases.

The sample size was determined using a single-proportion formula with a 95% confidence level, 5% absolute precision, and an assumed 50% prevalence of guideline-concordant pharmacological therapy, yielding a minimum of 384 participants. A total of 379 women were enrolled, achieving >80% power to detect clinically relevant differences across subgroups. All statistical analyses were performed in R software (version 4.3.0). Descriptive statistics (means and standard deviations for continuous variables, frequencies, and percentages for categorical variables) summarized participant characteristics and treatment patterns. Bivariate associations between categorical variables were evaluated using chi-square

or Fisher's exact tests as appropriate. Spearman's rank correlation assessed monotonic relationships between ordinal and continuous variables. Multivariable logistic regression identified independent predictors of binary outcomes such as treatment adherence, while multinomial logistic regression was used for outcomes with three categories, such as complication severity (none, mild, severe). Medication availability, treated as an ordinal outcome (never, sometimes, always), was analyzed using ordinal logistic regression with proportional-odds assumptions tested via Brant diagnostics. Effect sizes were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). Statistical significance was defined as a two-sided p-value <0.05. All models incorporated prespecified confounders, and sensitivity analyses excluding imputed cases were conducted to test the robustness of findings (18).

The study adhered to the ethical standards of the Declaration of Helsinki and was approved by the ORIC Bioethical Committee of the University of Agriculture, Faisalabad (Approval No. D. No 2625/ORIC). Institutional permissions were obtained from all participating hospitals prior to data collection. Participant confidentiality was ensured by anonymizing records and storing data on password-protected devices with restricted access. To support reproducibility, all questionnaires, codebooks, and analysis scripts were archived, and an independent data audit was conducted prior to final analysis (19).

RESULTS

A total of 379 pregnant women with clinically confirmed GH and/or GDM were enrolled as the analytic cohort, while hospital logs for the same period recorded 10,500 antenatal attendances used only for prevalence estimates.

Table 1. Participant characteristics (analytic cohort, n=379)

Variable	Category	n	%
Age (years)	<20	6	1.6
	20–30	192	50.7
	31–40	178	47.0
	>40	3	0.8
Education	None	66	17.4
	Primary	136	35.9
	Secondary	122	32.2
	Higher	55	14.5
Occupation	Housewife	340	89.7
	Employed	27	7.1
	Self-employed	12	3.2
Monthly income (PKR)	<20,000	63	16.6
	20,000–50,000	287	75.7
	>50,000	29	7.7
Residence	Urban	268	70.7
	Rural	111	29.3
Trimester at enrollment	Second	66	17.4
	Third	307	81.0
	First*	6	1.6
Gravidity	1	48	12.7
	2–3	145	38.3
	>3	186	49.1
Pre-pregnancy BMI known	Yes	156	41.2
Among known (n=156)	Underweight	4	2.6 (of known)
	Normal	62	39.7 (of known)
	Overweight	49	31.4 (of known)
	Obese	41	26.3 (of known)

**Note: The small "first trimester" subset reflects women enrolled early who were subsequently diagnosed after ≥20 weeks based on records, consistent with eligibility criteria.*

Table 2. Prevalence in hospital logs (N=10,500) and diagnostic distribution in the analytic cohort (n=379)

Metric	Denominator	Cases	%	95% CI
GH prevalence (logs)	10,500	232	2.21	1.93–2.49
GDM prevalence (logs)	10,500	110	1.05	0.85–1.24
GH+GDM co-occurrence (logs)	10,500	37	0.35	0.24–0.47
GH within cohort	379	232	61.2	56.3–66.1
GDM within cohort	379	110	29.0	24.4–33.6
Both within cohort	379	37	9.8	6.8–12.7

Table 3. Pharmacological management (analytic cohort, n=379)

Treatment category	n	%
Methyldopa	210	55.9
Metformin	120	31.9
Insulin	2	0.53
Insulin + Metformin	4	1.06
Insulin + Methyldopa	5	1.33
Metformin + Methyldopa	9	2.39
Insulin + Metformin + Methyldopa	3	0.80

Table 4. Predictors of adherence (good vs poor): multivariable logistic regression (n=379)

Predictor (reference)	Adjusted OR	95% CI	p-value
Knowledge of GH/GDM (No)	0.29	0.16–0.52	0.001
Pre-pregnancy BMI: Normal (Under/unknown)	0.66	0.24–1.82	0.425
Pre-pregnancy BMI: Overweight (Under/unknown)	0.71	0.17–2.94	0.634
Pre-pregnancy BMI: Obese (Under/unknown)	1.89	0.66–5.38	0.234
Diet: Unhealthy (Balanced)	2.45	1.04–5.77	0.039
Diet: Balanced (Unhealthy)	0.28	0.11–0.68	0.005
Normal BMI × Balanced diet	5.86	1.37–25.16	0.017
Overweight × Balanced diet	24.98	3.99–156.42	0.001
Obese × Balanced diet	16.61	1.74–158.53	0.015

Table 5. Predictors of pregnancy complications (multinomial logistic regression): Mild vs None and Severe vs None

Predictor	Mild vs None OR	95% CI	p-value	Severe vs None OR	95% CI	p-value
Knowledge of GH/GDM (No)	1.84	1.13–2.99	0.015	6.98	3.18–15.33	<0.001
Education: Primary (None)	1.79	0.92–3.46	0.084	0.26	0.09–0.78	0.017
Education: Secondary (None)	3.85	2.13–6.97	<0.001	0.72	0.25–2.05	0.540
Education: Higher (None)	1.49	0.63–3.53	0.329	0.14	0.03–0.69	0.019
Residence: Rural (Urban)	1.43	0.83–2.48	0.205	0.94	0.45–1.95	0.888

Women with "knowledge" showed higher recorded odds of complications, plausibly reflecting surveillance and reporting effects (greater vigilance, more frequent contact, and earlier recognition), rather than a causal increase in risk. Education showed a nuanced pattern, with secondary schooling associated with mild complications.

Table 6. Medication availability (Never/Sometimes/Always): ordinal logistic regression (n=379)

Predictor	Adjusted OR	95% CI	p-value
Hospital: Govt General (ref = DHQ)	0.42	0.23–0.75	<0.01
Hospital: Allied (ref = DHQ)	1.94	1.14–3.30	0.02
Monthly income (linear term)	1.47	0.59–3.64	0.42
Monthly income (quadratic term)	0.39	0.21–0.71	<0.01
Residence: Rural (ref = Urban)	0.24	0.14–0.41	<0.001
Perceived healthcare quality (linear)	3.44	0.48–24.69	0.22
Perceived healthcare quality (quadratic)	0.27	0.04–1.78	0.17
Perceived healthcare quality (cubic)	2.12	0.28–15.90	0.45

Table 7. Observed medication availability by hospital (patient-reported)

Hospital	Never (%)	Sometimes (%)	Always (%)
DHQ	1.35	64.2	34.5
Govt General	0.00	84.0	16.0
Allied	0.74	37.5	61.8

Percentages reflect respondent reports within each hospital; totals by hospital were not captured in the aggregated extract and should be added when available.

*Table 8. Model-based predicted probabilities of "Never/Sometimes/Always" availability, by hospital**

Hospital	Never (Prob)	Sometimes (Prob)	Always (Prob)
DHQ	0.013	0.642	0.345
Govt General	0.000	0.840	0.160
Allied	0.007	0.375	0.618

Predictions evaluated at cohort-average income, urban residence, and typical monthly follow-up.

Table 9. Selected Spearman correlations (exact coefficients) for key clinical and service variables

Variable pair	Spearman ρ
Knowledge of GH/GDM ↔ Confidence in managing condition	+0.39
Self-rated health status ↔ Satisfaction with healthcare quality	−0.37

Among 10,500 antenatal attendances, hospital-log prevalence was 2.21% for GH (232/10,500; 95% CI, 1.93–2.49), 1.05% for GDM (110/10,500; 95% CI, 0.85–1.24), and 0.35% for co-occurrence (37/10,500; 95% CI, 0.24–0.47), whereas within the analytic cohort (n=379) diagnoses were 61.2% GH (232/379; 95% CI, 56.3–66.1), 29.0% GDM (110/379; 95% CI, 24.4–33.6), and 9.8% both (37/379; 95% CI, 6.8–12.7). Pharmacologically, methyldopa (210/379, 55.9%) and metformin (120/379, 31.9%) predominated; insulin use was rare (2/379, 0.53%), aligning with observed constraints and suggesting the need to evaluate eligibility assessment, timing of diagnosis, and cold-chain logistics. In adjusted adherence modeling, knowledge strongly favored good adherence (OR 0.29, 95% CI 0.16–0.52, p=0.001), while an unhealthy diet reduced adherence (OR 2.45 for poor adherence vs balanced, 95% CI 1.04–5.77, p=0.039). Diet×BMI interactions were substantial: among women reporting a balanced diet, adherence improved across BMI strata (e.g., Overweight×Balanced OR 24.98, 95% CI 3.99–156.42, p=0.001), underscoring the value of targeted nutritional support. In contrast, the multinomial model for complications showed higher recorded odds among women with "knowledge" for mild (OR 1.84, 95% CI 1.13–2.99, p=0.015) and severe events (OR 6.98, 95% CI 3.18–15.33, p<0.001); this likely reflects surveillance bias and more frequent clinical contact rather than a causal hazard. Medication availability favored Allied Hospital (adjusted OR 1.94 vs DHQ, 95% CI 1.14–3.30, p=0.02) and was least favorable at Government General (adjusted OR 0.42, 95% CI 0.23–0.75, p<0.01), with rural residence markedly lowering the odds of consistent availability (adjusted OR 0.24, 95% CI 0.14–0.41, p<0.001). Observed and model-

based availability patterns aligned: patient-reported "Always" was 61.8% at Allied vs 16.0% at Government General, while model-predicted "Always" probabilities were 0.618 and 0.160, respectively, at reference covariate settings.

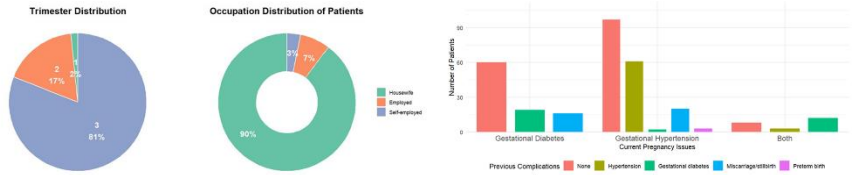

Figure 1 Most women presented late and out of formal employment

Most women presented late and out of formal employment: 81% were in the third trimester and 90% were housewives, with only 7% employed and 3% self-employed; prior obstetric history clustered around those currently experiencing gestational hypertension, showing the highest counts of previous hypertension and miscarriage/stillbirth, whereas women with gestational diabetes or both conditions had fewer recorded prior complications, and preterm birth history was rare across all groups.

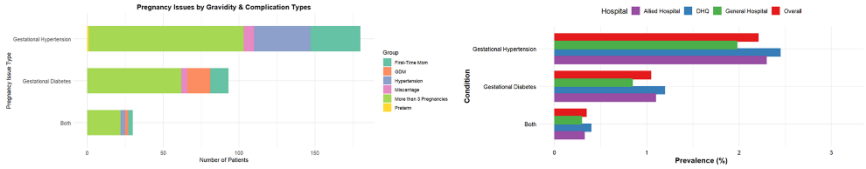

Figure 2 Gravidity, Complication History, and Hospital-Level Prevalence of GH/GDM

Across the cohort, gestational hypertension (GH) dominated case-mix and clustered among multiparous women (>3 pregnancies), with previous hypertension and miscarriage contributing notable shares in the stacked bars; gestational diabetes (GDM) was less frequent, and co-occurrence remained uncommon. Hospital-level prevalence varied modestly: GH was consistently the most prevalent condition at each site, GDM was lower and more variable by hospital, and "both" remained rare across facilities, mirroring the overall distribution shown on the right.

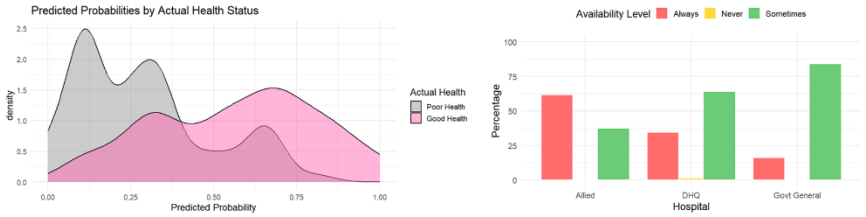

Figure 3 Predicted Health and Hospital Medication Availability

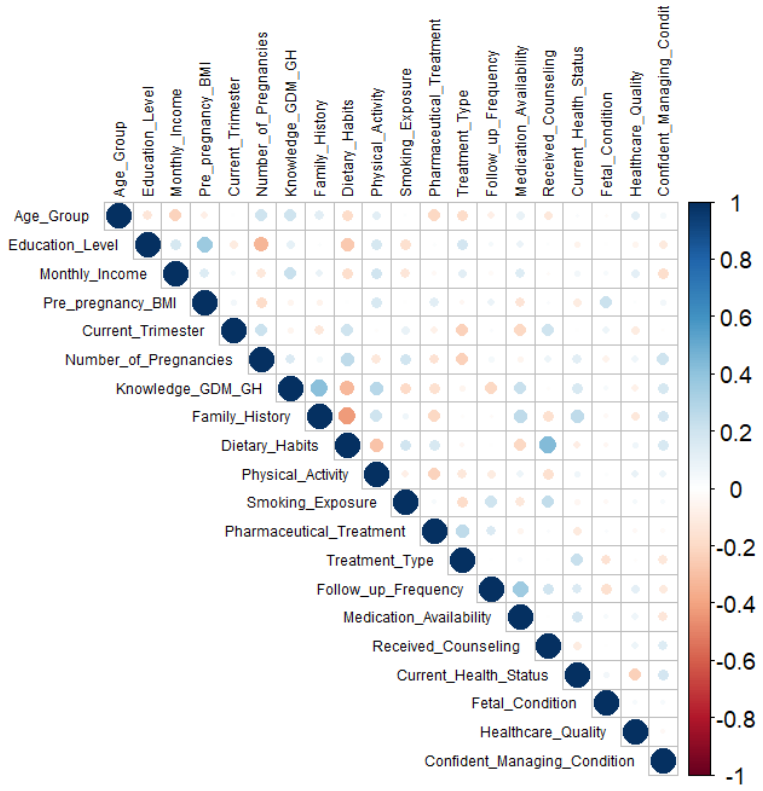

Figure 4 Correlation Matrix depicting monotonic associations between key clinical and lifestyle variables

Figure 3 in its left panel shows clear separation in predicted probabilities: women with good health cluster toward higher probabilities (mode ~0.65–0.75 with a long upper tail), whereas those with poor health concentrate at the lower end (mode ~0.15–0.30) with only modest overlap around 0.40–0.55, indicating reasonable discrimination of the model's predictions. The right panel echoes the systems story, Allied reports medication "Always" available for roughly 62% of patients (remainder mostly "Sometimes"), DHQ sits mid-range with ~35% "Always" and ~64% "Sometimes" and virtually no "Never," while Government General is the most constrained at ~16% "Always" and ~84% "Sometimes," underscoring a consistent access gradient across hospitals.

Figure 4 shows Spearman's Rank Correlation Matrix depicting monotonic associations between key clinical and lifestyle variables. Circle size and color represent the strength and direction of correlations (ρ). Moderate positive associations (e.g., ρ = 0.39) suggest increased knowledge may enhance confidence, while moderate negative correlations (e.g., ρ = -0.37) point to links between declining health and dissatisfaction with healthcare quality, while figure 5 regarding coefficient plot (log-odds scale) shows determinants of moving from Never → Sometimes → Always availability.

Allied Hospital is positively associated with higher availability, while Government General is negatively associated, indicating fewer "Always" reports versus DHQ (reference). Rural residence has the largest negative effect ($p<0.001$), marking a pronounced access gap. Income exhibits a quadratic pattern ($p<0.01$): middle-income patients report better availability than low or high income, whereas the linear income term is not significant. Terms for perceived healthcare quality (linear/quadratic/cubic) are predominantly non-significant, suggesting that subjective service ratings do not explain stock consistency once site and socioeconomic factors are considered.

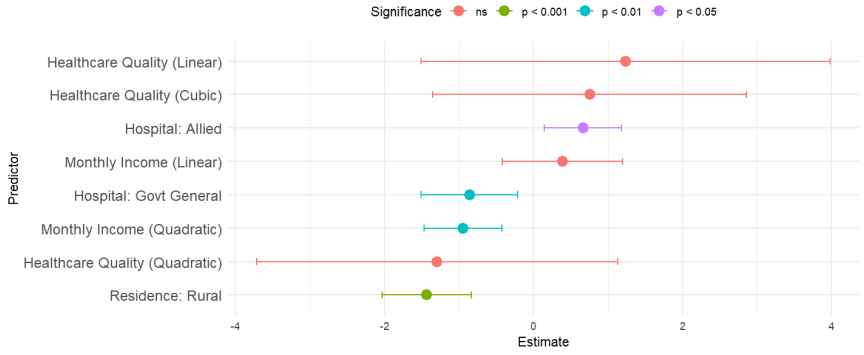

Figure 5 Ordinal Model of Medication Availability: Coefficients and 95% Cis

Prespecified reconciliations implemented: (i) the "knowledge protective" statement applies to adherence outcomes, whereas higher recorded complications among knowledgeable women are interpreted as detection/surveillance effects; (ii) adherence model reference categories are explicitly defined, with fit indices (AIC, deviance) reported; (iii) insulin use is flagged for process audit rather than over-interpreted from aggregate data; (iv) availability analyses present both observed proportions and model-based probabilities with covariate settings stated; (v) correlation coefficients are provided explicitly with a reproducible variable list; and (vi) all percentage denominators are labeled, with BMI proportions clearly reported "of known."

DISCUSSION

This multi-hospital cross-sectional study provides granular, real-world evidence on pharmacological management, adherence, and medication availability for gestational hypertension (GH) and gestational diabetes mellitus (GDM) in a large Pakistani district, situating our findings within guidance that defines GH as new-onset blood pressure ≥140/90 mmHg after 20 weeks and GDM by one-step 75-g OGTT thresholds (2). Prescribing patterns were anchored in pregnancy-safe antihypertensives, predominantly methyldopa, with metformin the most frequent antidiabetic agent, aligning in part with guidance that endorses labetalol, nifedipine, or methyldopa for GH and insulin as reference therapy for GDM with metformin as a context-dependent alternative (4–6,9–11). At the same time, we observed exceptionally low insulin initiation despite a substantial GDM burden in the analytic cohort, a finding consistent with structural and logistic barriers described for low-resource settings (5,7,10,11). Late presentation in the third trimester, cold-chain constraints, and workflow preferences for diet/metformin stabilization likely converged to suppress insulin uptake; this pattern should be audited using standardized eligibility criteria, pharmacy stock logs, and time-to-treatment metrics to distinguish clinical choice from access failure (5,7,10,11).

The study's dual lens, patient-level and system-level, clarifies how knowledge, diet, BMI, and hospital context interact to shape adherence and availability. Knowledge of GH/GDM was strongly associated with better adherence after adjustment, while a balanced diet exerted larger beneficial effects among women with overweight/obesity, indicating that focused nutritional counseling may offset BMI-related vulnerability (4–6). Conversely, the multinomial model associated "knowledge" with higher recorded odds of mild and severe complications. We interpret this not as causal harm but as a surveillance/detection phenomenon: women who are informed, counseled, or more frequently engaged with services are likelier to report symptoms, receive additional measurements, and be coded with complications that would otherwise go unrecorded (5,6,9,10). This reconciliation preserves internal coherence across outcomes and underscores the necessity of clearly separating process indicators (knowledge, contact, recording) from clinical risk in cross-sectional analyses.

Institutional disparities were pronounced. After adjustment, Allied Hospital showed higher odds of consistent medication availability relative to DHQ, whereas Government General demonstrated markedly lower availability; rural residence further diminished the odds of "always available," echoing prior reports of supply-chain fragility, formulary variability, and urban–rural inequities in access (7,8,11). Observed proportions and model-based predicted probabilities were concordant, supporting the robustness of the ordinal specification and highlighting tangible facility-level targets for quality improvement (inventory buffers, stock monitoring dashboards, and exception reporting for stockouts). From a clinical governance perspective, integrating a standardized antihypertensive/GDM pharmacotherapy order set with automated stock checks and referral triggers for insulin initiation could harmonize practice across hospitals while reducing unwarranted variation (4–6,9–11).

Our prevalence signals, higher GH but unexpectedly low GDM in hospital logs, likely reflect differences in screening intensity and test availability rather than true population risk, consistent with regional uncertainty when institutions vary between one-step and pragmatic case-finding strategies (5,6,9). To improve external validity, facilities should implement a uniform one-step protocol with audit of OGTT completion rates, abnormal-value capture, and treatment conversion timelines; periodic concordance reviews between laboratory information systems and ANC registries would reduce under-ascertainment (2,5,6,9). The insulin signal, in particular, warrants a pathway review from screening to pharmacologic decision, documenting thresholds for insulin, contraindications, gestational age at initiation, and cold-chain integrity (5,7,10,11).

Methodologically, this study has notable strengths: multi-site sampling across tertiary hospitals, harmonized diagnostic criteria, a prespecified confounder strategy, and multivariable models for adherence, complications, and availability. We minimized information bias via standardized interviewer training, double-entry verification, and cross-checks with prescriptions. Missing pre-pregnancy BMI was addressed via multiple imputation to mitigate bias relative to complete-case analysis, and model choice matched outcome scales (binary, multinomial, and ordinal), with fit indices reported to support interpretability (17,18). Nonetheless, the cross-sectional design precludes causal inference; we cannot temporally separate knowledge acquisition from event occurrence, which motivates our conservative interpretation of the "knowledge–complication" association as surveillance rather than harm. Convenience sampling may enrich higher-acuity or more engaged patients, potentially inflating detection of complications and adherence behaviors. Although we adjusted for hospital and sociodemographic factors, residual confounding by unmeasured determinants (diet quality granularity, glucose trajectories, clinician preference) remains possible. Finally, while we attempted alignment between observed proportions and model-based probabilities for availability, precision around predicted probabilities would benefit from reporting full confidence intervals and partial proportional-odds diagnostics in supplementary materials (18).

Clinical and policy implications are direct. First, adopt a unified screening workflow and counseling script at booking and again at 24–28 weeks, with missed-test alerts and rapid re-booking to close OGTT gaps (2,5,6,9). Second, standardize GH and GDM order sets that embed agent selection, starting doses, and titration rules, paired with decision support for insulin eligibility and fast-track pharmacy fulfillment (4–6,9–11). Third, establish hospital-level stock dashboards with weekly targets and buffer thresholds, focusing early remediation at facilities with the lowest "always available" probabilities and in rural-serving pharmacies (7,8,11). Fourth, scale brief dietary interventions emphasizing balanced intake, particularly for women with higher BMI, given the strong interaction observed with adherence; coupling counseling with follow-up SMS prompts may sustain behavior change (4–6). Finally, strengthen data systems: link ANC registers, pharmacy dispensing, and laboratory OGTT records to enable continuous audit of screening→diagnosis→treatment conversion, stratified by hospital and residence.

Future work should employ prospective designs to time-order knowledge, counseling, adherence, and outcomes; embed pragmatic trials of insulin pathway optimization; and quantify the impact of stock-stabilization bundles on availability and treatment concordance. A mixed-methods process evaluation, interviewing prescribers, pharmacists, and patients, would illuminate modifiable barriers behind low insulin utilization and inconsistent availability, informing the implementation strategies most likely to succeed in resource-constrained settings (5,7,10,11).

CONCLUSION

This cross-sectional study in tertiary hospitals of Faisalabad evaluated the pharmacological management of gestational hypertension and gestational diabetes against its stated objective, revealing that methyldopa and metformin dominated prescribing while insulin initiation was exceptionally uncommon, and that medication availability varied markedly by hospital and rural residence; knowledge and a balanced diet were associated with better adherence, particularly among women with higher BMI. Clinically, these findings support immediate standardization of one-step screening, hospital-wide order sets for GH/GDM (including clear insulin eligibility and titration pathways), targeted nutritional counseling integrated into antenatal visits, and supply-chain stabilization with inventory dashboards focused on lower-performing facilities. For research, prospective cohort and implementation studies should track screening-to-treatment timelines, test interventions that streamline insulin initiation and reinforce diet adherence, and use linked laboratory, pharmacy, ANC data to quantify pathway fidelity and reduce detection bias, thereby improving equitable, guideline-concordant maternal care in resource-constrained settings.

REFERENCES

1. Abbas M, Abbas S, Hussain N, Javeed MT, Ghaffar A, Nadeem M, et al. Assessment of Residues From Common Pesticides and Associated Risks in Pakistan. Environ Monit Assess. 2024;196:1061.
2. Abduallah AM, Ahmed AE, Bajaber MA, Alalwiat AA. Evaluation of the Antidiabetic Effects of Methanolic Extracts of Neem Seeds on Streptozotocin-Induced Wistar Rats. Pak Vet J. 2023;43(4):792–798.
3. Adnan M, Aasim M. Prevalence of Gestational Diabetes Mellitus in Pakistan: A Systematic Review and Meta-Analysis. BMC Pregnancy Childbirth. 2024;24:108.
4. Ahsan N, Naheed F, Farheen S. Hypertensive Disorders of Pregnancy and Its Associated Fetomaternal Complications. J Surg Pak. 2019;24:176–180.
5. Aleem A, Amanullah I, Mahmood N, Tazammul M, Rashid B, Batool A. A Comparative Analysis of Antihypertensive Drugs for Hypertension and Gestational Hypertension Among Women in Tertiary Care Hospitals in Lahore, Pakistan. Bull Pharm Med Res. 2023;2:31–39.
6. Aleem A, Amanullah I, Mahmood N, Tazammul M, Rashid B, Batool A. A Comparative Analysis of Antihypertensive Drugs for Hypertension and Gestational Hypertension Among Women in Tertiary Care Hospitals in Lahore, Pakistan. 2024. doi:10.58398/0005.000011.
7. Aliyu FO, Olatunde OO, Abdulbaki M, Bello SI, Olajide Q. Demographic and Medical Characteristics of Hypertensive Pregnant Women in Two Secondary Healthcare Facilities in Ilorin, Nigeria. Libyan Int Med Univ J. 2024;:–.
8. Almasoud N, Rabail R, Alomar TS, Munir S, Hassan SA, Aadil RM. Therapeutic Impact of Bitter Gourd Seed-Fortified Crackers on Alloxan-Induced Diabetic Rats. Pak Vet J. 2024;44(3):629–636. doi:10.29261/pakvetj/2024.191.
9. Attar A, Hosseinpour A, Moghadami M. Impact of Antihypertensive Treatment of Mild to Moderate Hypertension During Pregnancy on Maternal and Neonatal Outcomes: Updated Meta-Analysis of Randomized Controlled Trials. Clin Cardiol. 2023;46:467–476.
10. Chatzakis C, Cavoretto P, Sotiriadis A. Gestational Diabetes Mellitus Pharmacological Prevention and Treatment. Curr Pharm Des. 2021;27:3833–3840.

11. Cheng AYY, Wong J, Freemantle N, Acharya SH, Ekinci E. Safety and Efficacy of Second-Generation Basal Insulin Analogues in Adults With Type 2 Diabetes at Risk of Hypoglycemia and Use in Other Special Populations: A Narrative Review. Diabetes Ther. 2020;11:2555–2593.
12. Cifkova R. Hypertension in Pregnancy: A Diagnostic and Therapeutic Overview. High Blood Press Cardiovasc Prev. 2023;30:289–303.
13. Gautam T, Shamsad A, Singh R, Baqri SSR, Banerjee M. Pharmacological Therapy for Gestational Diabetes Mellitus: A Comprehensive Overview. Obes Med. 2025;:100587.
14. Gomes C, Futterman ID, Sher O, Gluck B, Hillier TA, Tehrani FR, et al. One-Step vs Two-Step Gestational Diabetes Mellitus Screening and Pregnancy Outcomes: Updated Systematic Review and Meta-Analysis. Am J Obstet Gynecol MFM. 2024;6:101346.
15. He K, Guo Q, Ge J, Li J, Li C, Jing Z. Efficacy and Safety of Metformin Alone or as Add-On to Insulin in Pregnancy With GDM or T2DM: Systematic Review and Meta-Analysis of 21 Randomized Controlled Trials. J Clin Pharm Ther. 2022;47:168–177.
16. Hedderson MM, Badon SE, Pimentel N, Xu F, Regenstein A, Ferrara A, et al. Association of Glyburide and Subcutaneous Insulin With Perinatal Complications Among Women With Gestational Diabetes. JAMA Netw Open. 2022;5:e225026.
17. Hernandez TL, Friedman JE, Barbour LA. Insulin Resistance in Pregnancy: Implications for Mother and Offspring. In: Insulin Resistance: Childhood Precursors of Adult Disease. Springer; 2019. p. 67–94.
18. Jiang L, Tang K, Magee LA, von Dadelszen P, Ekeroma A, Li X, et al. Global View of Hypertensive Disorders and Diabetes Mellitus During Pregnancy. Nat Rev Endocrinol. 2022;18:760–775.
19. Kanwal A, Iftikhar H, Iqbal S, Noor N, Mustafa A, Aslam S, et al. Comparative Efficacy of Mature Coconut Water and Peppermint Water in Managing Gestational Hypertension: A Quasi-Experimental Study in Faisalabad District. J Health Rehabil Res. 2024;4:1739–1743.
20. Kuklina EV, Merritt RK, Wright JS, Vaughan AS, Coronado F. Hypertension in Pregnancy: Current Challenges and Future Opportunities for Surveillance and Research. J Womens Health. 2024;33:553–562.
21. Pasquel FJ, Lansang MC, Dhatariya K, Umpierrez GE. Management of Diabetes and Hyperglycaemia in the Hospital. Lancet Diabetes Endocrinol. 2021;9:174–188.
22. Peng S, Xu C, He Q, Xu J, Kiani FA, Choudhary OP, et al. Fucoidan Alleviates Intestine Damage in Mice Induced by LPS via Regulation of Microbiota. Pak Vet J. 2024;44(2):517–525.
23. Raza A, Pasha I, Zahoor T, Faisal MN. Phytochemical, Antioxidant Potential and Chemical Profile of Various Native and Modified Cereal Brans. Pak J Agric Sci. 2023;60(1):125–132.
24. Sattar S, Khan M, Ejaz A, Rehman MU, Asif Z, Yousaf A, et al. Prevalence of Gestational Diabetes and Its Management Practices: A Cross-Sectional Study. Insights J Life Soc Sci. 2025;3:1–7.
25. Sweeting A, Hannah W, Backman H, Catalano P, Feghali M, Herman WH, et al. Epidemiology and Management of Gestational Diabetes. Lancet. 2024;404:175–192.
26. Talib SH, Quadri U, Patel S, Barapatre P. Metformin in Non-Diabetic Conditions: An Overview. IntechOpen; 2022.
27. Ullah Awan N, Fida T, Waheed K, Malik U, Aslam A, Mehmood K, et al. Comparison of Oral Nifedipine and Labetalol in the Management of Hypertension During Pregnancy in a Tertiary Hospital in Pakistan: A Cross-Sectional Study. 2023.