MITIGATING CLIMATE CHANGE IMPACTS ON PREGNANCY OUTCOMES AND NEWBORN HEALTH IN PAKISTAN

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ABSTRACT

Pakistan's extreme climate vulnerability necessitates targeted maternal health interventions. This research explores the impact of rising temperatures and floods on pregnancy outcomes in urban Karachi and rural Thatta. The project introduced Enhanced Antenatal Care (EANC), a proactive antenatal care protocol featuring heat-adaptation counseling for the pregnant women. We trained the healthcare providers in the project sites in how to deliver EANC. Utilizing a quasi-experimental design with 1,116 participants, we measured the changes in the Knowledge, Attitudes, and Practices (KAP) and physiological risk indicators among pregnant women.

Results highlighted a significant burden of adverse outcomes, including high rates of miscarriage and a 17.5% neonatal death rate. Despite these challenges, EANC achieved highly significant improvements ($P < 0.001$) in all KAP domains. The intervention was particularly transformative in Thatta, where it reduced "Poor" knowledge from 57.1% to 27.2% and tripled "Good" attitudes. Beyond literacy, EANC recipients demonstrated lower physiological risk scores for heat exhaustion, dehydration, and heat stroke. Behavioral adherence was strong, with 84.1% of Karachi recipients achieving "Good" practice levels, including better dietary management.

The study concludes that EANC is a vital, effective, doable, life-saving tool that empowers mothers to mitigate climate-related health risks. These findings provide a robust evidence base for policymakers to institutionalize climate-resilient maternal health interventions within Pakistan’s national disaster management and public health frameworks.

PREFACE

Pakistan stands at the frontline of the global climate crisis, where rising temperatures, recurrent flooding, and environmental instability are no longer abstract threats but lived realities shaping health outcomes—particularly for mothers and newborns. The intersection of climate change and maternal health represents an urgent yet underexplored policy domain, demanding context-specific evidence and actionable solutions. This report, developed under the Research for Social Transformation and Advancement (RASTA) initiative of the Pakistan Institute of Development Economics, addresses this critical gap.

The Project "Mitigating Climate Change Impacts on Pregnancy Outcomes and Newborn Health in Pakistan," advances the discourse from vulnerability to intervention. Conducted across urban Karachi and rural Thatta—two settings that reflect contrasting yet equally compelling climate-health realities—this study investigates how environmental stressors influence pregnancy outcomes and how health systems can respond proactively.

At the core of this research is the introduction of Enhanced Antenatal Care (EANC), an innovative, climate-informed model that integrates heat-adaptation counseling into routine maternal care. By equipping healthcare providers with the knowledge and tools to deliver EANC, and by empowering pregnant women through targeted education and behavioral interventions, the project moves beyond diagnosis of the problem to testing a scalable solution.

While the study reveals a substantial burden of adverse pregnancy outcomes, including a high neonatal mortality rate, it simultaneously demonstrates that informed, anticipatory care can significantly mitigate risk. The statistically robust improvements in knowledge, attitudes, and practices, alongside measurable reductions in physiological vulnerability to heat-related stress, underscore the transformative potential of EANC—particularly in underserved rural contexts such as Thatta.

This report contributes to a growing body of evidence that climate change is not creating new causes of maternal and neonatal morbidity and mortality, but intensifying existing ones. It reinforces the imperative to embed climate resilience within maternal health systems, aligning public health strategy with disaster preparedness and sustainable development priorities.

The insights presented herein are intended to inform policymakers, health system leaders, and development partners. As Pakistan advances its commitments to maternal mortality reduction and climate adaptation, this work offers a practical, evidence-based pathway to safeguard the most vulnerable. Protecting mothers and newborns in a changing climate is not only a health priority—it is a national development imperative.

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ABBREVIATIONS

ANC	Antenatal Care
EANC	Enhanced Antenatal Care
OB-GYN / OB/GYN	Obstetrician and Gynaecologist
PTSD	Post-Traumatic Stress Disorder
UTI	Urinary Tract Infections
NCD	Non-Communicable Diseases
HEAT_EXP	Heat Exposure Score
DEHYDRATION	Dehydration Score
STROKE	Heat Stroke Score
DY_URINE	Dark Urine
DIZZI	Dizziness
CONSTIPAT	Constipation
FALSE_LP	False Labor Pains
RI	Resistance Index
CDC	Centre for Disease Control
RMNCH	Reproductive, Maternal, Newborn, and Child Health
DHIS	District Health Information System
RHCS	Rural Health Centre
LHVs	Lady Health Visitors
KAP	Knowledge, Attitudes, and Practices
OSCE	Objective Structured Clinical Examination
G	Normalized Gain Score
GCRI	Global Climate Risk Index
GHGs	Greenhouse Gases
LMIC	Low and Middle-Income Countries
SMS	Short Message Service

INTRODUCTION

According to the *Global Climate Risk Index (CRI) 2025,* published by Germanwatch, Pakistan ranked among the countries most affected by extreme weather events, placing at the very top of the global list, alongside Belize and Italy (Adil, et al., 2025). This ranking is a key factor in Pakistan's high long-term vulnerability. During the past few decades, Pakistan has recorded an annual increase of 0.63°C in mean temperature, which is expected to rise by more than 3.0°C by the end of the century (UNEP, 2021).

Pakistan has experienced extreme climate-related events, including heat waves and devastating floods, causing over 1,700 deaths and displacing more than 8 million people in 2022 alone. The government estimates the losses due to damage to infrastructure, crops, and livestock at over 30 billion US dollars (World Bank, 2022). This is unfortunate because Pakistan's contribution to global emission of greenhouse gases (GHGs) is less than 1%, and the per capita average emission of GHGs is less than half the global average (Ritchie, et al., 2020).

1.1. Aims and Research Questions:

Our project comprised a comprehensive and policy-oriented intervention research to generate evidence on the impact of rising ambient temperature and recurring floods on reproductive, maternal, newborn, and child health (RMNCH) among underprivileged population groups. The project examined the interplay between rising temperatures, floods, and health risks to the women during pregnancy, childbirth, and postpartum period. We developed and tested strategic and clinical interventions for the mitigation of climate change impacts on maternal and newborn health.

We explored the association between excessive heat exposure during pregnancy and the maternal, fetal, and neonatal outcomes. We also developed and tested an antenatal care protocol comprising assessment of maternal exposure to high heat, providing targeted treatment and health education on nutrition, oral rehydration, and birth preparedness to improve pregnancy outcomes and neonatal health. We also devised strategies to prepare the public sector health system for identifying and addressing climate change impacts on pregnancy and its outcomes.

Our project generated evidence on the association between heat and maternal, fetal, and neonatal health, highlighting the impacts of high ambient temperatures on pregnancy outcomes and neonatal health. We introduced an enhanced antenatal care (EANC) protocol to assess and alleviate the impact of heat on pregnancy by educating the pregnant women to take measures for heat adaptation and mitigation during pregnancy, childbirth, and postnatal period.

Through this project, we have gathered evidence to inform and influence policy and clinical practice, which will help provincial and national stakeholders (policymakers, health managers, healthcare providers, and community leaders) in reducing the burden of adverse pregnancy outcomes and neonatal deaths.

Our project team has engaged with local communities, women, and healthcare providers in the research process. We believe that our policy briefs for healthcare providers and district health managers will help improve clinical practices and birth preparedness.

LITERATURE REVIEW

There is growing evidence of the impact of heat on pregnant women's health, pregnancy outcomes, and newborn survival. A study in India found that working in extremely high temperatures doubled the pregnant women's risk of miscarriage, stillbirth, preterm delivery, and low birth weight (CDC, 2025).

Extreme heat and flooding have been linked to reproductive health problems like anemia in pregnancy, gestational diabetes, preeclampsia, low birth weight, stillbirth, and preterm birth (Child Health Task Force, 2023). A multi-country retrospective study found between 5% and 13% increase in preterm births and hypertensive disease of pregnancy due to a rise in ambient temperatures in the second trimester of pregnancy (Dalugoda, 2022). A narrative review of 20 studies on heat and pregnancy outcomes found an association between heat and stillbirth risk (Baig, 2025). Beyond physical health risks related to nutrition, water, and hygiene, exposure to climate hazards during and after pregnancy can also affect the women's mental health (Baig, 2025). Pregnant and postpartum women are also at a higher risk of experiencing post-traumatic stress disorder and depression after natural disasters and displacement. Flooding has been associated with poor nutrition and malaria, while extreme heat exposure can lead to dehydration, kidney failure, and heat stroke in pregnant women. Pregnant women require reliable access to transportation and medical care, which are disrupted during and after extreme weather events such as floods. At the same time, biological and behavioral changes during pregnancy make women more prone to water-borne diseases, which may affect the pregnancy outcomes and newborn survival.

Emerging evidence underscores the significant role of maternal heat exposure in driving adverse pregnancy outcomes, particularly in low- and middle-income countries such as Pakistan. A recent systematic review and meta-analysis synthesizing data from 198 studies across 66 countries concluded that maternal exposure to elevated ambient temperatures is consistently associated with increased risks of preterm birth, stillbirth, and low birth weight (Zhang et al., 2025). Importantly, these associations were observed across both short exposure windows (single hot days) and cumulative exposures during late pregnancy, highlighting the sensitivity of the third trimester to thermal stress.

Methodological Advances and Knowledge Gaps: Recent methodological reviews have emphasized improvements in exposure assessment, including the use of heatwave definitions, apparent temperature, and wet-bulb globe temperature. However, persistent gaps remain, particularly in low-resource settings where personal heat metrics and indoor temperature monitoring are rarely employed (Mehta et al., 2023). Furthermore, few studies have evaluated protective behaviors or cooling interventions, leaving a critical evidence gap for pragmatic, community-based solutions.

Scoping Reviews and Regional Evidence: A scoping review by (Dalugoda et al., 2022) reported positive associations between elevated ambient temperature and a wide range of maternal, fetal, and neonatal outcomes, including hypertensive disorders, gestational diabetes, preterm birth, stillbirth, and neonatal distress. The authors highlighted the need for standardized heat metrics and trimester-specific analyses to better capture vulnerability windows. Clinical guidance from the CDC (Centers for Disease Control and Prevention, 2025) further supports these findings, noting that even one day of extreme heat can elevate risks of preterm birth and stillbirth, with the third trimester being particularly sensitive due to increased maternal metabolic load and reduced thermoregulatory reserve.

Magnitude of Risk: Quantitative estimates suggest that each 1 °C rise in ambient temperature is associated with approximately a 4% increase in preterm birth risk, while exposure to extreme heat events can elevate risk by up

to 26% (Chersich et al., 2020; Lakhoo et al., 2025). These findings are consistent with pooled estimates across multiple meta-analyses, though magnitudes vary by study design and exposure metric. The devastating floods and heatwaves in South Asia, particularly Pakistan, have further amplified these risks, with observational reports linking maternal heat exposure to high rates of stillbirths and neonatal mortality (Lakhoo et al., 2025; Jan et al., 2025; Anwer, 2025; National Commission for Human Rights Pakistan & Islamic Relief, 2024; Pan et al., 2023).

Practical Cooling and Exposure-Avoidance Strategies: Programmatic guidance emphasizes simple, low-cost interventions such as hydration, rest breaks, shade use, cross-ventilation, and evaporative cooling. Forecast-linked messaging, such as SMS alerts tied to Heat Risk thresholds, has been proposed as a scalable intervention to reduce exposure during critical late-trimester windows (Centers for Disease Control and Prevention, 2025). However, randomized or quasi-experimental evaluations of such interventions remain scarce, representing a priority area for future research.

Research Gaps: Despite growing evidence, several gaps persist in our understanding of the impact of heat on pregnancy and its outcomes:

1. *Local exposure metrics*—few studies capture personal or indoor heat exposures in South Asian households.
2. *Intervention trials*—limited evaluation of education-based cooling packages in pregnancy.
3. *Compound stressors*—co-exposures such as air pollution and dehydration remain underexplored.
4. *Equity considerations*—household roles and gender dynamics shape women's ability to adopt cooling behaviors, requiring family-level interventions.

RESEARCH METHODOLOGY

We investigated the association between climate change and adverse maternal, fetal, and neonatal outcomes in urban Karachi and rural areas of Sindh. We developed and tested innovative health interventions to assess and treat climate-related disorders in pregnancy, particularly those caused by exposure to excessive heat. The project sites included PNS Shifa Hospital in Karachi and the District Hospital, the Taluka Hospital, and six Rural Health Centers in Thatta district of Sindh.

Following is a brief description of the project's approach and methodology:

3.1. Key Features

Population: Pregnant women in third trimester (at baseline) and recently delivered (end line, on the day of delivery).

Intervention: Provision of enhanced antenatal care (EANC), including counseling on heat mitigation and adaptation strategies and dissemination of pictorial educational materials.

Data Collection: Structured questionnaires and qualitative interviews administered at baseline and end line as described above.

Outcome Measures: Changes in knowledge, attitudes, and practices regarding heat exposure, heat mitigation, and heat adaptation; neonatal outcomes were also tracked through health system data.

Analysis: Paired comparisons between baseline and end line responses, conducted to assess the impact of the intervention. We conducted this analysis between women who reported to have received EANC and those who received the routine antenatal care.

3.2. Intervention Design

This research project adopted a quasi-experimental pretest–posttest design to evaluate the effectiveness of EANC interventions in reducing the health risks associated with heat exposure during pregnancy. We enrolled the pregnant women attending the health facilities in their first antenatal care (ANC) visit in the third trimester.

We started with a desk review of available literature and government policies; a literature search to explore and evaluate clinical practice protocols and nature-based solutions to mitigate the impacts of climate change on reproductive, maternal, newborn, and child health (RMNCH), with special focus on the underprivileged populations of developing countries. We used these findings to summarize and modify project interventions and methodology as needed.

At baseline (pretest), data were collected on women's knowledge of the adverse effects of heat exposure, their attitudes and beliefs toward heat mitigation measures, and their current practices to protect themselves from heat. In addition, we elicited a history of heat-related signs and symptoms. We reassessed the same domains at the time of delivery (post-test), again in a random sample of the women who delivered in the facility. We compared the levels of the knowledge, attitudes, and practices (KAP) before and after the intervention. Both the pre-test and post-test surveys were conducted in random samples of pregnant women visiting the ANC clinics.

This design allowed for within-subject comparisons of knowledge/beliefs, attitudes (likes and dislikes/agreements and disagreements), and actual practices (consciously following the EANC provider's advice to mitigate heat and/or adapt to the hot weather) before and after exposure to the intervention. The approach

was particularly suited to the study context, where randomization was not feasible due to ethical and operational considerations.

The intervention consisted of structured counseling sessions during the ANC visits, dissemination of pictorial educational materials to the women, and provider-led guidance on practical heat mitigation strategies through interactive sessions. This design allowed for measurement of the change in the knowledge, attitudes, practices, and heat-effects among pregnant women over time without randomization, which was not feasible in the study context.

3.3. Training of Healthcare Providers in EANC

The EANC training program aimed to integrate climate resilience into maternal healthcare. It focused on transforming traditional antenatal care into a proactive "heat-aware" clinical practice, specifically targeting low-resource and high-heat environments like urban Karachi and rural Sindh province of Pakistan. The program was structured around three core pillars that move from clinical facility adjustments to community-based education and advanced technological screening.

The program trained the providers to treat heat as a vital clinical factor, as follows:

Symptom Screening: Transitioning from general checks to specific history taking for heat exhaustion (dizziness, cramps, syncope).
Operational Shifts: Adapting the "when" and "how" of care by scheduling appointments during cooler hours and adjusting medication to avoid diuretics or drugs that exacerbate dehydration.
Nutritional Support: Focusing on electrolyte balance and Vitamin D supplementation to compensate for "sun-avoidance" behaviors.

The community and family empowerment component of the training shifted the burden of care from the clinic to the home, and included:

Environmental Monitoring: Training families to monitor indoor/outdoor temperatures 4–6 times daily.

Home-Based Mitigation: Teaching "Heat Action Plans" that include using fans, shaded areas, and cold showers.

Social Support: Educating male family members and the wider community to act as a support system for pregnant women during extreme weather.

Technological integration (use of UmbiFlow or other Doppler technology): A pivotal part of the training was the intended introduction of UmbiFlow, a portable, low-cost Doppler device. Unfortunately, we could not acquire the equipment due to import restrictions and used other Doppler devices to achieve the same objective. However, UmbiFlow has a primary care focus, designed for use by nurses and midwives (rather than just specialists) in remote settings. We used available ultrasound devices for placental assessment, measuring the Umbilical Artery Resistance Index (RI), which is directly affected by heat stress, to identify fetuses at risk of oxygen or nutrient deprivation.

The program aimed to achieve measurable improvements in maternal and neonatal health through the following outcomes:

Table 1: Measurable Improvements in Maternal And Neonatal Health

Outcome Area	Expected Result
Stillbirth Reduction	Potential prevention of up to **4,000 stillbirths annually** if 95% of third-trimester women are screened.
Early Risk Detection	Shift from reactive to proactive care through the identification of abnormal placental blood flow patterns before they lead to fetal distress.
Climate Resilience	Increased capacity of pregnant women to maintain thermoregulation and hydration within their own homes, reducing heatstroke admissions.
Skill Task-Shifting	Empowerment of LHVs, midwives, and nurses to perform sophisticated fetal monitoring that was previously restricted to urban hospitals.
Reduced Preterm Births	Mitigation of the non-linear relationship between heat stress and preterm labor through better monitoring and timely specialist referrals.

Source: Authors' compilations.

3.4. Training Evaluation

Given the diverse professional backgrounds of the trainees—ranging from specialist OB-GYNs to frontline Midwives and Lady Health Visitors (LHVs)—the assessment tool played a critical role in bridging clinical knowledge with community-based adaptation. The tools had a comprehensive scope, covering the "Triple Threat" of heat: maternal physiological impact, fetal outcomes, and practical mitigation strategies. It included a "Justification Requirement", which was the strongest feature of the test: By asking trainees to "Justify your choice," the tool moved beyond rote memorization (Bloom's Taxonomy: Remember) to higher-order thinking (Bloom's Taxonomy:

Understand/Analyze). It prevented "guessing" the "All of the above" option and revealed the depth of trainee's reasoning. The inclusion of family engagement (Q13) and environmental monitoring (Q11) is vital for the Thatta context, where domestic living conditions and family support structures significantly influence health outcomes.

The areas for Improvement included weak distinction between knowledge and skill; the questionnaire was heavy on *knowledge* (the "what") but lighter on *clinical skills* (the "how"). For instance, Q12 mentions "Heat exposure diaries," but the questionnaire did not test if the trainee knows how to teach a patient to design and maintain such diaries. Secondly, for LHVs and Midwives in rural Sindh, terms like "Congenital anomalies" or "Metabolic" might have been overly academic.

To measure the effectiveness of the training, the project used this tool in a **Comparative Analysis** framework. By comparing the Pre-test score to the Post-test score, we could calculate the Normalized Gain Score:

$G = (Post\% - Pre\%) \div (100 - Pre\%)$

This helped determine how much of the "unlearned" material was mastered during the session. If an OB-GYN starts at 80% and goes to 90%, and an LHV starts at 40% and goes to 70%, the LHV actually showed a higher learning gain relative to their starting point.

Assessment of Skill and Reasoning: The "Justify your choice" sections allow a thematic analysis:

Baseline Misconceptions - in the pretest, do trainees believe heat only causes thirst?

Nuanced Understanding: In the post-test, do they mention specific pathways (e.g., placental insufficiency or uterine blood flow) in their justifications?

Clinical Application: Do they move from "drink water" (pre-test) to "monitor urine color and avoid peak sun hours" (post-test)?

Tiered Competency Mapping: Since the cohort is multidisciplinary, the tool helps identify different training needs, e.g. for Doctors, focus on identifying physiological triggers (Q4, Q5, and for LHVs/Midwives, focus on community engagement and monitoring tools (Q11, Q13).

3.5. Expected Outcomes

Primary outcomes: Changes in knowledge, attitudes, and practices related to heat exposure and mitigation.
Secondary outcomes: Neonatal health indicators, including neonatal mortality rates derived from the District Health Information System (DHIS).

3.6. Analytical Approach

Cross-tabulation and logistic regression analyses were conducted to compare pretest and post-test responses. Quantitative data were analyzed using appropriate statistical tests for change, while qualitative data from interviews were thematically analyzed to capture contextual insights into women's perceptions and practices.

EANC included an assessment of the heat exposure in pregnant women in third trimester and health education to prepare expectant mothers for protection against the adverse effects of extreme heat during pregnancy. The health education comprised measures for rehydration, avoiding heat exposure, and healthy diet. In addition, we introduced the pregnant women to household level nature-based solutions for heat mitigation, including green rooftops, insulation, natural ventilation, use of indigenous cooling devices, and planting of rapidly growing trees and indoor plants.

Healthcare providers—including doctors, nurses, midwives, and Lady Health Visitors—were trained in EANC guidelines tailored to their level of expertise. Training curricula and methodology were developed by experienced obstetricians in consultation with climate experts. The training emphasized both clinical preparedness and community education for heat and flood resilience.

3.7. Project Components

The main project components were:

1. Baseline survey – This comprises: a) qualitative in-depth interviews of a sample of pregnant women visiting the project sites to assess their understanding of the heat and floods and their impact on pregnancy outcomes, breastfeeding, and care of the newborn babies; and b) estimation of neonatal mortality rate from the District Health Information System (DHIS).

2. Development of materials – These include the training curriculum and support materials for the healthcare providers training in EANC, and pictorial educational materials in the local language to be disseminated to the pregnant women and their families.

3. Training of healthcare providers (doctors, nurses, midwives, and Lady Health Workers) in EANC. This short training focused on evaluation of the adverse effects of heat exposure in pregnant women through history and clinical examination; use of Doppler to monitor umbilical blood flow; and the

methods for educating pregnant women and their families in heat mitigation and disaster preparedness. Healthcare providers also learned to use the pictorial materials developed for the pregnant women and their families. The training included pre-test and post-test and an objective structured clinical exam (OSCE).

4. End-line survey – This was along the same lines as the baseline survey, using the same questionnaire and eliciting information from participating pregnant women on the day of delivery.

5. Data analysis and preparation of a comprehensive report, followed by dissemination seminars for the government.

In addition, we plan to conduct a national workshop for dissemination of our findings and recommendations to healthcare providers, policymakers, health managers, and academicians from public and private sectors.

3.8. KAP Data Analysis Methods:

Knowledge, Attitude, and Practice (KAP) scoring framework: This section explains how we transformed the raw questionnaire data into quantifiable indices to assess the participants' heat adaptation capabilities.

3.8.1. KAP Score Computation and Categorization

The study utilized a structured scoring system to evaluate three primary domains: knowledge of heat risks, attitudes toward heat adaptation, and actual behavioral practices.

1. Total Knowledge Score (Range: 0–12)

The Knowledge domain was assessed through a two-part identification process:

General Concepts: Six items (Q301–Q306) assessed the participants' agreement with foundational heat safety concepts. Responses were binary-coded, where **"Agree"** received **1 point** and all other responses received **0**.

Symptom Identification: Participants were asked to identify signs of heat-related illness (Q320). Each correctly identified symptom (up to 6) was awarded **1 point**.

Calculation: The **Total Knowledge Score** was the sum of these two components, resulting in a cumulative index ranging from **0 to 12**.

2. Total Attitude Score (Range: 0–4)

The Attitude domain measured the participants' internal perspective and perceived importance of heat protection.

Scoring: Four specific items (Q307–Q310) were evaluated. Similar to the knowledge domain, a point was only awarded for an **"Agree"** response, signifying a positive or proactive attitude toward heat safety.

Calculation: The **Total Attitude Score** was the sum of these four items, resulting in a cumulative index ranging from **0 to 4**.

3. Total Practice Score (Range: 0–27)

The Practice domain assessed real-world behavioral adherence to heat adaptation strategies across three dimensions:

- **Frequency of Action:** Six items (Q311–Q316) used a 5-point Likert scale. These were weighted to reward consistency: **"Always" (4 points)**, "Often" (3 points), "Sometimes" (2

points), "Rarely" (1 point), and "Never" (0 points).

- **Seeking Advice:** One item (Q317) assessed whether the participant sought heat-related health advice, with **1 point** awarded for a "Yes" response.
- **Proactive First Aid:** Two items (Q318–Q319) evaluated the participants' immediate reaction to heat stress. Proactive measures (e.g., cooling down, rehydrating) were awarded **1 point**, while "doing nothing" or "not knowing" received **0 points**.
- **Calculation:** The **Total Practice Score** was the sum of these weighted responses, resulting in a cumulative index ranging from **0 to 27**.

3.8.2. Categorization of KAP Levels

To provide a qualitative interpretation of these quantitative scores, a percentage-based categorization was applied. Each participant's total score for each domain was converted into a percentage of the maximum possible score:

KAP (%) = Observed Score / Maximum Possible Score × 100

Participants were then categorized into three proficiency levels based on their percentage:

Table 2: Proficiency Levels

Percentage Range	Category Level	Interpretation
0% to 49.99%	Level 1	Poor
50% to 74.99%	Level 2	Moderate
75% to 100%	Level 3	Good

Source: Authors' computations.

This tiered approach allows for a clear comparison between the effectiveness of Enhanced Antenatal Care (EANC) versus routine care in moving women from "Poor" to "Good" levels of heat adaptation.

Conversion of reported symptoms into risk categories:

To convert the reported symptoms into a risk category, we utilized **cumulative additive indices**. This approach implies that each reported symptom contributes equally to the overall severity or risk level for that specific condition.

3.8.3. Computation of Heat-Related Risk Scores

To quantify the physiological impact of heat on the study participants, three distinct composite scores were calculated by summing the binary responses (Presence = 1, Absence = 0) of specific symptoms reported by the pregnant women.

1. Heat Exposure Score (HEAT_EXP)

The **Heat Exposure Score** serves as an index of early-stage heat strain and physical exhaustion. It was computed as the sum of five self-reported symptoms:

- Heavy Sweating
- Fatigue
- Muscle Cramps
- Feeling of Overheating
- Nausea

Score Range: 0 to 5, where higher scores indicate a greater cumulative burden of heat exhaustion symptoms.

2. Dehydration Score (DEHYDRATION)

The **Dehydration Score** measures the systemic impact of fluid loss and inadequate hydration during pregnancy. This score was derived from the sum of the following six indicators:

- Dry Lips
- Dark Urine (DY_URINE)
- Dizziness (DIZZI)
- Headache
- Constipation (CONSTIPAT)
- False Labor Pains (FALSE_LP)

Score Range: 0 to 6, with higher values reflecting more severe clinical markers of dehydration.

3. Heat Stroke Score (STROKE)

The **Heat Stroke Score** was designed to capture high-severity clinical indicators that suggest a transition from heat exhaustion to potentially life-threatening heat-related illness. It was calculated by summing these six critical symptoms:

- Fever-like Symptoms
- Anhidrosis (Low Sweating)
- Mental Confusion
- Tachycardia (Fast Heart Rate)
- Loss of Consciousness/Coma
- Feeling of Overheating

Score Range: 0 to 6. This index emphasizes neurological and cardiovascular distress, where a higher score signifies a high risk of heat stroke.

Table 3: Summary Table for Reference

Score Name	Components	Max Score	Interpretation
HEAT_EXP	5 Symptoms (Sweat, Fatigue, Cramps, Overheat, Nausea)	5	Early heat strain/exhaustion
DEHYDRATION	6 Symptoms (Dry lips, Urine, Dizziness, Headache, Constipation, False LP)	6	Systemic fluid deficiency
STROKE	6 Symptoms (Fever-like, Low sweat, Confusion, Fast heart, Coma, Overheat)	6	Severe heat-related emergency

Note: The variable "Overheating" is utilized in both the Heat Exposure and Heat Stroke scores, as it acts as a primary subjective marker for the body's inability to thermos-regulate.
Source: Authors' computations.

FINDINGS AND DISCUSSION

This section is organized in four sub-sections:

1. Assessment of the training of ANC providers (Ob/Gyn., doctors, nurses, Lady Health Visitors, and midwives), who were trained in the EANC methodology along with their participation in heat education, heat signs assessments, and Doppler technology use to assess placental blood flow. The pretest and posttest results are also provided and compared between Karachi and Thatta.
2. Comparative analysis of the knowledge, attitudes, and practices (KAP) between women who received EANC with those who received routine antenatal care (without special training on heat adaptation during pregnancy). The participants were from Shifa Hospital Karachi and District Hospital and affiliated Rural Health Centers (RHCS) in Thatta.

In the survey results sub-section, the first few tables report the demographic characteristics of the respondents to assess the comparability between sites and between baseline and end line surveys.

Section 1: Assessment of Training of Providers

We conducted multiple rounds of training and refresher training of the ANC providers. All training programs included a combined session, followed by separate training session of each category of ANC providers. Although we carried out an assessment of the learning of the participants at the end of each type of training, here we submit only the results of the first comprehensive training conducted in Karachi and Thatta sites. The number of participants was 35 in Karachi and 50 in Thatta.

Table 4: Results of the First Comprehensive Training Conducted in Karachi and Thatta Sites

Trainee category	Karachi	Thatta	TOTAL
Ob/Gyn. Specialists (N)	10	5	15
Doctors (medical officers, interns, and residents) (N)	20	16	36
Nurses, Lady Health Visitors, and Midwives (N)	25	53	78
TOTAL:	55	74	129
Pretest Average Score			
Posttest Average Score			
Normalized Gain Score (G)			

Source: Authors' computations.

Section 2: Comparative analysis of KAP Survey between EANC and non-EANC Groups

Before carrying out a full-scale data analysis of the KAP Survey, we conducted a question-by- question comparison of the knowledge questions included in the questionnaire, with the following results. This analysis was carried out while data collection was still going on, and it does not reflect the final data analysis (which follows this table).

Table 5: Perceptions of Excessive Heat Exposure during Pregnancy and Its Adverse Effects before the Intervention (Percent of Women Giving the Correct Answer) in the Pilot Analysis of the KAP Survey

Knowledge Question	Shifa (%)	Thatta (%)	P-value
Do you think that excessive heat exposure can negatively affect your health in pregnancy and health of your baby?	45.4	68.5	0.028
Do you think that heat exposure can increase your blood pressure and cause serious diseases like fits?	34.2	59.0	0.003
Do you think that prolonged exposure to heat during pregnancy may increase the risk of premature birth?	24.3	23.0	0.252
Do you think that extreme heat exposure can cause stillbirth?	20.4	42.5	0.015
Do you think that extreme heat exposure can lead to the birth of a low birth weight baby?	23.7	50.5	0.003
Do you believe that the mother's dehydration in pregnancy caused by heat can affect the baby's growth?	44.1	49.5	0.093
Do you think that pregnant women should be given special care to avoid excessive heat exposure?	61.2	79.0	0.003
Do you think that women in your community and family are aware about the adverse impact of excessive heat on the pregnant woman's health and her pregnancy outcome?	21.7	50.5	< 0.001
Are you confident that you can take necessary precautions to prevent heat-related risks during pregnancy?	59.9	57.0	0.195
Do you think that the healthcare providers should offer more guidance to women on reducing heat exposure risks during pregnancy?	76.3	77.0	0.325

Note: Women in Thatta consistently demonstrated higher awareness of heat-related maternal and neonatal risks compared to Shifa, with significant differences observed for hypertension, stillbirth, low birth weight, and community-level awareness.
Source: Authors' computations.

This table highlights the differences in knowledge and perceptions of heat-related maternal and neonatal health risks among women in Shifa Hospital Karachi and District Hospital Thatta.

Respondents in Thatta generally demonstrated higher awareness of adverse outcomes, with significant differences observed for hypertension, stillbirth, low birth weight, and community-level awareness. These findings underscore the need for integrating climate-health education into antenatal care and community outreach to strengthen maternal resilience against rising temperatures.

It is interesting to note that the rural women in Thatta consistently reported higher recognition of heat-related health risks compared to the urban women in Shifa: Awareness of heat's impact on maternal and neonatal health (68.5% vs. 45.4%, $p = 0.028$) and risks such as high blood pressure and fits (59.0% vs. 34.2%, $p = 0.003$) was significantly higher in Thatta. Similarly, knowledge about extreme heat leading to stillbirth (42.5% vs. 20.4%, $p = 0.015$) and low birth weight (50.5% vs.

23.7%, $p = 0.003$) also showed stronger recognition of severe consequences in Thatta compared to Shifa. More importantly, a striking difference was observed in perceptions of community-level awareness (50.5% vs. 21.7%, $p < 0.001$), indicating Thatta respondents believe their communities are more informed about heat's adverse impacts.

Some items, such as premature birth (p = 0.252), dehydration effects (p = 0.093), personal confidence in taking precautions (p = 0.195), and provider guidance (p = 0.325), did not show statistically significant differences, suggesting similar levels of knowledge or attitudes across both sites.

These findings suggest that while Thatta respondents demonstrate higher awareness of specific heat- related risks, gaps remain in both communities regarding premature birth, dehydration, and confidence in preventive actions. Strengthening provider-led education and community-level interventions could help bridge these gaps.

KNOWLEDGE, ATTITUDES, AND PRACTICES (KAP) SURVEY – RESULTS AND INTERPRETATIONS

The project planned to interview pregnant women to assess their knowledge, attitudes, and practices regarding heat adaptation before and after they received the enhanced antenatal care (EANC) from their healthcare providers. We included only the women in their last trimester of pregnancy. In many cases, it was difficult to follow and interview the same woman before and after her exposure to EANC. We, therefore, decided to divide the women simply into two groups – those who had received the EANC at the time of their KAP interview, and those who had not received EANC till that time.

The original sampling plan was to interview 360 women in each group and in each site (Karachi and Thatta), a total sample size of 1,440. However, this target could not be achieved due to logistic constraints (to be described separately). The total number of women interviewed was 1,116 (481 in Karachi and 635 in Thatta). All of the respondents were either in their last trimester or in the immediate postpartum period (day 1 to 3 after delivery).

Table 6: Distribution of pregnant women by EANC and Site

Antenatal care type	Karachi (n=481)	Thatta (n=635)	Total (N=1116)
Enhanced ANC (Yes)	54.90%	58.10%	56.70%
Enhanced ANC (No)	45.10%	41.90%	43.30%

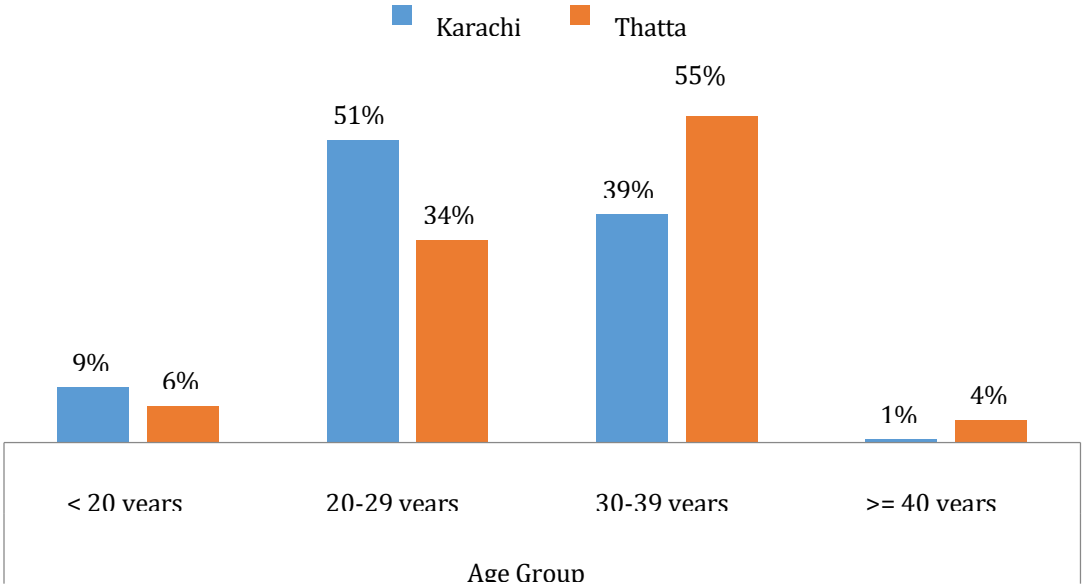
Source: Authors' computations.

Table 6 presents the distribution of pregnant women by Enhanced Antenatal Care (EANC) and site. This table provides a breakdown of the study sample (N=1,116) across the two study sites, Shifa Hospital Karachi and the District Hospital and Rural Health Centers in Thatta. It indicates that over half of the participants in both sites received EANC (54.9% in Karachi and 58.1% in Thatta). The difference in EANC utilization between the two sites was not statistically significant (P=0.300), suggesting a relatively balanced distribution for the intervention study.

Section I: Characteristics of the Pregnant Women Interviewed

1. Age distribution of respondents by site:

Figure 1: Percentage distribution of pregnant women by age-group and site



Source: Authors' computations.

Figure 1 serves to establish the age demographics of the study participants in both urban (Karachi) and rural (Thatta) settings to ensure comparability. In general, the women in Karachi are younger than the women in Thatta ($P < 0.001$). Nonetheless, the vast majority (90%) of women in both sites are between the ages of 20 and 39 years.

2. Respondents' level of education:

Table 7: Pregnant Woman's Education

	Karachi	Thatta
No schooling	30.8%	73.9%
< 10th grade	20.8%	18.5%
Secondary School	29.3%	6.3%
More than Secondary School	29.3%	6.3%
Other types of education	1.2%	0.2%
P < 0.001		

Source: Authors' computations.

Table 2 presents the percentage distribution of the interviewed women by level of education. There is a large gap in basic education between the two sites: In **Thatta**, nearly three-quarters (**73.9%**) of pregnant women have had **no schooling**, compared to **30.8%** in Karachi, which is still significantly low for an urban center. On the other hand, the situation in Thatta represents a severe lack of foundational education. Karachi shows a much stronger trend toward higher educational attainment. Nearly **60%** of women in Karachi have reached secondary school or higher (**29.3%** at Secondary School and **29.3%** above Secondary School). In contrast, only about **12.6%** of women in Thatta have reached these levels. The percentage of women with some education but less than 10th grade is relatively similar in both regions (**20.8%** in Karachi vs. **18.5%** in Thatta), suggesting that even in rural areas, about one-fifth of women manage to access early-level schooling before dropping out. The differences between sites are statistically significant (**P < 0.001).** The high rate of "No schooling" in Thatta reflects a vast majority of pregnant women as likely to face barriers in access to maternal health information and healthcare. Pregnant women in Karachi are more likely to be educated, with better health-seeking behavior, higher autonomy in decision-making and better nutritional outcomes for both mother and child.

3. Respondents' occupation:

Table 8: Pregnant Woman's Occupation

	Karachi	Thatta
Housewife	67.6%	70.2%
Works at home	11.0%	8.6%
Works at other homes	6.9%	7.2%
Factory or office	6.9%	7.2%
Field, farm, farm animals	1.0%	10.1%
Any other	2.1%	2.7%
P<0.001		

Source: Authors' computations.

Table 3 compares the occupational status of pregnant women **Karachi** (a major urban center) and **Thatta** (which is a more rural/semi-urban district). In both sites, the vast majority of pregnant women are identified as **housewives**, accounting for **67.6%** in Karachi and **70.2%** in Thatta. This suggests a consistent cultural or socioeconomic trend where domestic management is the primary responsibility for expectant mothers

regardless of the region. In rural Thatta, **10.1%** of pregnant women are engaged in agricultural work, compared to a mere **1.0%** in urban Karachi. This highlights the region-specific economic dependencies. Karachi shows a slightly higher percentage of women who "Work at home" (**11.0%**) compared to Thatta (**8.6%**), which may point toward more urban cottage industries or remote work opportunities in the city. Finally, engagement in "Factory or office" work is relatively low and surprisingly similar in both regions, hovering around **6.9% to 7.2%**. The differences in the two sites are statistically significant (**P < 0.001)**. The primary differentiator in employment is agricultural labor. Across both regions, less than **8%** of pregnant women are in formal office or factory environments. This indicates a potential lack of formal maternity benefits or protections for the majority of the population, who are either in the informal sector or working at home. Since nearly **70%** of the target group are housewives, maternal health awareness campaigns and outreach programs should be heavily focused on home-based interventions and community health workers rather than workplace-based initiatives.

4. Children ever born (number of previous live births):

Table 9: Percent of women by number

	Karachi	Thatta
Primigravida	16.4%	20.9%
1-2 live births	37.8%	26.1%
3-4 live births	33.7%	27.6%
5 or more live births	33.7%	27.6%
P<0.001		

Source: Authors' computations.

Table 4 presents the number of prior children born to the participant women. There is a higher percentage of first-time mothers in **Thatta (20.9%)** compared to **Karachi (16.4%)**. A significantly higher proportion of women in **Karachi (37.8%)** have 1 to 2 children compared to those in **Thatta (26.1%)**. This trend is typical of urban environments like Karachi, where factors such as higher education levels, increased access to family planning, and higher living costs often lead to smaller family sizes. **Karachi** shows a substantial proportion of women with 3 or more children (33.7% for both categories listed), which is higher than the **27.6%** observed in Thatta for those categories. The differences in the number of live births between Karachi and Thatta are **statistically highly significant (P < 0.001)**. It may be concluded that the data reflects a clear demographic divide.

Karachi's population shows a strong leaning toward small-to-moderate family sizes (1–2 children), while Thatta has a higher influx of new mothers (Primigravida). The significant portion of women in both regions with 3 or more births highlights the ongoing need for maternal health services to manage risks associated with multiple births, which can increase the likelihood of complications during subsequent pregnancies.

5. History of miscarriages, stillbirths, preterm births, and neonatal deaths:

Table 10: Percent of pregnant women who reported a pregnancy

Pregnancy outcome	Karachi	Thatta	Total	P-value
Miscarriage	57.4	31.5	42.7	P < 0.001
Stillbirth	31.6	20.5	25.3	P < 0.001
Premature birth	29.1	17.2	22.3	P < 0.001
Neonatal death	24.7	12.0	17.5	P < 0.001

Source: Authors' computations.

Table 5 provides a comparative analysis of adverse pregnancy outcomes—including miscarriages, stillbirths, premature births, and neonatal deaths—reported by women in **Karachi** and **Thatta**.

Miscarriage is the most common adverse outcome in both regions, with **42.7%** of the women in the

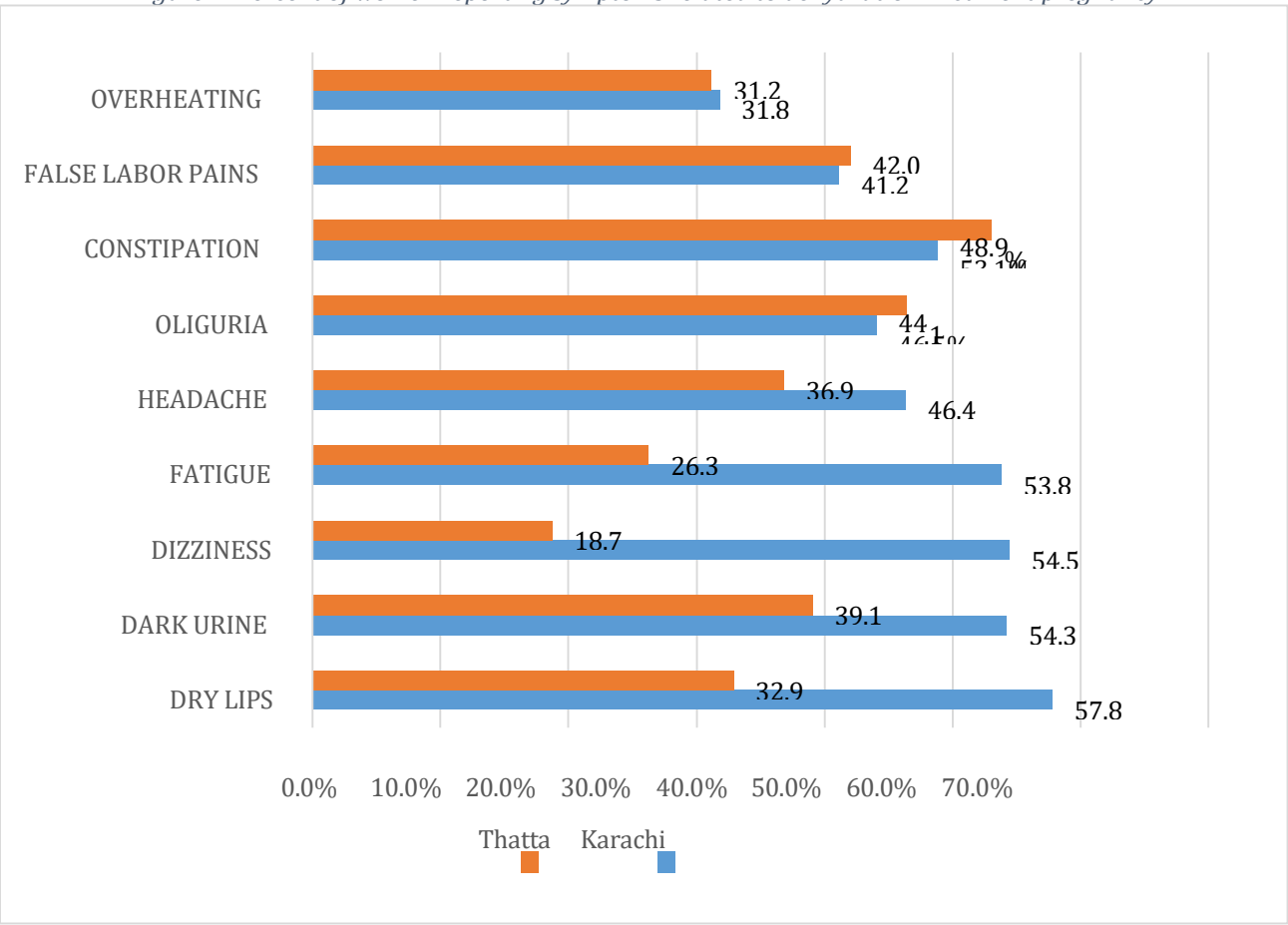
sample reporting a prior miscarriage. Across the four categories of pregnancy loss, the reported percentages are significantly higher in **Karachi** than in **Thatta,** as follows**:**

- **Miscarriages r**eported by **57.4%** of women in Karachi compared to **31.5%** in Thatta;
- **Stillbirths, r**eported by **31.6%** in Karachi vs. **20.5%** in Thatta;
- **Premature births,** reported by **29.1%** in Karachi vs. **17.2%** in Thatta; and
- **Neonatal deaths (deaths within first month of birth),** reported by **24.7%** in Karachi vs. **12.0%** in Thatta.

These findings present an "urban paradox", whereby urban areas like Karachi are expected to have better pregnancy outcomes due to healthcare access. However, these figures show a higher burden of pregnancy loss in the city. This could be due to better recall and reporting in Karachi than in Thatta and/or e**nvironmental and lifestyle stressors**, such as heat, pollution, noise, overcrowding, and psychological stress, all of which are linked to adverse pregnancy outcomes. All the differences between the sites are highly significant ($P < 0.001$). These data confirm that the prevalence of pregnancy losses is extremely high among this sample. In particular, with a total neonatal death rate of **17.5%**, there is a clear requirement for improved postnatal and special neonatal care.

6. History of dehydration symptoms reported in current pregnancy:

Figure 2: Percent of women reporting symptoms related to dehydration in current pregnancy



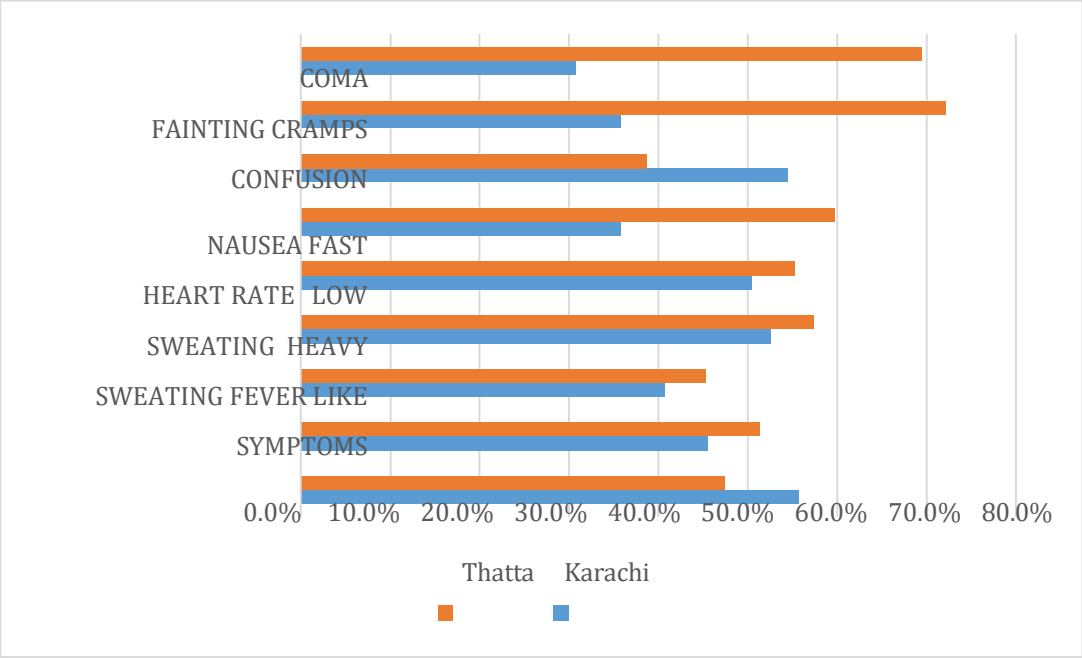
Source: Authors' computations.

Figure 2 outlines the dehydration symptoms reported by pregnant women in **Karachi** and **Thatta**. The differences in the percent of women reporting symptoms between the two sites are statistically significant in dry lips, dark urine, dizziness, fatigue, and headache ($P \leq 0.001$) but not in cases of oliguria, constipation, false labor pains, and overheating. Karachi shows a markedly higher prevalence of neurological and systemic symptoms compared to Thatta, such as: **dizziness (r**eported by **54.5%** in Karachi vs. only **18.7%** in Thatta); **fatigue (r**eported by **53.8%** in Karachi vs. **26.3%** in Thatta); and **dry lips (57.8%** in Karachi vs. **32.9%** in Thatta). Both sites show high

rates of **Dark Urine** (54.3% in Karachi, 39.1% in Thatta) and **Oliguria** (44.1% in Karachi, 46.5% in Thatta). Interestingly, while Karachi women report more "feeling" thirsty (dry lips), women in Thatta report slightly higher rates of actual low urine output (oliguria), which is a more severe physiological sign of dehydration. Symptoms like **Constipation** (approx. 49-53%), **False Labor Pains** (approx. 41-42%), and **Overheating** (approx. 31%) are relatively consistent across both sites. This suggests these issues may be more closely tied to the biological state of pregnancy and the general regional climate rather than specific urban or rural lifestyles. The overall conclusion from this figure is that there is a high burden of dehydration, and that urban stress and/or high levels of urban pollution may be causing significantly higher rates of dizziness, fatigue, and dry lips in Karachi. Chronic dehydration and overheating during pregnancy are linked to complications such as low amniotic fluid, preterm labor, and urinary tract infections (UTIs). The high reported rate of "False Labor Pains" (over 40%) could potentially be linked to this lack of hydration, as dehydration can trigger uterine contractions.

7. History of heat exposure symptoms during current pregnancy:

Figure 3: Percent of women reporting symptoms related to heat exposure in current pregnancy



Source: Authors' computations.

Figure 3 presents the heat-related symptoms across the two sites. The differences in the percent of women reporting symptoms between the two sites are statistically significant in confusion, cramps, fainting, and coma ($P \leq 0.001$) and fever-like symptoms ($P=0.006$) but not in cases of heavy sweating, low sweating, fast heart rate, and nausea. A striking trend in the data is that the most critical, life-threatening neurological symptoms are dramatically more prevalent in **Thatta.**

Fainting affects over **70%** of surveyed individuals in Thatta, compared to approximately 35% in Karachi; **coma** is reported at nearly **70%** in Thatta, while the rate in Karachi, though still very high for a symptom of this severity, is below 30%; and **confusion** is also significantly higher in Thatta (near 60%) compared to Karachi (approx. 35%). However, **f**or symptoms considered "heat exhaustion" markers, the difference is less pronounced: h**eavy sweating** and f**ast heart rate** are slightly higher in Thatta while **Karachi** shows higher rates for other symptoms, specifically **cramps**

and **fever like symptoms**. This could reflect a different pattern of adaptation or environmental factors. These figures present a picture of a catastrophic health burden, signaling a public health crisis in Thatta. Extremely high rates of coma and fainting associated with heat are indicative of widespread and severe cases of medical emergencies. The disparity suggests that the women in Thatta lack access to critical cooling infrastructure (e.g., electricity, reliable water, or shaded structures) or are more frequently engaged in mandatory, physically strenuous outdoor work during peak temperatures. Even though Karachi has lower rates of the *most* severe symptoms, it still has significant heat-related issues, as evidenced by the higher incidence of cramps and fever-like symptoms. This likely reflects distinct challenges, such as the urban heat island effect or particular air quality factors that manifest differently physiologically.

8. History of chronic diseases in the past:

Table 11: Percent of pregnant women reporting a chronic disease that was present from prior to current pregnancy

Disease prior to pregnancy	Karachi	Thatta	Total	P-value
Diabetes Mellitus	32.0%	70.8%	54.0%	P < 0.001
Hypertension	35.3%	55.7%	46.9%	
Heart Disease	36.3%	70.5%	55.7%	

Source: Authors' computations.

Table 6 provides a snapshot of the prevalence of pre-existing chronic conditions among pregnant women in **Karachi** and **Thatta**. The data reveals a significantly higher burden of non- communicable diseases (NCDs) among pregnant women in Thatta. The most notable finding is the prevalence of **Diabetes Mellitus** (including past gestational diabetes). In **Thatta**, a staggering **70.8%** of pregnant women reported having diabetes prior to their pregnancy, which is more than double the rate found in **Karachi (32.0%)**. This suggests either a massive regional health crisis or specific genetic/dietary factors prevalent in the Thatta population. High blood pressure is also more common in **Thatta (55.7%)** compared to **Karachi (35.3%)**. Hypertension during pregnancy is a leading cause of maternal morbidity and mortality (e.g., pre-eclampsia), making this a high-risk factor for the Thatta cohort. Similarly, **Heart Disease** is also reported at a much higher frequency in **Thatta (70.5%)** than in **Karachi (36.3%)**. These differences are statistically significant (P < 0.001). That over 70% of pregnant women in Thatta enter pregnancy with pre-existing diabetes or heart disease is alarming. These women are at an extremely high risk for complications like stillbirth, preterm labor, and maternal death. However, one possible explanation is that the majority of the sample in Thatta lies in its district hospital, which is the main referral hospital for the district, attracting most of the high-risk pregnancies to its antenatal care. While Karachi has lower rates than Thatta, 1 in 3 pregnant women in the city still suffers from a chronic illness. This indicates that throughout the Sindh region, pregnancy is being complicated by a "double burden" of reproductive health needs and chronic disease management.

9. Dietary patterns – food items consumed during the past 24 hours:

Table 12: Percent of pregnant women reporting consumption of

Food Type	Karachi	Thatta	Total	P-value
SPICY FOOD	46.4%	53.1%	50.2%	0.026
FRIED FOOD	46.6%	43.9%	45.1%	0.382
SALTY FOOD	46.8%	36.4%	40.9%	< 0.001
SWEETS	48.0%	50.2%	49.3%	0.465
COFFEE, TEA, SODA	53.2%	22.4%	35.7%	< 0.001
ICE-CREAM	44.5%	53.7%	49.7%	0.002
MILK AND YOGURT	42.6%	58.4%	51.6%	< 0.001

Source: Authors' computations.

Table 7 highlights the dietary preferences and consumption patterns of participants in **Karachi** and **Thatta**, showing distinct urban-rural differences in how these populations fuel themselves. The most significant difference is found in the consumption of **Coffee, Tea, or Soda**. In **Karachi, 53.2%** of participants report high consumption, more than double the rate in **Thatta (22.4%)**. This suggests a heavy reliance on stimulants and processed beverages in the urban environment.

Interestingly, Thatta shows significantly higher consumption of **Milk/Yogurt (58.4%)** and **Ice Cream (53.7%)** compared to Karachi. This could be a cultural preference for traditional dairy- based diets or a specific response to heat stress in a rural setting. While both regions enjoy flavorful food, participants in **Thatta** lean more toward **Spicy Food (53.1%)**, whereas **Karachi** participants favor **Salty Food (46.8%)**. Finally, the fried foods and sweets show high prevalence in both sites (roughly 45–50%), indicating that high-calorie, processed snacks are a universal dietary staple regardless of the urban-rural divide. The P-values for **Salty Food, Coffee/Tea/Soda, Ice Cream, and Milk/Yog** are all **.002 or less**, indicating that the differences between Karachi and Thatta in these categories are **highly statistically significant**. However, the consumption of **Fried Food (P=.382)** and **Sweets (P=.465)** is statistically similar across both sites, suggesting these dietary habits are widespread across the region. It may be concluded that high intake of caffeine, soda, and salty foods in **Karachi**—coupled with the significant rates of chronic disease noted in previous tables—suggests an "urban diet" that may be contributing to hypertension and heart disease. At the same time, higher consumption of milk and yogurt in **Thatta** is a positive nutritional indicator, as these are primary sources of calcium and protein. However, the high intake of spicy food and ice cream in a high-heat environment could potentially complicate digestive health or indicate a high sugar intake.

Section II: Comparison of dietary patterns among women who received EANC with those who did not receive EANC

Table 13: Percent of pregnant women by dietary habits (food items consumed during the last 24 hours) by EANC status

Food Type	Karachi		Thatta		Total		
	Enhanced ANC Received						
	No	Yes	No	Yes	No	Yes	P-value
SPICY FOOD	43.8%	48.5%	52.3%	53.7%	48.4%	51.5%	0.026
FRIED FOOD	44.2%	48.5%	62.4%	30.6%	54.2%	38.1%	0.382
SALTY FOOD	38.7%	53.4%	50.8%	26.0%	45.3%	37.4%	< 0.001
SWEETS	41.0%	53.8%	61.3%	42.3%	52.2%	47.1%	0.465
COFFEE, TEA, SODA	60.8%	47.0%	31.2%	16.0%	44.5%	28.9%	< 0.001
ICE-CREAM	38.2%	49.6%	62.4%	47.4%	51.6%	48.3%	0.002
MILK AND YOGURT	37.3%	47.0%	68.8%	50.9%	54.7%	49.3%	< 0.001

Source: Authors' computations.

Table 8 evaluates the effectiveness of **Enhanced Antenatal Care (EANC) –** which specifically includes dietary advice and heat adaptation education—compared to routine care across Karachi and Thatta. By analyzing food consumption in the 24 hours prior, we can see how behavioral advice translated into actual dietary choices.

Dietary Behavior Changes:

Impact on High-Risk Intake (Salts and Stimulants): In **Thatta**, EANC appears highly effective in reducing intake of risky items. Salty food consumption dropped from **50.80%** to **26.00%**, and coffee/tea/soda dropped from **31.20%** to **16.00%**. In **Karachi**, however, the trend is reversed or less effective. Women receiving EANC actually reported *higher* intake of salty foods (**53.40%**) and sweets (**53.80%**) compared to those who did not.

Fried Food Reduction: A significant success of the EANC program in **Thatta** was the reduction of fried food intake by half (**62.40%** to **30.60%**). In Karachi, EANC had almost no impact on fried food consumption (**44.20%** vs **48.50%**).

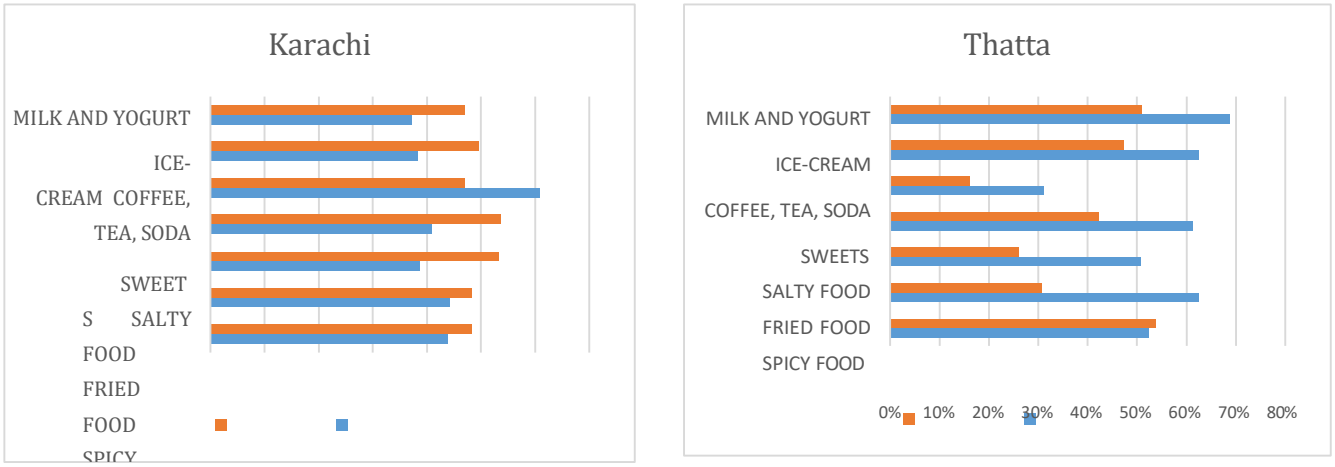
Nutritional Consistency (Milk and Yogurt): In both regions, women receiving EANC showed relatively high dairy intake (47–51%), though in Thatta, those *without* EANC actually had higher dairy consumption (**68.80%**). This might suggest that EANC is shifting the diet away from traditional heavy dairy toward other balanced options, or it highlights a baseline cultural difference.

The differences in consumption patterns between those who received EANC and those who didn't are **highly significant** for **Salty Food, Coffee/Tea/Soda, and Milk/Yogurt** (P **< 0.001)**. The EANC clearly altered dietary patterns, though the direction of that change varies by geography.

The EANC program seems significantly more effective at reducing "unhealthy" dietary markers (salts, fats, stimulants) in **Thatta** than in **Karachi**. This may be because women in rural areas have fewer "fast food" alternatives and are more likely to adhere strictly to healthcare provider advice. The fact that EANC recipients in Karachi still consumed high levels of salt and sweets suggests that urban lifestyle pressures—such as the availability of processed foods and work-related stress— may be undermining the effectiveness of dietary counseling. The significant reduction in caffeine (Coffee/Tea/Soda) in Thatta leads to successful implementation of the healthcare providers' instructions for dehydration prevention and heat adaptation. Future EANC modules may need to be "urban-tailored" for Karachi, focusing more on how to navigate processed food environments, while continuing the successful "habit-replacement" strategies that are working in Thatta.

Figure 4 presents a comparison of the two sites with regard to dietary patterns and exposure to EANC, showing clear differences in the use of most food items.

Figure 4: Percent of pregnant women reporting foods consumed in last 24 hours by type of ANC



Source: Authors' computations.

Section III: Comparison of knowledge, attitudes, and practices of heat adaptation among pregnant women who received EANC with those who did not receive EANC:

The knowledge, attitudes, and practices (KAP) survey questionnaire focused on the topics of dehydration, heat exposure, and heat stroke. These questions elicited the pregnant women's understanding and beliefs about heat mitigation and heat adaptation during pregnancy. We first compare the mean scores in these areas, calculated simply by summing up the correct answers to the KAP questions.

Table 14: Mean Total Scores of Knowledge, Attitude, and Practice of heat mitigation and heat adaptation measures by site and exposure to EANC

SITE	EANC		Total Knowledge Score (0-12)	Total Attitude Score (0-4)	Total Practice Score (0-27)
Karachi	No	Mean	8.8018	2.1336	20.6313
		N	217	217	217
	Yes	Mean	9.9886	2.9053	23.4811
		N	264	264	264
	Total	Mean	9.4532	2.5572	22.1954
		N	481	481	481
Thatta	No	Mean	6.6015	1.3120	15.5902
		N	266	266	266
	Yes	Mean	8.3631	2.6179	19.3360
		N	369	369	369
	Total	Mean	7.6252	2.0709	17.7669
		N	635	635	635
Total	No	Mean	7.5901	1.6812	17.8551
		N	483	483	483
	Yes	Mean	9.0411	2.7378	21.0648
		N	633	633	633
	Total	Mean	8.4131	2.2805	19.6756
		N	1116	1116	1116
P-value			P < 0.001	P < 0.001	P < 0.001

Source: Authors' computations.

Table 9 evaluates the effectiveness of **Enhanced Antenatal Care (EANC)** by comparing Knowledge, Attitude, and Practice (KAP) scores between women who received the specialized heat- adaptation education and those who received routine care in Karachi and Thatta.

Detailed Interpretation of Mean Scores

1. Total Knowledge Score (Range 0–12)

This score measures how much information the women retained regarding heat risks and adaptation strategies.

EANC Impact: In both Karachi and Thatta, women who received EANC scored significantly higher than those who did not. In Thatta, the jump was particularly notable, rising from a mean of 6.60 to 8.36. Karachi generally started with a higher baseline knowledge (8.80) compared to Thatta (6.60). This suggests that urban women may have more initial exposure to health information, but the EANC intervention successfully closed a large portion of that "knowledge gap" for rural women.

2. Total Attitude Score (Range 0–4)

This score reflects the women's perspective, beliefs, and willingness to adopt heat-protective behaviors.

EANC Impact: The intervention had a profound effect on attitudes. In Thatta, the score doubled from 1.31 to 2.61. In Karachi, it improved from 2.13 to 2.90. An improved attitude score is critical because it indicates that the

women did not just learn the facts; they began to value the importance of heat adaptation for their pregnancy health.

3. Total Practice Score (Range 0–27)

This is the most critical metric, as it measures actual behavioral changes (e.g., drinking more water, staying in the shade).

EANC Impact: There was a clear improvement in practices across both sites. Total mean scores for those with EANC (21.06) were significantly higher than the women who did not receive EANC (17.85). Karachi women showed the highest practice scores overall (23.48), suggesting they were very successful at implementing the education into their daily urban routines. Women in Thatta who received no EANC had the lowest scores across all categories. This aligns with the previous data showing lower education levels in Thatta, making them a "high-priority" group for intervention.

Consistency of Improvement: The most encouraging aspect of the data is that the **"Yes" (EANC)**

group consistently outperformed the **"No"** group in every single category at every site.

We conclude that there was **high intervention success;** the high levels of statistical significance (**P**

< 0.001) across all totals confirms that the Enhanced Antenatal Care program is an extremely effective tool for improving maternal health literacy and behavior regarding heat. Note that, while Thatta started with lower baseline scores, the EANC intervention brought their Attitude and

Practice scores much closer to Karachi's levels. This proves that specialized education can empower rural populations despite lower formal schooling. Note that the data shows a logical progression: EANC increased **Knowledge**, which shifted **Attitude**, which ultimately led to better **Practices**. This

validates the EANC model as a holistic way to protect pregnant women from climate-related health risks like heat stress.

Section IV: Comparison of the Risk of Heat Exposure, Dehydration, and Heat Stroke (Based Upon the Reported Symptoms) by Site and Exposure to EANC

Table 15: Mean Total Scores of the Risk of Heat Exposure, Dehydration, and Heat Stroke (Based Upon the Reported Symptoms) by Site and Exposure to EANC

SITE	EANC		Heat Exposure Score (0-5)	Dehydration Score (0-6)	Heat Stroke Score (0-6)	P-value
Karachi	No	Mean	2.6452	3.2949	2.3825	P < 0.001
		N	217	217	217	
	Yes	Mean	2.1288	2.8106	2.5492	
		N	264	264	264	
	Total	Mean	2.3617	3.0291	2.4740	
		N	481	481	481	
Thatta	No	Mean	2.4925	2.4850	3.5714	P < 0.001
		N	266	266	266	
	Yes	Mean	1.6938	2.0407	2.7669	
		N	369	369	369	
	Total	Mean	2.0283	2.2268	3.1039	
		N	635	635	635	
Total	No	Mean	2.5611	2.8489	3.0373	P < 0.001
		N	483	483	483	
	Yes	Mean	1.8752	2.3618	2.6761	
		N	633	633	633	
	Total	Mean	2.1720	2.5726	2.8324	
		N	1116	1116	1116	

Source: Authors' computations.

Table 15 provides a critical evaluation of how **Enhanced Antenatal Care (EANC)**—specifically focused on heat adaptation education—reduces the physiological risks of heat among pregnant women in Karachi and Thatta.

Detailed Interpretation of Risk Scores

1. Heat Exposure Score (Range 0–5)

This score quantifies the level of environmental and behavioral exposure to high temperatures.

EANC Impact: There is a clear reduction in exposure across both sites for women who received EANC. In Thatta, the mean score dropped from 2.49 to 1.69, and in Karachi, it fell from 2.64 to 2.12. This means that the education provided in the EANC program successfully encouraged

women to modify their environments or behaviors (e.g., seeking shade, avoiding peak sun hours) to lower their direct contact with extreme heat.

2. Dehydration Score (Range 0–6)

This score measures physiological indicators and symptoms associated with a lack of proper fluid intake.

EANC Impact: The intervention led to a significant decrease in dehydration risks. The total mean score for the EANC group (2.36) is notably lower than the routine care group (2.84). The reduction was most pronounced in

Thatta, where the score dropped by nearly 0.44 points. This suggests that dietary and hydration advice is particularly effective in rural settings where baseline risks may be higher due to physical labor.

3. Heat Stroke Score (Range 0–6)

This score tracks the most severe symptoms associated with heat-related illness, such as fainting, confusion, or high body temperature.

EANC Impact: In Thatta, receiving EANC resulted in a major drop in the Heat Stroke Score from

3.57 (the highest risk score in the table), down to 2.76. Interestingly, in Karachi, the scores remained relatively stable (around 2.3–2.5). This suggests that while urban women can reduce their *exposure*, the "Urban Heat Island" effect might make it harder to completely avoid the systemic physiological symptoms of heat stroke compared to rural areas where behavioral changes might have a more direct impact.

The data demonstrates a consistent downward trend in risk for women receiving EANC. The high levels of statistical significance ($P < 0.001$) for all totals confirms that these improvements are statistically significant. The program is not just increasing "knowledge" (as seen in previous tables) but is actively translating into reduced physiological risk.

These results are quite encouraging as they have a life-saving potential. The significant reduction in Heat Stroke Scores—especially in the high-risk Thatta region—suggests that EANC is a life- saving intervention that can prevent the most severe maternal complications associated with rising temperatures. The results also confirm that there was mitigation of dehydration. The lower Dehydration Scores provide the evidence that the dietary advice included in the EANC (reducing salts/caffeine and increasing fluids) is being followed and is effectively improving the hydration status of expectant mothers. Finally, targeted rural benefits are obvious. While effective everywhere, the intervention shows the most dramatic "gap closure" in Thatta. This indicates that rural populations, which often face the highest environmental heat risks, have the most to gain from specialized heat-adaptation counseling.

Section V: Qualitative comparison of the knowledge, attitudes, and practices of heat adaptation among pregnant women who received EANC with those who did not receive EANC:

Improvement in Knowledge:

Table 16: A qualitative comparison of the knowledge of pregnant women about heat mitigation and heat adaptation strategies during pregnancy, between women who received the EANC and those who received routine ANC

SITE			EANC		Total	P-value
			No	Yes		
Karachi	Knowledge Level	Poor	15.6%	9.8%	12.7%	
		Moderate	25.6%	32.8%	29.3%	
		Good	58.8%	57.4%	58.1%	
	Total		100.0%	100.0%	100.0%	P = 0.106
Thatta	Knowledge Level	Poor	57.1%	27.2%	40.1%	
		Moderate	13.4%	32.4%	24.2%	
		Good	29.6%	40.4%	35.7%	
	Total		100.0%	100.0%	100.0%	P < 0.001
Total	Knowledge Level	Poor	38.6%	20.5%	28.8%	
		Moderate	18.8%	32.6%	26.3%	
		Good	42.6%	46.9%	44.9%	
	Total		100.0%	100.0%	100.0%	P < 0.001

Source: Authors' computations.

Table 11 evaluates the impact of EANC on the knowledge levels of pregnant women regarding heat mitigation and adaptation. Participants fall into the **Poor**, **Moderate**, or **Good** knowledge levels based on their assessment scores.

1. Impact in Thatta (Rural/Semi-Urban)

The intervention was most transformative in Thatta, where baseline knowledge was significantly lower. Without EANC, a staggering **57.1%** of women had poor knowledge. This dropped drastically to **27.2%** after receiving the enhanced education. The percentage of women with a "Good" knowledge level rose from **29.6%** to **40.4%**. These changes were highly significant in statistical terms (**P < 0.001**), proving that structured education is an effective tool in rural settings where formal schooling may be lower.

2. Impact in Karachi (Urban)

Karachi women started with a much higher baseline of knowledge, making the impact of the EANC intervention appear more subtle. Even without EANC, **58.8%** of Karachi women already had "Good" knowledge levels. The intervention reduced the "Poor" knowledge group from **15.6% to 9.8%** and increased the "Moderate" group. The observed changes in the knowledge categories are not statistically significant (**P = 0.106**). The observed changes are not as dramatic as in Thatta, probably because the urban population already had better access to general health information.

3. Overall Trends

When looking at the combined data for both sites, we can examine the **EANC effectiveness.** The "Poor" knowledge category was nearly halved, dropping from **38.6% to 20.5%** overall.

Consequently, there is a **shift toward "Moderate" and "Good"** categories of knowledge' the intervention successfully pushed a large segment of the population into higher categories, with **46.9%** of all EANC recipients achieving a "Good" knowledge level.

These data reveal a clear **"Catch-Up" effect**. The EANC program acted as a powerful equalizer for women in Thatta, bringing their knowledge levels much closer to their urban counterparts in Karachi. While urban women in Karachi benefitted, the rural population in Thatta showed the most significant behavioral and cognitive growth from the intervention.

We conclude that the EANC module is highly effective at teaching pregnant women about heat mitigation. It successfully moves women out of the "Poor" knowledge category and into "Moderate" or "Good" levels. In particular, the EANC is **crucial for the rural populations.** Because Thatta had such high levels of "Poor" knowledge initially (**57.1%**), the EANC program is essential for rural maternal health. It fills a critical gap that routine antenatal care currently misses.

Improvement in Attitude:

Table 17: A qualitative comparison of the attitudes of pregnant women toward the heat mitigation and heat adaptation strategies during pregnancy, between women who received the EANC and those who received routine ANC

SITE			EANC		Total	P-value
			No	Yes		
Karachi	Level of Attitudes	Poor	28.6%	9.1%	17.9%	
		Moderate	28.1%	18.6%	22.9%	
		Good	43.3%	72.3%	59.3%	
	Total		100.0%	100.0%	100.0%	P < 0.001
Thatta	Level of Attitudes	Poor	61.7%	32.5%	44.7%	
		Moderate	18.4%	12.5%	15.0%	
		Good	19.9%	55.0%	40.3%	
	Total		100.0%	100.0%	100.0%	P < 0.001
Total	Level of Attitudes	Poor	46.8%	22.7%	33.2%	
		Moderate	22.8%	15.0%	18.4%	
		Good	30.4%	62.2%	48.5%	
	Total		100.0%	100.0%	100.0%	P < 0.001

Source: Authors' computations.

Table 17 evaluates the effectiveness of EANC in shifting the attitudes of pregnant women toward heat mitigation and adaptation. The data categorizes their mindsets into **Poor**, **Moderate**, or **Good** levels.

1. Impact in Karachi (Urban)

In Karachi, the intervention significantly bolstered an already receptive population. Among those receiving EANC, the percentage of women with a "Good" attitude jumped from **43.3% to 72.3%**. The number in the "Poor" category reduced by more than two-thirds, dropping from **28.6% down to 9.1%**. The changes were highly significant statistically (**P < 0.001**), indicating that the EANC education module was effective at convincing urban women of the importance of heat adaptation.

2. Impact in Thatta (Rural/Semi-Urban)

Thatta showed the most dramatic improvement in baseline sentiment. Initially, a majority of women (**61.7%**) held a "Poor" attitude toward heat adaptation. After the EANC intervention, this plummeted to **32.5%**. The percentage of women with a "Good" attitude nearly **tripled**, rising from **19.9% to 55.0%**. The changes were highly significant statistically (**P < 0.001**), indicating that the EANC education module was effective at convincing urban women of the importance of heat adaptation.

3. Overall Trends

Looking at the aggregate data, the EANC intervention doubled the overall percentage of women with a "Good" attitude (**30.4% vs. 62.2%**). The EANC also proved to be a powerful tool for reducing apathy or misinformation, as the total "Poor" attitude category dropped from **46.8% to 22.7%**.

These findings highlight a **perception shift**. Attitude is often the hardest metric to change because it involves breaking long-held cultural beliefs or habits. The EANC program successfully moved women from a state of relative indifference ("Poor") to a state of active concern and readiness ("Good"). Notably, while Thatta's baseline was much lower, the intervention was able to bring more than half of the rural cohort into the "Good" category, demonstrating that clear, focused health education can overcome geographic and educational barriers.

We conclude that **t**he significant increase in "Good" attitude levels across both sites suggests that women are not just learning facts, but are becoming psychologically prepared to adopt protective behaviors. The intervention is particularly critical in rural areas like Thatta. Moving a majority of women out of the "Poor" attitude category is a prerequisite for any physical behavioral change (like increased water intake or seeking shade). These findings, which are a statistically significant, provide evidence for a high return on investment for public health. Changing a mother's attitude is a sustainable way to ensure she protects both herself and her unborn child from heat-related risks. The evidence generate thus supports the recommendation for mandatory inclusion of heat-adaptation counseling in standard antenatal care protocols for heat-vulnerable regions.

Improvement in Practices:

Table 18: A qualitative comparison of the practices of pregnant women for heat mitigation and heat adaptation during pregnancy, between women who received the EANC and those who

SITE			EANC		Total	
			No	Yes		
Karachi	Level of Practice	Poor	3.7%	.4%	1.9%	
		Moderate	41.9%	15.5%	27.4%	
		Good	54.4%	84.1%	70.7%	
	Total		100.0%	100.0%	100.0%	P < 0.001
Thatta	Level of Practice	Poor	22.6%	7.3%		
		Moderate	50.4%	56.4%		
		Good	27.1%	36.3%		
	Total		100.0%	100.0%	100.0%	P < 0.001
Total	Level of Practice	Poor	14.1%	4.4%		
		Moderate	46.6%	39.3%		
		Good	39.3%	56.2%		
	Total		100.0%	100.0%	100.0%	P < 0.001

Source: Authors' computations.

Table 18 illustrates the impact of EANC on the actual behaviors and practices adopted by pregnant women to mitigate heat stress. The table categorizes the participants into **Poor**, **Moderate**, or **Good** practice levels based on their adherence to heat-protective strategies.

1. Impact in Karachi (Urban)

The EANC intervention led to an exceptional level of behavioral adoption in the urban cohort. For women receiving EANC, the percentage achieving a "Good" practice level surged from **54.4% to 84.1%**. The "Poor" practice category nearly disappeared, dropping from **3.7% to a negligible 0.4%**. This suggests that urban women in Karachi were highly successful at integrating the heat adaptation education into their daily routines. The observed differences between EANC and routine ANC groups were statistically significant (P < 0.001).

2. Impact in Thatta (Rural/Semi-Urban)

In Thatta, the intervention was critical in moving women away from high-risk behaviors. Without EANC, nearly 1 in 4 women (**22.6%**) had "Poor" heat-mitigation practices. With the intervention, this dropped significantly to **7.3%**. The percentage of women with "Good" practices increased from **27.1% to 36.3%**, with the majority moving into the **"Moderate"** category (**56.4%**). This signifies that, while rural women faced more environmental challenges, the EANC program successfully improved the safety profile of their daily activities. The observed differences between EANC and routine ANC groups were statistically significant (P < 0.001).

3. Overall Trends

Looking at the aggregate results for both regions, the overall percentage of women with "Good" practices increased from **39.3% to 56.2%**. Moreover, the EANC intervention successfully reduced the total "Poor" practice category from **14.1% to 4.4%**.

The data confirms that the EANC program is highly effective at translating **knowledge** and **attitude** into **action**. There is a distinct "ladder of improvement" visible: women who previously engaged in high-risk behaviors (Poor) moved into the safer Moderate and Good categories after receiving specialized counseling. The success in Karachi suggests that when given the tools, urban populations can reach very high levels of protective compliance, while the results in Thatta show that even in resource-limited settings, significant behavioral improvements are achievable.

We conclude that the EANC intervention is highly successful at changing how pregnant women behave during heatwaves. It significantly reduces the prevalence of dangerous or "Poor" practices that lead to heat-related illness. It appears that the EANC intervention is also a vital equalizer. It helped rural women in Thatta—who are often more exposed to the elements—adopt the previously underutilized safer practices. The adherence rates were high, jumping to **84.1% "Good" practices** in Karachi, indicating that the education provided is practical, easy to understand, and highly actionable for the participants. Hence the most important message of our analysis is regarding **maternal safety**, because practicing the heat mitigation and adaptation strategies is the final line of defense against heat stroke and dehydration, as well as a robust prevention against pregnancy complications such as eclampsia and preterm births. This provides strong evidence for the nationwide rollout of heat-specific antenatal counseling in the form of EANC.

CONCLUSIONS

We have achieved the following outcomes from this project:

1. We have gathered scientific evidence on the association between exposure to elevated ambient temperatures during pregnancy and adverse maternal, fetal, and neonatal outcomes.
2. We have developed an outline for a standardized plan for uninterrupted RMNCH services during floods at the public sector health facilities in rural Thatta district.
3. We have revised antenatal care protocols incorporating assessment of maternal exposure to heat, targeted treatment, health education, and birth preparedness plans.
4. We have successfully imparted heat adaptation education to the pregnant women, which includes personal and home-based solutions for excessive heat.
5. We have trained the facility-based healthcare providers in revised antenatal care protocols, safe and hygienic delivery, and postnatal and neonatal care.

Expected Impact on Policy

1. In a rapidly warming world, the health of mothers and newborns faces unprecedented and unrecognized challenges. We hope that our research and intervention project will bring together climate change and health to safeguard maternal and newborn health and well- being by addressing the adverse impact of climate change on pregnancy outcomes and newborn survival. Our approach of introducing EANC prepared the healthcare providers in the assessment and treatment of climate-related disorders among pregnant women. The providers imparted health education to prepare the pregnant women in methods to safeguard themselves from adverse effects of extreme heat and to take necessary measures to cool down their homes using nature-based solutions (green rooftops, insulation, natural ventilation, cooling devices, and planting rapidly growing trees and indoor plants in homes).
2. Our project was about driving change at the local and district levels, with an ultimate goal to influence national and provincial policymakers and institutionalize maternal and newborn health interventions within disaster management frameworks.

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