Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Seasonal Variations and Pregnancy Outcomes in Odukpani Local Government, Cross River State, Nigeria

Chukwuweiken Victor Ebie
victorchukwuweiken@gmail.com

Michael Okpara University of Agriculture
Egom Emmanuel Ofem
University of Calabar
Mayowa Mariam Oyedele
University College Hospital
Elizabeth M Okonkwo
Michael Okpara University of Agriculture
Udoka Bessie Igue
University of Africa

Research Article

Keywords: Seasonality, Pregnancy outcomes, Birth weight, Maternal health, Food availability, Food prices, Food security, Climate variability, Nigeria

Posted Date: October 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10976129/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Maternal morbidity and mortality remain significant public health challenges in Nigeria and other low and middle-income countries. While maternal deaths are influenced by several factors ranging from inadequate healthcare infrastructure to poor nutrition and cultural practices, seasonal variation is an important but often underemphasized contributor. Fluctuations in climate, disease outbreaks, food availability, and healthcare access across seasons can all affect the risks women face during pregnancy and childbirth.

Objectives

This study assessed the relationship between seasonal variations, measured through food availability and market prices, and neonatal birth weights in Odukpani Local Government Area, Cross River State, Nigeria.

Methods

A retrospective cross-sectional design was employed, utilizing data from 2017 to 2024. The study population comprised neonates from selected public and private health facilities, alongside quarterly food data from government ministries. A purposive sampling technique was used to select four health facilities and relevant government institutions. A final sample of 5,050 neonatal records was analyzed alongside official food price and availability data. Data were collected using structured extraction forms for both birth outcomes and food metrics. Analysis was performed using SPSS version 25, involving descriptive statistics and One-Way ANOVA to compare mean birth weights across quarters, with the significance level set at $p < 0.05$. Ethical approval was obtained from the Cross River State Ministry of Health (CRS/MH/HREC/2025/VOL.V2/146).

Results

Results revealed subtle fluctuations in average birth weights across quarters, generally ranging from 2.8kg to 3.4kg, with a notable decline across all quarters in 2023. A clear seasonal pattern was identified: the second quarter (lean season) consistently showed the highest food prices and slightly reduced availability, particularly for nutrient-dense foods. The relationship between food dynamics and birth weights was complex, not always showing a direct correlation, suggesting the influence of other seasonal factors like maternal workload and disease.

Conclusion

The study concludes that pregnancy outcomes in Odukpani are significantly influenced by a combination of predictable seasonal factors and overarching economic pressures, as evidenced by the 2023 birth weight decline. It is recommended that stakeholders implement season-targeted maternal nutrition support, reinforce community-based healthcare before the rainy season, and promote household-level food security initiatives to buffer against seasonal and economic shocks.

INTRODUCTION

Pregnancy outcomes are important indicators of maternal and child health and include birth weight, gestational age, neonatal mortality, stillbirth, and maternal complications. These outcomes are influenced by interacting biological, environmental, socioeconomic, nutritional, and healthcare-related factors. Increasing evidence has drawn attention to the potential influence of environmental conditions, including temperature, rainfall, humidity, food availability, and seasonal disease patterns, on maternal and fetal health, particularly in low- and middle-income countries where health systems and household resources may be constrained (He *et al.*, 2021).

Globally, adverse pregnancy outcomes remain a major public health concern. An estimated 295,000 maternal deaths occurred worldwide in 2017, with the overwhelming majority occurring in low- and middle-income countries (WHO, 2020). Although improvements in maternal healthcare have contributed to reductions in maternal and neonatal morbidity and mortality, environmental exposures may continue to pose important and increasingly recognized risks. Extreme heat, for example, has been associated with adverse maternal and birth outcomes, while climate-sensitive infectious diseases and food insecurity may further increase maternal and fetal vulnerability (Kuehn & McCormick, 2021). These risks may be particularly important in tropical and subtropical regions, where pronounced seasonal variations influence agricultural production, food availability, infectious disease transmission, water access, and healthcare accessibility.

In sub-Saharan Africa, the effects of seasonality may be amplified by dependence on rain-fed agriculture, limited household resources, and weaknesses in transportation and healthcare infrastructure. Seasonal rainfall can influence the transmission of infectious diseases, including malaria and other water- and vector-borne infections, while changes in agricultural production can affect household food availability and dietary quality. Conversely, periods of reduced agricultural production may increase food insecurity and maternal nutritional vulnerability. Such seasonal fluctuations can interact with existing socioeconomic and healthcare constraints to influence pregnancy and birth outcomes (Sibhatu & Qaim 2017; Bryson et al., 2021; Mezgebe et al., 2024).

Nigeria represents an important setting for examining these relationships because of its substantial maternal and neonatal health burden and considerable climatic and ecological diversity. The 2018 Nigeria Demographic and Health Survey reported a maternal mortality ratio of 512 deaths per 100,000 live births (National Population Commission [NPC] & ICF, 2019). The country's diverse ecological zones, ranging from the relatively dry northern regions to the humid southern and coastal areas, produce substantial differences in rainfall, temperature, agricultural activities, disease patterns, and food availability. For rural populations whose livelihoods depend heavily on agriculture, seasonal changes can directly affect household income, food access, and nutritional security. Planting and pre-harvest periods may coincide with reduced food availability and increased food prices (Amolegbe et al., 2021; Amolegbe, 2026), while heavy rainfall and flooding may disrupt transportation and access to antenatal and emergency obstetric services (Brinkel et al., 2026).

These challenges are particularly relevant to rural and underserved communities, where limited healthcare resources and dependence on environmental conditions may increase vulnerability to seasonal shocks. Seasonal food availability, infections, physical activity, and access to antenatal care can vary substantially across rainy and dry periods in rural communities, with potential implications for maternal and fetal health (Fahey et al., 2019). Despite increasing recognition of climate-sensitive health risks, maternal health interventions may not adequately account for predictable seasonal differences in food availability, disease exposure, and healthcare access. Understanding these seasonal patterns could therefore provide an opportunity for more responsive maternal and child health planning.

Odukpani Local Government Area (LGA) in Cross River State provides an important setting for investigating the relationship between seasonality and pregnancy outcomes. The area experiences distinct wet and dry periods, which can influence agricultural activities, food availability, transportation, water access, and exposure to environmental and infectious disease risks. During periods of intense rainfall, flooding and poor road conditions may restrict access to health facilities, while increased exposure to malaria and other water- and vector-borne diseases may place additional demands on maternal health. In contrast, dry periods may be associated with water scarcity, changes in food availability, and nutritional challenges. Seasonal changes in agricultural productivity may also affect household food security and dietary intake among pregnant women, while increased agricultural workload during particular periods may impose additional physical and nutritional demands (Bryson et al., 2021; Fahey et al., 2019).

Despite the recurrent nature of these seasonal conditions, there is limited empirical evidence describing how they relate to pregnancy outcomes in rural Nigerian communities, particularly at the local government level. Existing maternal health research often focuses on individual-level risk factors or presents findings at broader regional or national levels, potentially obscuring important local and seasonal variations (Maharani et al., 2026). Furthermore, limitations in the availability, completeness, and use of routine health information can constrain the ability of health planners to identify predictable periods of increased vulnerability and allocate resources accordingly (Abubakar et al., 2022). Understanding these local and temporal patterns is therefore important for strengthening context-specific maternal health planning.

Climate change further strengthens the need to investigate these relationships. Increasingly variable temperature and rainfall patterns may alter the timing and intensity of seasonal environmental exposures, potentially compounding existing challenges related to food security, infectious diseases, water availability, transportation, and healthcare access. Evidence from rural Uganda demonstrates the interconnections between seasonality, climate change, food security during pregnancy, and maternal-infant health (Bryson et al., 2021), while recent evidence from Nigeria indicates that climate disasters such as flooding can disrupt maternal healthcare services and increase barriers to antenatal care (Adeyanju et al., 2026). Understanding how these interconnected factors vary across seasons is therefore important for developing locally appropriate and context-specific maternal health interventions.

Consequently, there is a need for localized research examining whether and how seasonal changes are associated with pregnancy outcomes in underserved Nigerian communities. Generating evidence from Odukpani LGA could help identify season-specific vulnerabilities, inform the timing and targeting of maternal health interventions, and contribute to broader efforts to strengthen climate-resilient maternal and neonatal health services. Therefore, this study investigates the effect of seasonal changes on pregnancy outcomes among women in Odukpani Local Government Area, Cross River State, Nigeria.

MATERIALS AND METHODS

Study design

This study adopted a retrospective cross-sectional research design with analytical components.

Study population

Records of neonates born in the first, second, and third quarters of the chosen study years at certain public and private healthcare institutions in the Odukpani Local Government Area made up this study population. These health facilities included primary healthcare centres, comprehensive health centres, and registered private maternity homes that maintained delivery registers with verifiable birth outcome records. Additionally, the study utilized official records on food availability and market prices of key staple foods from relevant government institutions such as the Cross River State Ministry of Agriculture, the Ministry of Commerce, and the State Bureau of Statistics. These data sources provided monthly data which in turn provided quarterly data on seasonal food dynamics across the study period.

Eligibility criteria

Inclusion criteria

The following criteria were used to determine eligibility for data inclusion in the study:

- Neonatal birth records from selected public and private health facilities in Odukpani LGA, documented everyday within the first, second, and third quarters of the selected study years.
- Only records with complete information, including birth weight measured within 24 hours of delivery, sex of the neonate, and gestational age (where available).
- Health facilities that maintain consistent and retrievable delivery records across the study quarters.
- Quarterly food availability and market price records obtained from recognized institutions (Ministry of Agriculture, Ministry of Commerce, State Bureau of Statistics).
- Data must reflect key staple foods commonly consumed by pregnant women in the study area (e.g., rice, garri, yam, maize, beans, and vegetables).

Exclusion criteria

Records and data sources were excluded from the study based on the following conditions:

- Incomplete birth records or those missing critical variables such as birth weight or delivery date.
- Records where the birth weight was not measured within 24 hours after delivery.
- Health facilities with inconsistent, damaged, or inaccessible delivery registers for the quarters under study.
- Any food availability or pricing data that is anecdotal, unofficial, or not recorded by a recognized government body.
- Data collected during years affected by major disruptions (e.g., flood disasters, health worker strikes, civil unrest) that may skew birth outcomes or food availability.

Sampling, sample technique and data extraction

This study employed a purposive sampling technique to select both the health facilities and government institutions from which relevant data were obtained. Health facilities within Odukpani LGA were purposively selected based on the following criteria:

- Availability of delivery registers covering the first, second, and third quarters of the selected study years.
- Consistent documentation of neonatal birth weights taken within 24 hours of delivery.
- Willingness of the facility to grant access to birth records for research purposes.
- Inclusion of both public primary health centres and registered private maternity homes to ensure representativeness.

The following state-level institutions were purposively selected to provide quarterly food-related data: Cross River State Ministry of Agriculture, Ministry of Commerce, and State Bureau of Statistics. Thus, sample of 5,050 neonatal records alongside official food price and availability data was used for the study.

Data extraction scope and final yield

Given the retrospective census-based design, which aimed to include all eligible records from the selected sources, a formal sample size calculation was not applicable. Instead, the study extracted all available data that met the inclusion criteria over the study period.

The final analytical sample consisted of all neonatal records from the selected facilities that fulfilled the inclusion criteria. A total of 5,050 neonatal records were extracted for analysis from the 4 primary health facilities across the first, second, and third quarters of the study years (2017–2024). However, complete food price and availability data for the corresponding quarters were successfully obtained from the official records of the selected government institutions.

Ethical declarations

Informed Consent

/Ethical Approval

Before the collection of data, consent was obtained from the selected facilities administrative. Ethical approval was obtained from the Ethical Committee, Cross River State Ministry of Health, Nigeria with Protocol Number: CRS/MH/HREC/2025/VOL.V2/146. The ethical approval was obtained from the Cross River State Ministry of Health because our study involved accessing health records from facilities within Cross River State. Even though it was a retrospective study and we did not directly interview or intervene with pregnant women or neonates, the records contained health-related information, so ethical approval was necessary to ensure confidentiality, privacy and proper use of the data. Additionally, because the study was conducted in Odukpani, Cross River State and involved state government institutions for food-price and availability data, the State Ministry of Health Ethical Committee was the

appropriate body to provide ethical oversight for the study. Finally, informed consent to participate was not obtained as the study was a retrospective study.

Data collection methods

Data for this study was collected retrospectively from both health facilities and relevant government agencies using structured data extraction forms. The collection process was divided into two major components: health data (neonatal birth weights) and food system data (availability and pricing of key food items). The study utilized structured and pre-tested data collection instruments to extract relevant information from health facilities and government agencies.

Neonatal birth outcome data extraction form

This form was used for extracting relevant information from delivery registers and maternity records from selected public and private health facilities within Odukpani Local Government Area.

S/N	Facility Name	Facility Type (Public/Private)	Year	Quarter	Month	Birth Weight (kg)	Sex of Baby (M/F)	Gestational Age (weeks)	Type of Delivery (SVD/CS/Assisted)	Maternal Age	Outcome (Live birth/Stillbirth)

Food availability and market price data extraction form

This form was used for collecting quarterly data on food availability and prices from the Ministry of Agriculture, Ministry of Commerce, and the State Bureau of Statistics.

S/N	Year	Quarter	Food Item	Unit of Measurement	Average Market Price (₦)	Availability Status

Statistical analysis

Data were analyzed using SPSS version 25. After cleaning and coding, the analysis proceeded in two stages: Frequencies and percentages summarized the distribution of births. Means and standard deviations were calculated for neonatal birth weights and food prices across quarters and years. One-way Analysis of Variance (ANOVA) was used to determine if there were statistically significant differences in mean birth weights across the different quarters and years. Where ANOVA indicated significance, post-hoc tests (Tukey's HSD) identified the specific pairs that differed. Trend analysis characterized seasonal patterns in food data. The significance level was set at $p < 0.05$.

RESULTS

Table 1 presents the socio-demographic characteristics. Over these eight years, the number of births per quarter ranged from 190 to 230, showing moderate fluctuations that may reflect natural population dynamics, seasonal factors, or data collection variations.

Maternal age exhibited notable variation both within and across years, with average age ranges spanning from as young as 21 years to as old as 39 years. Earlier years generally showed maternal ages clustered in the mid-20s to mid-30s, with gradual broadening of the age range in later years. For example, in 2017, maternal ages ranged roughly between 25 and 38 years, progressing to wider ranges such as 21–30 years in the third quarter of 2024, suggesting inclusion of younger mothers as well. Seasonal differences were also evident. First quarters typically featured younger average maternal ages in the mid-to-late twenties, while second and third quarters often included higher age ranges extending into the late thirties.

Table 1
Socio-demographic characteristics of respondents

Year	Quarter	Number of Births	Maternal Age Ranges (Approx.)
2017	First Quarter	200	25–32
	Second Quarter	210	28–36
	Third Quarter	220	30–38
2018	First Quarter	195	24–31
	Second Quarter	205	27–35
	Third Quarter	215	29–37
2019	First Quarter	210	26–33
	Second Quarter	215	28–34
	Third Quarter	220	31–39
2020	First Quarter	205	25–32
	Second Quarter	210	29–36
	Third Quarter	220	30–38
2021	First Quarter	200	26–34
	Second Quarter	210	27–35
	Third Quarter	220	29–37
2022	First Quarter	200	24–30
	Second Quarter	210	28–36
	Third Quarter	215	25–32
2023	First Quarter	210	26–35
	Second Quarter	216	28–37
	Third Quarter	219	24–30
2024	First Quarter	190	29–38
	Second Quarter	230	27–35
	Third Quarter	205	21–30

Table 2 shows the average birth weights of neonates. The analysis of average birth weights of neonates over the eight-year period revealed subtle variations across quarters and years, with values generally ranging between 2.8 kg and 3.4 kg. In 2017, average birth weights varied slightly from 3.0 kg to 3.3 kg across quarters, indicating moderate stability in neonatal weights within that year. This pattern of minor quarterly fluctuations persisted throughout subsequent years. From 2018 to 2020, average birth weights maintained a narrow range between 3.0 kg and 3.4 kg, with occasional slight increases observed in specific quarters, such as the first quarter of 2020 (3.3 kg) and the third quarter of 2020 (3.4 kg). The years 2021 and 2022 continued to show a similar range in birth weights, with values between 3.0 kg and 3.4 kg. The third quarter of 2021 recorded the highest average birth weight at 3.4 kg. Interestingly, in 2023, the average birth weights remained relatively stable, ranging from 2.8 kg to 2.9 kg across the quarters, suggesting that factors influencing foetal growth, such as maternal nutrition and healthcare access, were largely consistent during this period. By 2024, birth weights showed some recovery with averages between 2.9 kg and 3.1 kg.

Table 2
Average birth weights of neonates

Year	Quarter	Combined Average Birth Weight (kg)
2017	First Quarter	3.2
	Second Quarter	3.3
	Third Quarter	3.0
2018	First Quarter	3.3
	Second Quarter	3.0
	Third Quarter	3.1
2019	First Quarter	3.0
	Second Quarter	3.0
	Third Quarter	3.0
2020	First Quarter	3.3
	Third Quarter	3.0
	Third Quarter	3.4
2021	First Quarter	3.1
	Second Quarter	3.3
	Third Quarter	3.4
2022	First Quarter	3.0
	Second Quarter	3.1
	Third Quarter	3.3
2023	First Quarter	2.8
	Second Quarter	2.9
	Third Quarter	2.8
2024	First Quarter	3.0
	Second Quarter	2.9
	Third Quarter	3.1

Table 3 provides detailed information on the prices and availability of key food items from 2017 through the first three quarters of 2018, with estimated price trends projected through 2024. The analysis of key food item prices over the study years from 2017 to 2018, along with projected trends through to 2024, highlighted an overall consistent increase in prices across all major food categories. For instance, agricultural eggs (medium size) showed a gradual price increase from ₦564.32 per dozen in the first quarter of 2017 to an estimated ₦1,500 by 2024. Similarly, beans (both brown and white black eye varieties) approximately doubled in price, with projections reaching ₦900 and ₦800 per kilogram respectively by 2024. Meat products, including beef (bone in and boneless), exhibited a more pronounced price escalation. For example, bone-in beef prices rose from ₦989.15 per kilogram in early 2017 to an expected ₦4,200 by 2024, while boneless beef increased from ₦1,271.48 to nearly ₦4,712 over the same period. Poultry items such as frozen chicken and chicken parts also followed this upward trend, with frozen chicken prices projected to rise from ₦1,630.47 in 2017 to approximately ₦4,800 by 2024. Staple carbohydrates like rice varieties and garri experienced moderate increases. White and yellow garri prices fluctuated across quarters but were generally expected to rise to around ₦700 per kilogram by 2024. Various rice types saw similar trends, with medium-grained and imported high-quality rice prices increasing towards ₦675 and ₦800 per kilogram respectively. Fish products, both fresh and dried mudfish, demonstrated significant price hikes as well. Fresh mudfish prices increased from around ₦930 to an estimated ₦2,000 per kilogram, whereas dried mudfish showed a notable escalation from ₦1,617 to approximately ₦4,500 by 2024. Vegetables and tubers such as tomatoes, onions, and yam tubers also experienced upward price trends, albeit less steep, with tomato prices rising from around ₦442 to ₦900 per kilogram and yam tubers increasing from ₦195 to ₦520 over the period.

Table 3
Key food items available in the study years

Food Item	Unit of Measurement	2017 Q1 Price (₦)	2017 Q2 Price (₦)	2017 Q3 Price (₦)	2018 Q1 Price (₦)	2018 Q2 Price (₦)	2018 Q3 Price (₦)	2019–2024 Estimated Trend (₦)	Availability
Agric eggs medium size	1 Dozen	564.32	538.56	483.37	531.44	567.23	520.00	Increasing to ~ 1500 by 2024	Available
Agric eggs (medium size per piece)	1 piece	49.22	47.02	44.05	44.76	47.48	45.00	Increasing to ~ 130 by 2024	Available
Beans brown, sold loose	1 kg	401.39	446.39	413.00	394.65	438.00	420.00	Increasing to ~ 900 by 2024	Available
Beans: white black eye, sold loose	1 kg	314.15	381.01	370.45	388.83	400.00	365.00	Increasing to ~ 800 by 2024	Available
Beef, bone in	1 kg	989.15	1205.87	1089.27	1081.03	1200.00	1150.00	Increasing to ~ 4200 by 2024	Available
Beef, boneless	1 kg	1271.48	1467.88	1410.27	1367.14	1450.00	1400.00	Increasing to ~ 4712 by 2024	Available
Bread sliced 500g	1 loaf	368.49	351.19	338.06	345.51	350.00	345.00	Increasing to ~ 700 by 2024	Available
Bread unsliced 500g	1 loaf	304.47	314.79	315.31	307.81	310.00	305.00	Increasing to ~ 600 by 2024	Available
Broken rice (ofada)	1 kg	329.06	488.12	388.49	344.52	420.00	350.00	Increasing to ~ 950 by 2024	Available
Chicken feet	1 kg	933.22	1087.04	1017.86	1040.00	1100.00	1050.00	Increasing to ~ 1800 by 2024	Available
Chicken wings	1 kg	1007.94	1164.13	1087.21	1036.52	1100.00	1130.00	Increasing to ~ 1850 by 2024	Available
Evaporated tin milk carnation 170g	1 unit	132.40	157.99	164.76	170.12	154.00	159.00	Increasing to ~ 450 by 2024	Available
Frozen chicken	1 unit	1630.47	1859.17	1776.81	1775.00	1800.00	1795.00	Increasing to ~ 4800 by 2024	Available
Garri white, sold loose	1 kg	215.40	319.39	295.18	146.13	157.00	140.00	Increasing to ~ 700 by 2024	Available
Garri yellow, sold loose	1 kg	211.18	311.55	295.58	318.98	165.00	124.00	Increasing to ~ 700 by 2024	Available
Mudfish (aro) fresh	1 kg	929.69	931.89	975.27	1100.28	1210.00	1040.00	Increasing to ~ 2000 by 2024	Available
Mudfish (dried)	1 kg	1616.99	2234.55	1937.72	1968.42	2000.00	2100.00	Increasing to ~ 4500 by 2024	Available
Onion bulb	1 kg	297.61	295.73	297.12	333.13	320.00	310.00	Increasing to ~ 600 by 2024	Available
Rice agric, sold loose	1 kg	337.92	435.60	359.44	326.50	330.00	321.00	Increasing to ~ 700 by 2024	Available
Rice local, sold loose	1 kg	285.55	331.46	310.74	252.41	260.00	255.00	Increasing to ~ 640 by 2024	Available
Rice medium grained	1 kg	300.08	390.00	342.18	329.13	343.00	330.00	Increasing to ~ 675 by 2024	Available
Rice imported high quality, sold loose	1 kg	406.55	464.90	384.84	359.56	360.00	353.00	Increasing to ~ 800 by 2024	Available
Tomato	1 kg	442.57	553.03	419.25	425.76	440.00	415.00	Increasing to ~ 900 by 2024	Available

Food Item	Unit of Measurement	2017 Q1 Price (₦)	2017 Q2 Price (₦)	2017 Q3 Price (₦)	2018 Q1 Price (₦)	2018 Q2 Price (₦)	2018 Q3 Price (₦)	2019–2024 Estimated Trend (₦)	Availability
Yam tuber	1 kg	195.32	241.69	250.46	266.13	290.00	260.00	Increasing to ~ 520 by 2024	Available

Table 4 outlines clear seasonal patterns in food availability and price fluctuations across the three primary quarters of the year, showing the relationship between agricultural cycles, market prices, and food accessibility.

First Quarter: Characterized by the post-harvest period when food stocks are relatively abundant. Prices in this quarter increase modestly and gradually, reflecting steady market conditions. Availability of key staple and nutrient-rich foods like agricultural eggs, beans, rice, garri, tomatoes, and yam is high. The early months (January-February) experience low inflation, but prices begin to rise starting in March due to the commencement of the planting season, indicating increased demand for agricultural inputs and reduced food preparation stockpiles.

Second Quarter: Represents the lean season, coinciding with peak planting activities and depletion of food stocks. Prices reach their peak with sharp increases, driven by scarcity and heightened demand. Availability is slightly reduced, especially for animal protein sources such as beef, frozen chicken, dried fish, mudfish, and tomatoes, which are significantly impacted. The period from May to June registers the highest inflation levels, reflecting the combined effects of limited supply and increased market demand during this critical agricultural phase.

Third Quarter: Marks the harvest period, characterized by an influx of new produce that stabilizes and eventually reduces prices. Food availability returns to high levels with fresh stocks replenishing the market. Staples such as rice varieties, garri, onions, yam, and tomatoes benefit from this replenishment. Prices generally moderate or decline through October and November, reflecting improved supply conditions. However, December sees a price spike linked to festive demand, temporarily increasing food costs despite food availability.

Table 4
Seasonal pattern in food availability and price fluctuations

Quarter	Seasonal Characteristics	Price Trend	Availability Pattern	Key Food Items Impacted	Notable Periods
First Quarter	Post-harvest period; relatively abundant stocks	Prices modestly increase slowly	High availability	Agric eggs, Beans, Rice, Garri, Tomato, Yam	January-February: low inflation; March starts price rise due to planting season
Second Quarter	Lean season, planting peak, stocks depleting	Prices peak, sharp increases	Slightly reduced due to scarcity	Beef, Frozen chicken, Dried fish, Mudfish, Tomato	May-June: highest inflation peak; prices spike due to low stocks and high demand
Third Quarter	Harvest period; influx of new produce stabilizes prices	Prices moderate, then decline	High availability with fresh stocks	Rice varieties, Garri, Onion, Yam, Tomatoes	October-November: prices stabilize/decline with harvest; December price spike due to festive demand

Table 5 illustrates the relationship between quarterly variations in food availability, price fluctuations, and average neonatal birth weights from 2017 to 2024.

The relationship between quarterly variations in food availability and average neonatal birth weights was examined over the study period, revealing notable seasonal and temporal patterns. In 2017, the first quarter characterized by the post-harvest period with abundant food stocks recorded an average birth weight of 3.2 kg. This period featured modest, slow price increases and high availability of key foods such as agricultural eggs, beans, rice, garri, tomato, and yam. During the lean second quarter, coinciding with peak planting and depleted stocks, birth weights slightly increased to 3.3 kg despite sharp price spikes and reduced availability, especially of high-demand items like beef, frozen chicken, dried fish, mudfish, and tomato. The third quarter, marking the harvest period with new produce inflows, saw a decline in average birth weight to 3.0 kg, alongside moderate to declining prices and renewed high availability of staples including rice varieties, garri, onion, yam, and tomatoes.

This seasonal pattern remained consistent through 2018 and 2019. Average birth weights fluctuated slightly but generally stayed within a narrow range between 3.0 and 3.1 kg. Price trends mirrored the seasonal cycle, with peak inflation during the lean second quarter and relative stabilization or decline during harvest periods. Availability patterns were largely consistent, maintaining high supply during post-harvest and harvest quarters and experiencing slight reductions during lean seasons.

In 2020, the first quarter continued to reflect the post-harvest scenario with an average birth weight of 3.3 kg and moderate to high prices alongside high availability. The lean second quarter saw a drop in average birth weight to 3.0 kg, concurrent with sustained high prices and slightly reduced availability of key foods such as beef and frozen chicken. Notably, the third quarter of 2020 recorded the highest average birth weight of 3.4 kg, corresponding with harvest period conditions of price moderation and abundant food supply.

The year 2021 demonstrated a more uniform average birth weight around 3.1 kg throughout all quarters, reflecting a stabilized seasonal pattern despite an increasing price trend and varying availability. The first and second quarters recorded slightly higher averages (~ 3.3 kg), consistent with previous post-harvest and lean season dynamics, while the third quarter saw a decline to 3.0 kg alongside price stabilization and high availability.

However, data from 2023 showed a modest decline in average birth weight to 2.8 kg across all quarters, despite maintained seasonal food availability and continued price increases. This decrease may indicate emerging nutritional or economic challenges affecting maternal and neonatal health during this period. In 2024, the average birth weight rebounded slightly to 3.0 kg, with stable availability and sustained price rises.

Table 5
Relationship between quarterly variations in available foods and birth weights

Year	Quarter	Avg Birth Weight (kg)	Seasonal Characteristics	Price Trend	Availability Pattern	Key Food Items Impacted	Birth Weight Pattern
2017	First Quarter	3.2	Post-harvest, abundant stocks	Prices increase slowly	High availability	Agric eggs, Beans, Rice, Garri, Tomato, Yam	Moderate consistent birthweight
	Second Quarter	3.3	Lean season, planting peak	Prices peak sharply	Slightly reduced	Beef, Frozen chicken, Dried fish, Mudfish, Tomato	Moderate consistent birthweight
	Third Quarter	3.0	Harvest period, new produce	Prices moderate then decline	High availability	Rice varieties, Garri, Onion, Yam, Tomatoes	Moderate consistent birthweight
2018	All Quarters	3.1	Similar to 2017	Similar price trends	Similar availability	Similar to 2017	Moderate consistent birthweight
2019	All Quarters	3.0	Similar to 2017	Similar price trends	Similar availability	Similar to 2017	Moderate consistent birthweight
2020	First Quarter	3.3	Post-harvest, abundant stocks	Prices moderate to high	High availability	Similar to prior years	Moderate consistent birthweight
	Second Quarter	3.0	Lean season, planting peak	Prices high	Slightly reduced	Beef, Frozen chicken, Dried fish, Mudfish, Tomato	Moderate consistent birthweight
	Third Quarter	3.4	Harvest period	Prices moderate then decline	High availability	Rice varieties, Garri, Onion, Yam, Tomatoes	Highest birthweight observed
2021	All Quarters	3.1	Typical seasonal pattern	Increasing price trend	Varied availability	Consistent food items	Moderate consistent birthweight
2022	First & Second Quarter	3.0	Post-harvest & lean season	Increasing price trend	Varied availability	Similar to previous years	Moderate consistent birthweight
	Third Quarter	3.3	Harvest period	Prices stabilize or decline	High availability	Consistent food items	Moderate consistent birthweight
2023	All Quarters	2.8	Maintained seasonal pattern	Increasing price trends	Stable availability	Consistent food items	Moderate consistent birthweight
2024	All Quarters	3.0	Maintained seasonal pattern	Increasing price trends	Stable availability	Consistent food items	Moderate consistent birthweight

Table 6 summarizes the relationship between quarterly birth weights and seasonal food availability, price trends, and key impacted food items from 2017 to 2024. The examination of quarters with higher or lower birth weights in relation to seasonal food availability and price trends revealed important patterns over the study period. In 2017, average birth weights remained consistently moderate, ranging from 3.0 to 3.3 kg across quarters. The first quarter, marked by the post-harvest period with abundant food stocks and slowly increasing prices, maintained low but stable birth weights despite high availability of key items such as agricultural eggs, beans, rice, garri, tomato, and yam. The lean second quarter, coinciding with peak planting and sharply increasing prices, also registered moderate consistent birth weights even as availability of high-demand foods like beef, frozen chicken, and dried fish slightly reduced. Similarly, the third quarter harvest period with moderate to declining prices and high food availability continued to show moderate consistent birth weights.

This overall moderate and stable birth weight pattern extended through 2018 and 2019, with all quarters resembling the 2017 seasonal and market conditions. Birth weights hovered around 3.0 to 3.1 kg despite similar price trends and availability profiles, suggesting persistent challenges in improving neonatal outcomes during these years.

In 2020, however, distinct changes emerged. The first quarter maintained a birth weight of 3.3 kg with moderate to high prices but abundant food availability, reflecting a moderate increase compared to prior years. The lean second quarter saw a notable improvement, with birth weights remaining at 3.0 kg but described as a significant increase, despite continued high prices and slightly reduced availability of essential foods such as beef and frozen

chicken. The third quarter harvest period experienced the highest birth weights to date at 3.4 kg, alongside moderating prices and plentiful food supply, marking a moderate increase.

The year 2021 exhibited a stable and marked increase in birth weights across all quarters, averaging 3.1 kg. This was attributed to a typical seasonal pattern with an increasing price trend but varied food availability, suggesting better resilience or other supportive factors influencing maternal and neonatal health.

In 2022, the first and second quarters recorded the highest birth weights observed in the study at around 3.0 kg, despite increasing price trends and varied availability. The third quarter showed a slight decline to 3.3 kg, corresponding with price stabilization and high food availability.

However, 2023 showed a slight decrease in birth weights to around 2.8 kg for all quarters, despite stable availability and continued price increases, highlighting a possible setback or emerging constraints in maternal nutrition or health. The trend remained similar in 2024, with birth weights stabilizing around 3.0 kg, comparable to the previous year.

Table 6
Quarters with higher or lower birth weights in relation with available foods

Year	Quarter	Avg Birth Weight (kg)	Seasonal Characteristics	Price Trend	Availability Pattern	Key Food Items Impacted	Birth Weight Pattern
2017	First Quarter	3.2	Post-harvest, abundant stocks	Prices increase slowly	High availability	Agric eggs, Beans, Rice, Garri, Tomato, Yam	Moderate consistent birth weight
	Second Quarter	3.3	Lean season, planting peak	Prices peak sharply	Slightly reduced	Beef, Frozen chicken, Dried fish, Mudfish, Tomato	Moderate consistent birth weight
	Third Quarter	3.0	Harvest period, new produce	Prices moderate then decline	High availability	Rice varieties, Garri, Onion, Yam, Tomatoes	Moderate consistent birth weight
2018	All Quarters	3.1	Similar to 2017	Similar price trends	Similar availability	Similar to 2017	Moderate consistent birth weight
2019	All Quarters	3.0	Similar to 2017	Similar price trends	Similar availability	Similar to 2017	Moderate consistent birth weight
2020	First Quarter	3.3	Post-harvest, abundant stocks	Prices moderate to high	High availability	Similar to prior years	Moderate consistent birth weight
	Second Quarter	3.0	Lean season, planting peak	Prices high	Slightly reduced	Beef, Frozen chicken, Dried fish, Mudfish, Tomato	Moderate consistent birth weight
	Third Quarter	3.4	Harvest period	Prices moderate then decline	High availability	Rice varieties, Garri, Onion, Yam, Tomatoes	Highest birthweight observed
2021	All Quarters	3.1	Typical seasonal pattern	Increasing price trend	Varied availability	Consistent food items	Moderate consistent birth weight
2022	First & Second Quarter	3.0	Post-harvest & lean season	Increasing price trend	Varied availability	Similar to previous years	Moderate consistent birth weight
	Third Quarter	3.3	Harvest period	Prices stabilize or decline	High availability	Consistent food items	Moderate consistent birth weight
2023	All Quarters	2.8	Maintained seasonal pattern	Increasing price trends	Stable availability	Consistent food items	Moderate consistent birth weight
2024	All Quarters	3.0	Maintained seasonal pattern	Increasing price trends	Stable availability	Consistent food items	Moderate consistent birth weight

Discussion

The socio-demographic characteristics indicate that the mothers represented in the study were largely within the reproductive-age range, although maternal age varied across the study periods. Maternal age is an important consideration when examining birth outcomes because biological and obstetric characteristics can differ across maternal age groups. Advanced maternal age, particularly age ≥ 35 years, has been associated with an increased risk of adverse pregnancy outcomes. A recent systematic review and meta-analysis conducted in Africa reported that advanced maternal age

was significantly associated with an increased risk of stillbirth, emphasizing the importance of maternal age in interpreting variations in pregnancy outcomes (Abate et al., 2024).

The variation in maternal age across the quarters may have implications for the interpretation of seasonal differences in birth outcomes. Maternal age can interact with other factors, including parity, maternal nutritional status, socioeconomic conditions and pregnancy complications. Therefore, differences observed in birth outcomes between quarters may partly reflect differences in the maternal characteristics of women delivering during those periods rather than seasonal conditions alone. Recent evidence from sub-Saharan Africa has similarly identified maternal demographic and pregnancy-related characteristics as important contributors to differences in perinatal outcomes (Mukherjee et al., 2024).

The distribution of births and variation in birth weight across quarters suggest that pregnancy outcomes may be influenced by the interaction of seasonal food, socioeconomic and environmental conditions. Seasonal changes in agricultural production can affect household food security, dietary diversity and maternal nutritional status, with evidence from Ethiopia and Malawi showing that food availability and agricultural seasons can influence household nutrition and birth size (Mezgebe et al., 2024; Hjertholm et al., 2022). In Nigeria, economic constraints and rising food prices may further limit access to diverse and nutrient-dense foods, highlighting the importance of distinguishing physical food availability from affordability.

Seasonal socioeconomic conditions may also modify birth outcomes. Evidence from Ghana indicates that poverty-reduction interventions can improve birth weight and reduce low birth weight, with effects varying by season (Quinones et al., 2023). Beyond nutrition and economic factors, environmental heat and temperature variability may contribute to seasonal differences in fetal growth. Studies across Africa and in tropical settings have linked maternal heat exposure and temperature variability with adverse birth outcomes, including low birth weight (Wang et al., 2023; Lakhoo et al., 2025; Brimicombe et al., 2025). Evidence from Ghana further suggests that the timing of heat exposure during specific gestational periods may influence infant birth size (Reddam et al., 2025), while Zhu et al. (2024) demonstrated the broader contribution of anthropogenic climate change to temperature-related low birth weight in low- and middle-income countries.

Overall, the findings indicate that seasonal variations in birth outcomes should be interpreted within a broader framework encompassing maternal nutrition, food affordability, household socioeconomic conditions and environmental exposures. The observed temporal differences cannot be attributed to seasonality alone because factors such as gestational age, maternal characteristics, parity, infections, antenatal care and socioeconomic status may also influence birth weight. Therefore, multivariable and trimester-specific analyses incorporating nutritional, socioeconomic and environmental exposures would provide stronger evidence of the independent contribution of seasonal conditions to birth outcomes.

the findings suggest that temporal variations in birth weight may reflect the combined influence of seasonal food conditions, maternal nutrition, socioeconomic circumstances and environmental exposures. Seasonal changes in food availability and affordability can influence household food security and maternal dietary quality, while temperature variability and heat exposure may independently contribute to adverse fetal growth. Evidence from African settings supports the roles of seasonal socioeconomic conditions and environmental exposures in shaping birth outcomes (Quinones et al., 2023; Wang et al., 2023; Brimicombe et al., 2025; Zhu et al., 2024). These findings highlight the importance of incorporating nutritional, socioeconomic and climate-related factors into maternal and newborn health surveillance.

Food affordability appears particularly important because physical availability does not necessarily ensure access to a nutritionally adequate diet. Evidence from Nigeria indicates that food-price increases and inflation can reduce household dietary diversity and adversely affect nutritional outcomes, particularly among economically vulnerable households (Fajobi et al., 2024; Olabisi et al., 2026). Similar evidence from Nigeria has shown that increases in staple-food prices can increase household food expenditure while reducing dietary diversity, with the effects differing according to socioeconomic status (Aker et al., 2022). Household food security and socioeconomic conditions may therefore determine whether pregnant women can translate market availability into adequate consumption of diverse and nutrient-rich foods.

Maternal dietary diversity and food security are also important pathways linking the food environment with fetal growth. Tareke et al. (2024) found that inadequate maternal dietary diversity was associated with increased risks of low birth weight and small-for-gestational-age birth, while Rocha et al. (2024) reported an association between maternal food insecurity and low birth weight. Evidence that improving maternal diet quality can reduce the risk of adverse birth outcomes further emphasizes the importance of dietary quality rather than food quantity alone (Salatas et al., 2025). Thus, seasonal increases in food prices may have implications for pregnancy outcomes when they restrict access to protein-rich foods, fruits, vegetables, legumes and other nutrient-dense foods.

Because the available data are descriptive, the observed seasonal patterns cannot be attributed exclusively to food availability, food prices or climate exposure. Maternal age, parity, gestational age, antenatal care, infections, socioeconomic status and other pregnancy-related factors may contribute to variations in birth weight. In addition, the apparent duplication or mislabelling of a quarter in the dataset should be resolved before definitive statistical interpretation. Future studies should therefore link individual birth records with maternal and neonatal characteristics, trimester-specific food-price and dietary information, and meteorological variables such as temperature, rainfall and humidity. Such analyses would provide stronger evidence regarding the independent and interacting effects of seasonal food environments and climate conditions on birth outcomes.

The observed seasonal variation in food prices may influence pregnancy nutrition primarily through changes in household purchasing power, food substitution and dietary diversity rather than through a direct effect on birth weight. When the prices of different food groups change, households may adjust their food choices according to affordability. Such substitutions may maintain energy intake while reducing access to protein-rich and micronutrient-dense foods. Tareke et al. (2024) demonstrated that inadequate maternal dietary diversity is associated with increased risks of low birth weight and small-for-gestational-age birth, highlighting the importance of overall dietary quality rather than access to individual staple foods alone.

The socioeconomic circumstances of households may further determine their capacity to withstand seasonal food-price increases. Olabisi, Adeyemi and Liverpool-Tasie (2026) reported that although households with female income earners generally had greater dietary diversity, dietary diversity declined substantially during Nigeria's recent inflationary period, particularly among rural households. Similarly, Ukonu, Wallace and Lowe (2024) found that household food security in southeastern Nigeria was related to socioeconomic characteristics such as income, employment and education, with economically constrained households relying more heavily on cereals, roots and tubers while consuming relatively costly protein-rich foods less frequently. These findings suggest that household economic resilience can influence whether food availability is translated into adequate and diverse dietary consumption.

The absence of a consistent relationship between seasonal food conditions and birth weight may therefore reflect the complex pathways linking the food environment with maternal and fetal health. Food availability does not necessarily guarantee affordability or adequate consumption, and households may employ coping strategies such as food substitution or adjustment of expenditure to maintain basic food intake. Nevertheless, prolonged reductions in access to diverse and nutrient-rich foods may compromise maternal nutritional adequacy. Rocha et al. (2024) found that maternal food insecurity was associated with an increased risk of low birth weight, while Fajobi et al. (2024) demonstrated an association between food prices and nutritional outcomes among women in Nigeria. Together, these findings support the interpretation that food prices may operate as an upstream socioeconomic determinant of maternal nutrition rather than as a direct determinant of birth weight.

The lack of a uniform seasonal pattern is also consistent with evidence indicating that maternal diet and birth outcomes are influenced by multiple interacting factors. Salatas et al. (2025) reported that improving maternal diet quality may have beneficial effects on birth outcomes, although the certainty of evidence varied across outcomes. The USDA Nutrition Evidence Systematic Review by Abrams et al. (2024) likewise concluded that evidence linking maternal dietary patterns specifically with birth weight remains inconsistent. Consequently, differences in birth weight across periods should not be attributed solely to seasonal food availability or price fluctuations.

Other maternal, pregnancy-related and socioeconomic factors may contribute to the observed variation, including gestational age, maternal nutritional status, parity, morbidity, antenatal care and household economic conditions. Moreover, quarterly food-price or availability measures may not accurately represent the conditions experienced by an individual woman throughout pregnancy because exposure depends on the timing and duration of pregnancy. Overall, the findings suggest that the relevance of seasonal food-price variation to pregnancy outcomes lies mainly in its potential influence on food affordability, household food security and maternal dietary diversity, rather than in a simple direct seasonal effect on birth weight. Future studies should therefore examine individual-level dietary intake, household food security, socioeconomic characteristics and trimester-specific food-price exposure to better clarify these relationships.

The timing and duration of nutritional exposure during pregnancy are important when interpreting the relationship between seasonal food conditions and birth weight. A quarterly measure of food availability may not adequately represent the dietary environment experienced by an individual woman throughout gestation because pregnancy may span different food and price seasons. Similarly, households with adequate reserves, alternative food sources or greater purchasing power may be able to buffer temporary increases in food prices. The observed pattern should therefore be regarded as an ecological description of the food environment rather than evidence of a direct seasonal effect on fetal growth.

Food affordability and dietary diversity may provide more meaningful pathways through which seasonal food conditions influence pregnancy outcomes. Fajobi et al. (2024) demonstrated an association between food prices and nutritional outcomes among Nigerian women, indicating that changes in the cost of foods can affect access to both energy-dense and nutrient-dense foods. Thus, increased physical availability of foods may not necessarily improve maternal nutrition when purchasing power is limited. This distinction is particularly important because households may respond to higher prices by substituting more expensive foods with cheaper alternatives, potentially maintaining food quantity while reducing dietary quality.

Maternal dietary diversity is particularly relevant to fetal growth. Tareke et al. (2024) found that inadequate dietary diversity during pregnancy was associated with increased risks of low birth weight and small-for-gestational-age birth. This suggests that the nutritional implications of seasonal food conditions may depend less on the availability of individual commodities and more on whether women can obtain a sufficiently varied diet throughout pregnancy. Seasonal abundance of staple foods may therefore provide limited nutritional benefit if access to protein-rich foods, fruits, vegetables and other nutrient-dense foods remains constrained.

The role of household food security provides another potential explanation for the absence of a uniform seasonal pattern. Rocha et al. (2024) reported an association between maternal food insecurity and increased risk of low birth weight, indicating that inadequate or uncertain access to food may contribute to impaired fetal growth. However, food insecurity is influenced by multiple dimensions of access, including income, food prices, household resources and coping capacity. Consequently, households may partially offset seasonal fluctuations through food storage, substitution, income diversification or alternative sources of food. Such mechanisms could weaken the correspondence between seasonal market conditions and birth weight.

Recent evidence also indicates that overall maternal diet quality may be more important than the availability of specific foods in isolation. Salatas et al. (2025) found evidence that dietary patterns and improvements in diet quality before or during pregnancy may influence birth outcomes, although the certainty of evidence varies across outcomes. This supports the interpretation that the nutritional composition of the maternal diet, rather than the simple presence of particular foods in the local environment, may be more closely related to fetal growth. Seasonal availability of cereals, roots and tubers, for example, may not necessarily improve pregnancy outcomes unless accompanied by adequate consumption of foods that provide protein, essential fatty acids, vitamins and minerals.

The variation observed across years should therefore also be interpreted within the broader context of maternal and pregnancy-related determinants of birth weight. Gestational age, maternal nutritional status, morbidity, parity, antenatal care, socioeconomic circumstances and other biological factors can influence fetal growth and may obscure a simple relationship between food seasonality and birth weight. In addition, the nutritional conditions experienced during critical periods of gestation may differ from those represented by the quarter in which delivery occurred. The absence of individual-level information on maternal dietary intake, household food security, income and timing of food-price exposure further limits the extent to which the observed differences can be attributed to seasonal food conditions.

The findings suggest that seasonal food availability and price fluctuations may form part of the broader nutritional and socioeconomic environment surrounding pregnancy, but they are unlikely to explain variations in birth weight independently. Their potential influence is more plausibly mediated through food affordability, household food security and maternal dietary diversity. The evidence from Fajobi et al. (2024), Tareke et al. (2024) and Rocha et al. (2024) supports these pathways, while Salatas et al. (2025) reinforces the importance of overall maternal diet quality. Future research should therefore integrate trimester-specific food-price and availability measures with individual dietary intake, household food security, socioeconomic characteristics and maternal health information to clarify the contribution of seasonal food environments to fetal growth.

CONCLUSION

This study offers strong evidence that pregnancy outcomes in the Odukpani Local Government Area are deeply influenced by the local environment and economy, rather than happenings in isolation. The research clearly shows a real connection between seasonal changes, which affect food availability and prices, and the health of newborns, as indicated by their birth weight. While seasonal patterns of post-harvest abundance, lean season scarcity, and harvest replenishment are a constant characteristic of life in Odukpani, their impact on birth weight is complex and sometimes counterintuitive. It's not just about having food available; it is also about how affordable it is, the strain it puts on mothers during crucial farming seasons, and the looming threat of seasonal illnesses. All of these factors come together to affect foetal development. The most alarming finding of this research was uniform decline in birth weights witnessed in 2023. This stands as a testament to the overpowering influence of macroeconomic shocks. It clearly shows that when inflationary pressures make nutritious food consistently unaffordable, the entire year can become a "lean season," effectively erasing the protective buffer that harvest periods might otherwise provide. This shows that the challenge of ensuring healthy birth outcomes is as much an economic issue as it is a medical or seasonal one. In essence, this research concludes that the well-being of the next generation in Odukpani is caught in a delicate balance between the predictable stress of seasonal cycles and the unpredictable stress of economic instability. Addressing one without the other will yield limited results. Therefore, safeguarding maternal and neonatal health demands an integrated approach that weaves together public health, agricultural policy, and economic intervention, creating a safety net that is both seasonally aware and economically resilient.

RECOMMENDATIONS

Based on the findings of this study the following recommendations are proposed for various stakeholders to mitigate the adverse effects of seasonal variations on pregnancy outcomes in Odukpani LGA and similar settings:

1. The government and health partners should initiate a programme that provides nutritional supplements, such as micronutrient powders or fortified foods, specifically targeted at pregnant women during the high-risk lean season (approximately April to September). This direct intervention can bridge the gap when healthy food is either scarce or too expensive.
2. To counter the reduced access to health facilities during the rainy season, there should be a pre-rainy season push. This involves strengthening Community Health Extension Workers (CHEWs) and deploying mobile clinics to ensure antenatal care, malaria prevention, and basic services reach remote villages when roads become impassable.
3. Support women's cooperatives and farming families with training and resources for dry-season gardening and simple food preservation techniques (like drying vegetables and fish). This helps households create their own buffer against seasonal food shortages and price hikes, improving year-round dietary diversity.
4. Future research should track the same cohort of women throughout their pregnancy to better capture the cumulative and trimester-specific impact of seasonal nutritional and environmental stresses.

Declarations

Acknowledgements: Authors acknowledged all selected facilities for their cooperation and providing the necessary materials and data for the research.

Author Contributions

C.V.E: Conception, methodology, data analysis, investigation, data curation, writing original draft, manuscript preparation, revision and resources.

E.E.O: Conception, methodology, data analysis, investigation, data curation, writing original draft and resources

M.M.O: Investigation, resources.

E.M.O: Investigation, validation, resources

U.B.I: Investigation, resources, supervision

All authors reviewed the manuscript.

Declaration of Generative AI and AI-Assisted Technologies in Scientific Writing

AI was used to comprise and correct grammatical. CHATGPT and quillbot was used.

Availability of data and materials

The data and materials supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Conflict of Interests: The authors have declared no conflicts of interest.

Source of Funding: The authors declared the study received no funding.

Consent for Publication: Not applicable

References

1. He Y, Li J, Yue T, Zheng W, Guo Y, Zhang H, et al. Seasonality and sex-biased fluctuation of birth weight in Tibetan populations. Phenomics. 2022;2. 10.1007/s43657-021-00038-7.
2. Kuehn L, McCormick S. Heat exposure and maternal health in the face of climate change. Int J Environ Res Public Health. 2017;14(8):853. 10.3390/ijerph14080853.
3. Bryson JM, Patterson K, Berrang-Ford L, Lwasa S, Namanya DB, Twesigomwe S, et al. Seasonality, climate change, and food security during pregnancy among Indigenous and non-Indigenous women in rural Uganda: implications for maternal-infant health. PLoS ONE. 2021;16(3). 10.1371/journal.pone.0247198.
4. World H, Organization UNICEF, World Bank Group, United Nations Population Division, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. Geneva: World Health Organization. UNFPA,. Trends in maternal mortality 2000 to 2017: estimates by WHO, 2019. ISBN:978-92-4-151648-8.
5. National Population Commission (NPC). [Nigeria], ICF. Nigeria Demographic and Health Survey 2018. Nigeria, and Rockville, Maryland, USA: NPC and ICF;: Abuja; 2019.
6. Sibhatu KT, Qaim M. Rural food security, subsistence agriculture, and seasonality. PLoS ONE. 2017;12(10). 10.1371/journal.pone.0186406.
7. Mezgebe B, Gari T, Belayneh M, Lindtjørn B. Seasonal variations in household food security and consumption affect women's nutritional status in rural South Ethiopia. PLoS Glob Public Health. 2024;4(8). 10.1371/journal.pgph.0003294.
8. Amolegbe KB, Upton J, Bageant E, Blom S. Food price volatility and household food security: evidence from Nigeria. Food Policy. 2021;102:102061. 10.1016/j.foodpol.2021.102061.
9. Amolegbe KB. Heterogeneous effects of weather shocks and crop diversification on household food security: a gender dimension. Agric Econ. 2026;57(4). 10.1111/agec.70119.
10. Brinkel J, Jalo RI, Bello MM, Kwaku AA, Abulfathi AA, Jalo MI, et al. Health-seeking amid conflict and climate stress: how climate disaster shapes maternal and child healthcare behavior in fragile and conflict-affected settings. BMC Health Serv Res. 2026;26:714. 10.1186/s12913-026-14744-3.
11. Fahey CA, Lutz W, Kieffer E, et al. Seasonality of antenatal care attendance, maternal dietary intake, and fetal growth in the VHEMBE birth cohort, South Africa. PLoS ONE. 2019;14(9). 10.1371/journal.pone.0222888.
12. Maharani AM, Le TL, Miah JJ, Mulla Z, Blakemore A, Aluh D, et al. Ambient temperature, rainfall, and adverse maternal and child health outcomes in Nigeria: evidence from a national cross-sectional study. Front Public Health. 2026;14:1841642. 10.3389/fpubh.2026.1841642.
13. Abubakar I, Dalglish SL, Angell B, Sanuade O, Abimbola S, Adamu AL, et al. The Lancet Nigeria Commission: investing in health and the future of the nation. Lancet. 2022;399(10330):1155–200. 10.1016/S0140-6736(21)02488-0.
14. Fajobi DT, Ajetomobi JO, Raufu MO, Fajobi MO, Paramasivam P. Effects of food price on nutrition outcomes among women in Nigeria. Food Sci Nutr. 2024;12(1):94–104. 10.1002/fsn3.3737.
15. Tareke AA, Melak EG, Mengistu BK, Hussen J, Molla A. Association between maternal dietary diversity during pregnancy and birth outcomes: evidence from a systematic review and meta-analysis. BMC Nutr. 2024;10:151. 10.1186/s40795-024-00960-9.
16. Rocha ARF, Morais NS, Azevedo FM, Morais DC, Priore SE. Maternal food insecurity increases the risk of low birth weight babies: systematic review and meta-analysis. Acta Paediatr. 2024;113(10):2180–8. 10.1111/apa.17327.
17. Salatas C, Bronnert A, Lawrence R, Alexander T, Wall C, Bloomfield FH, et al. Dietary patterns and diet quality before and/or during pregnancy and how these affect birth outcomes: a systematic review and meta-analysis. Adv Nutr. 2025;16(10):100490. 10.1016/j.advnut.2025.100490.
18. Abrams S, Andres A, Byrd-Bredbenner C, Deierlein AL, Eicher-Miller HA, Fisher JO, et al. Dietary patterns consumed during pregnancy and birth weight: a systematic review. Alexandria, VA: U.S. Department of Agriculture, Nutrition Evidence Systematic Review; 2024. 10.52570/NESR.DGAC2025.SR27.
19. Ukonu IC, Wallace CA, Lowe NM. Household food security and dietary diversity in south-eastern Nigeria. Matern Child Nutr. 2024;20(3). 10.1111/mcn.13599.
20. Olabisi M, Adeyemi U, Liverpool-Tasie LSO. Female earnings and dietary diversity: evidence from an inflationary economic crisis. Food Policy. 2026;139:103037. 10.1016/j.foodpol.2026.103037.

21. Brimicombe C, Jackson D, Mungatia A, Sulaiman Z, Monthaler T, Wieser K, et al. The influence of heat exposure on birth and neonatal outcomes in Mombasa, Kenya: a pooled time series analysis. J Clim Change Health. 2025;22:100409. 10.1016/j.joclim.2024.100409.
22. Quinones S, Mendola P, Tian L, Lin S, Novignon J, Angeles G, et al. Ghana's Livelihood Empowerment Against Poverty (1000) Program seasonally impacts birthweight: a difference-in-differences analysis. Int J Public Health. 2023;68:1605336. 10.3389/ijph.2023.1605336.
23. Wang P, O'Donnell KJ, Warren JL, Dubrow R, Chen K. Temperature variability and birthweight: epidemiological evidence from Africa. Environ Int. 2023;173:107792. 10.1016/j.envint.2023.107792.
24. Zhu Z, Zhang T, Benmarhnia T, Chen X, Wang H, Wulayin M, et al. Estimating the burden of temperature-related low birthweight attributable to anthropogenic climate change in low-income and middle-income countries: a retrospective, multicentre, epidemiological study. Lancet Planet Health. 2024;8(12). 10.1016/S2542-5196(24)00242-0.
25. Ahmadi P, Bayat N, Abbasi B. Diet diversity score might be associated with reproductive health in women and infant outcomes: a systematic review. J Nutr Sci. 2025;13. 10.1017/jns.2024.81.
26. Lakhoo DP, Brink N, Radebe L, Craig MH, Pham MD, Haghighi M, et al. A systematic review and meta-analysis of heat exposure impacts on maternal, fetal and neonatal health. Nat Med. 2025;31:684–94. 10.1038/s41591-024-03395-8.
27. Reddam A, Mujtaba MN, Tuholske C, Kaali S, Ae-Ngibise KA, Wylie BJ, et al. Prenatal exposure to heat and humidity and infant birth size in Ghana. Environ Res. 2025;266:120557. 10.1016/j.envres.2024.120557.