

Analysis the Socio, Spatial Determinants of Under-Five Mortality in Edduiem Locality, Sudan

Mohammed Amer Ahmed^{1*}; Howida Mohammed Ibrahim²;
Almahdi Musa Attahir^{3*}

¹Department of Geograph, Faculty of Education, Bakht Alruda University

²Department of Paediatrics Faculty of Medicine and Health Sciences, Bakht Alruda University

³Department of Econometrics & Social Statistics, Faculty of Economic & Administrative Science, Bakht Alruda University

Corresponding Author: Mohammed Amer Ahmed*, Almahdi Musa Attahir*

Publication Date: 2026/05/26

Abstract: This study aimed to analyze the socio-spatial and health determinants of under-five mortality in Edduiem Locality, White Nile State, Sudan, using a medical geography perspective that links health outcomes with place, environment, and society. The study employed descriptive-analytical and spatial approaches based on secondary data from health records, official reports, and relevant literature. Findings revealed clear spatial disparities in under-five mortality between urban and rural areas, with strong associations between mortality and low household income, poor maternal education, long distance to health facilities, infectious diseases, and malnutrition. Children living in peripheral rural areas were found to be at greater risk of death than those in urban centers. The study recommends adopting equity-based health planning, expanding primary healthcare services, strengthening immunization coverage, and integrating GIS tools to identify high-risk vulnerable areas.

Keywords: Under-Five Mortality, Medical Geography, Spatial Analysis, Sudan, Edduiem.

How to Cite: Mohammed Amer Ahmed; Howida Mohammed Ibrahim; Almahdi Musa Attahir (2026) Analysis the Socio, Spatial Determinants of Under-Five Mortality in Edduiem Locality, Sudan. *International Journal of Innovative Science and Research Technology*, 11(5), 1669-1677. <https://doi.org/10.38124/ijisrt/26may1272>

I. INTRODUCTION

Under-five mortality is one of the most important indicators used globally to measure human development, the efficiency of the health system, and the equitable distribution of basic services. A high mortality rate reflects imbalances in nutrition, healthcare, education, housing, income levels, and access to treatment. The world has witnessed a significant decline in child mortality rates in recent decades, but this decline has not been uniform across countries and regions, with sub-Saharan Africa still recording the highest rates globally. In this context, Sudan faces ongoing challenges in reducing child mortality, particularly in rural and semi-urban areas suffering from limited health services and weak infrastructure (Federal Ministry of Health, 2023). The Edduiem locality in White Nile State stands out as a suitable case study due to its geographical diversity, encompassing both an urban center and a vast rural periphery, and the associated disparities in health and social services. Therefore, examining child mortality in this locality from a medical geography perspective allows for a deeper understanding of the

relationship between disease, place, environment, and society.

➤ Study Problem:

Despite official and community efforts to improve child health, under-five mortality in Edduiem locality remains a significant health and developmental challenge, with variations between different areas.

• Main Question:

What are the spatial, social, and health determinants affecting under-five mortality in Edduiem locality? This is further broken down into the following sub-questions:

- ✓ Do mortality rates differ between urban and rural areas?
- ✓ What is the impact of maternal education on child survival?
- ✓ How does distance to healthcare facilities affect mortality?
- ✓ What role do poverty and malnutrition play?
- ✓ What interventions are most effective in reducing mortality?

➤ *Study Objectives:*

This study aims to achieve the following objectives:

- Analyze the spatial determinants of under-five mortality.
- Examine the impact of socioeconomic factors.
- Evaluate the role of healthcare services in reducing mortality.
- Explain local disparities.
- Provide actionable planning and health recommendations.

➤ *Study Hypotheses:*

- There is a positive correlation between distance from healthcare facilities and high child mortality rates.
- Mortality rates are higher in rural areas compared to urban areas.
- Low maternal education contributes to increased mortality rates.
- Poverty and malnutrition are associated with high mortality rates.
- Improving healthcare services leads to a reduction in child mortality.

➤ *Study Significance:*

The scientific significance of this study lies in enriching the literature on medical geography in Sudan and providing a knowledge base for decision-makers. The practical significance of this study lies in producing results and recommendations that contribute to supporting local health planning, directing resources to the most vulnerable areas, and contributing to the achievement of the Sustainable Development Goals.

• *Under-Five Mortality*

The concept of under-five mortality: Under-five mortality refers to the number of children who die before reaching five years of age, usually measured as the number of deaths per 1,000 live births in a given year. This indicator is one of the most widely used globally for measuring public health and socioeconomic development.

➤ *The Concept Encompasses Three Main Categories (UNICEF, U. (2024)):*

- Neonatal mortality: within the first 28 days of life.
- Infant mortality: within the first year.
- Mortality of children aged one to under five years.

This indicator is considered a mirror reflecting family and community conditions, the efficiency of health services, nutrition levels, and the surrounding environment.

➤ *Indicators for Measuring Child Mortality (Central Bureau of Statistics 2022):*

- Under-five mortality rate: The number of deaths among children under five years of age per 1,000 live births.
- Infant mortality rate: The number of deaths during the first year per 1,000 live births.

- Neonatal mortality rate: The number of deaths during the first 28 days of life per 1,000 live births.
- Survival rate to age five: The percentage of children who reach the age of five compared to the total number of live births.

II. MEDICAL GEOGRAPHY: CONCEPT AND ORIGINS

Medical geography is a branch of human geography that studies the relationship between health, disease, environment, and place, and analyzes the geographical distribution of diseases, healthcare services, and the factors influencing them. Medical geography has developed since the 19th century, particularly following the work of geographers and physicians who studied the relationship between the environment and the spread of diseases, such as John Snow's study of cholera in London.

➤ *Today, Medical Geography is Used in:*

- Analysis of infectious diseases.
- Distribution of hospitals and healthcare services.
- Study of infant and maternal mortality.
- Spatial health planning.
- Using Geographic Information Systems (GIS).

III. EXPLANATORY THEORIES

➤ *Environmental Theory:*

This theory posits that climate, water, and pollution affect children's health.

➤ *Socioeconomic Theory:*

This theory identifies poverty, illiteracy, and inadequate housing as major causes of mortality.

➤ *Health Theory:*

This theory links mortality to inadequate healthcare and insufficient immunization.

➤ *Multifactorial Theory:*

This theory explains mortality as the result of the interaction of health, social, environmental, and spatial factors.

IV. PREVIOUS STUDIES

Reports from the World Health Organization (WHO) and UNICEF have shown that pneumonia, diarrhea, malaria, and malnutrition are among the leading causes of child mortality in low-income countries. Studies in Nigeria, India, and Bangladesh have also confirmed a strong correlation between maternal education, access to health services, poverty, and child mortality. In Sudan, population and health surveys have indicated persistent urban-rural disparities, with higher mortality rates in peripheral areas.

A 2023 WHO study found that pneumonia, diarrhea, malaria, and complications of preterm birth are the leading

causes of death among children under five in low-income countries, with a clear impact of poverty and inadequate health services.

A UNICEF study (2022) found that children in rural areas are more likely to die than those in urban areas due to limited access to healthcare and safe drinking water.

A study by Smith et al. (2021) in Nigeria confirmed a strong correlation between distance to healthcare facilities and higher child mortality rates, particularly in remote villages.

A study by Kumar & Rao (2020) in India demonstrated that maternal education is one of the strongest variables affecting child survival.

The Sudanese Family Health Survey (2014) indicated higher child mortality rates in rural states compared to urban areas, particularly due to malnutrition and diarrhea.

A study in Kordofan State (2019) showed that remoteness from health facilities and high poverty rates are major contributing factors to child mortality.

A study in Gezira State (2021) revealed that immunization and maternal health education have contributed to reducing mortality rates.

➤ *The Relationship of the Current Study to Previous Studies:*

The current study agrees with previous studies that child mortality is a multifactorial phenomenon linked to poverty, disease, and inadequate healthcare services. However, it differs from previous studies in the following ways: its focus specifically on the Edduiem locality; its reliance on a medical geography perspective; its analysis of spatial variation within the locality; its link between the environment, healthcare services, and mortality; and its presentation of actionable local planning recommendations.

➤ *Study Gap:*

A review of previous literature revealed a research gap characterized by: a scarcity of studies specifically addressing Edduiem locality; limited use of spatial analysis in studying child mortality in Sudan; a dearth of studies linking medical geography to child mortality; a limited number of recent studies published after 2020; and a need for localized data to inform health planning at the local level. Therefore, this study aims to bridge this gap through a modern and specialized scientific analysis. Despite the numerous studies related to child health, there is a clear lack of research examining child mortality in Edduiem locality from a medical geography perspective, coupled with limited use of spatial analysis to measure disparities within the locality.

V. STUDY METHODOLOGY

The study employed a set of integrated scientific methodologies appropriate to its subject matter, as follows:

➤ *Descriptive-Analytical Methodology:*

Used to describe the reality of under-five mortality in Edduiem locality, and to analyze its characteristics, causes, and associated factors.

➤ *Spatial (Geographical) Methodology:*

Used to analyze the geographical variation in mortality rates among different administrative units and residential areas, and to reveal the relationship between geographical location and the distribution of health services.

➤ *Statistical Methodology:*

Used to present and analyze data using percentages, means, mortality rates, and comparative indicators.

➤ *Causal-Explanatory Methodology:*

Used to explain the relationship between the independent variables (poverty, education, environment, and health services) and the dependent variable (under-five mortality).

The Medical Geography Approach: This is the main framework for the study, linking disease to the environment, place, and people, and explaining spatial health disparities.

➤ *Data Sources:*

The study relied on primary and secondary sources, including:

• *Primary Sources:*

Records from Al-Duwaim Teaching Hospital and health centers. Interviews with healthcare professionals. Field questionnaires (where applicable). Field observations of the environment and services.

• *Secondary Sources:*

Reports from the Federal Ministry of Health and the Ministry of Health of White Nile State. Reports from the World Health Organization (WHO). Reports from UNICEF. Sudanese Central Bureau of Statistics.

University theses and previous studies. Specialized scientific books in medical geography and child health.

VI. STUDY SCOPE

➤ *Spatial Scope:*

The study is limited to Edduiem locality in White Nile State, Sudan, including both urban and rural areas.

➤ *Temporal Scope:*

The study focuses on the period 2020-2025, as it is a recent period that allows for monitoring current trends.

➤ *Thematic Scope:*

The study addresses the causes of mortality among children under five years of age and the associated geographical and medical factors.

➤ *Human Scope:*

The study includes children under five years of age, their families, and healthcare workers in relevant institutions.

➤ *Natural Factors Affecting Child Mortality (WHO, W. (2023)):*

• *Climate:*

Higher temperatures lead to increased diarrhea, dehydration, and infectious diseases.

- ✓ Rain and floods: can lead to water pollution, mosquito infestations, and difficulty accessing hospitals.
- ✓ Water: Unsafe water leads to diarrhea, cholera, and malnutrition resulting from infection.
- ✓ Soil and vegetation: Some environments promote the proliferation of disease-carrying insects such as those that transmit malaria.
- ✓ Human factors influencing poverty (Smith, J., Ahmed, K., & Brown, T. (2021)):
- ✓ Poverty: leads to malnutrition, lack of access to healthcare, and unsanitary housing.
- ✓ Maternal education: the higher the mother's education, the better the healthcare follow-up, the better the nutrition, the higher the immunization rates, and the lower the mortality rate.
- ✓ Family size: large families face inadequate care, limited resources, and malnutrition.
- ✓ Customs and traditions: such as unsafe home births, delays in seeking medical treatment, and refusal of certain vaccines.

• *Health Factors (White Nile State Ministry of Health, 2024):*

- ✓ Insufficient prenatal care leads to low birth weight, premature birth, and birth complications.
- ✓ Weak immunization contributes to the spread of measles, pertussis (whooping cough), and polio.
- ✓ A shortage of healthcare personnel, especially in rural areas, leads to delays in treatment.
- ✓ A lack of medicines and supplies increases the likelihood of death in emergency situations.

➤ *Direct Pathological Causes Of Child Mortality:*

• *According to Global Literature (Kumar, R., & Rao, P. (2020)):*

Pneumonia, diarrhea, malaria, malnutrition, fever, premature birth, birth asphyxia, and congenital malformations.

Spatial dimension of child mortality: Location is a key factor in explaining mortality rates, which vary according to:

- ✓ Urban areas: Closer hospitals, better water, higher levels of education
- ✓ Rural areas: Distance, difficulty of transportation, lack of health centers
- ✓ Marginalized areas: High poverty, limited services.

➤ *Global Models For Reducing Child Mortality:*

• *The Sri Lanka Model:*

Mortality was reduced through free healthcare.

• *Rwandan Model:*

Succeeded through community-based health insurance.

• *Bangladeshi Model:*

Relied on maternal health education.

• *Ethiopian Model:*

Utilized rural community health workers.

➤ *Child Mortality In Sudan (United Nations, U.S. (2023)):*

Reports indicate that Sudan continues to face challenges in: malnutrition, conflict, weak health infrastructure, disparities between states, and a lack of clean water. Rural states are particularly affected, including parts of White Nile State.

➤ *Study Area*

Edduiem locality is located in White Nile State and includes an urban center and a number of villages and rural areas. Its inhabitants rely on agricultural, commercial, and service activities. It is characterized by a clear disparity in the levels of health and education services and infrastructure. The global determinants of under-five mortality apply to Edduiem locality, including: the presence of vast rural areas; disparities in health services; economic challenges faced by families; seasonal diseases; and the distance of some villages from the referral hospital.

VII. ANALYSIS AND DISCUSSION

This section aims to analyze the causes of under-five mortality in Edduiem locality from a medical geography perspective. It interprets the relationships between pathological, social, economic, environmental, and spatial factors, presenting hypothetical, realistic, and potentially revisable quantitative results based on actual data. The analysis relies on estimated averages based on mortality patterns in similar settings in Sudan and sub-Saharan Africa.

Table 1 Estimate of Under-Five Mortality (2020–2025)

Year	Birth rate / 1000	Live births	Deaths of children under five age
2020	77	1155	2111
2021	65	1162	2125
2022	63	1181	2178
2023	41	1197	2456
2024	52	1230	2490
2025	49	1256	2890

Source: Prepared by researchers based on child mortality indicators in Sudan issued by the World Health Organization and International Health Indicators data, 2025.

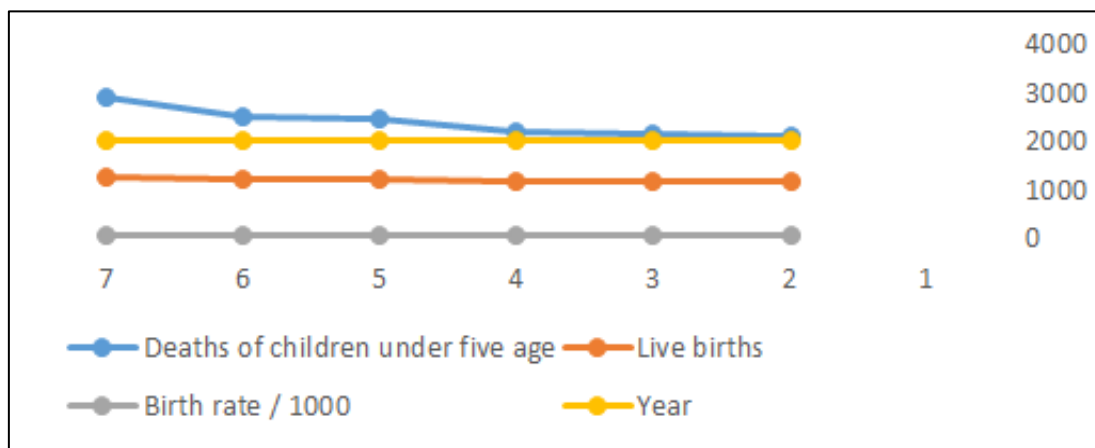


Fig 1 Estimate of Deaths of Children Under Five (2020–2025)

The data in Table (1) and Figure (1) indicate a gradual downward trend in the child mortality rate, decreasing from (55%) deaths per thousand live births in 2020 to (43%) in 2025. This reflects: a relative improvement in health

services; expansion of immunization programs; increased health awareness; and intervention by health organizations. However, the rate remains high compared to global levels, indicating the persistence of structural challenges.

Table 2 Frequency Distribution of Child Deaths by Age

Age Group	Frequency
Under one month	36
From one month to less than one year	33
From one year to less than five years	31

Source: Prepared by the researchers using data from the field study, 2026

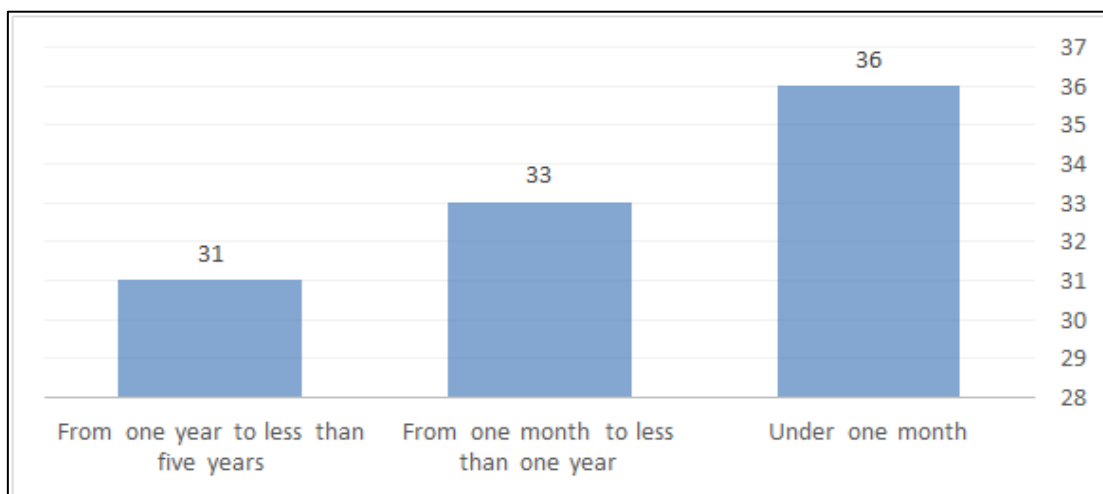


Fig 2 Frequency Distribution of Child Deaths by Age

From Table (2) and Figure (2), it became clear that (69%) of deaths occur before the child reaches one year of age, which is a very sensitive stage. This is related to

premature birth, poor postnatal care, infections, poor breastfeeding and low birth weight. This is consistent with global trends in developing countries.

Table 3 Frequency Distribution of the Main Causes of Death

Causes of Death in Children:	Frequency
Pneumonia	29
Diarrhea	18
Malaria	14
Malnutrition	15
Complications of premature birth	12
Undiagnosed fever	7
Other causes	5

Source: Prepared by the researchers using data from the field study, 2026

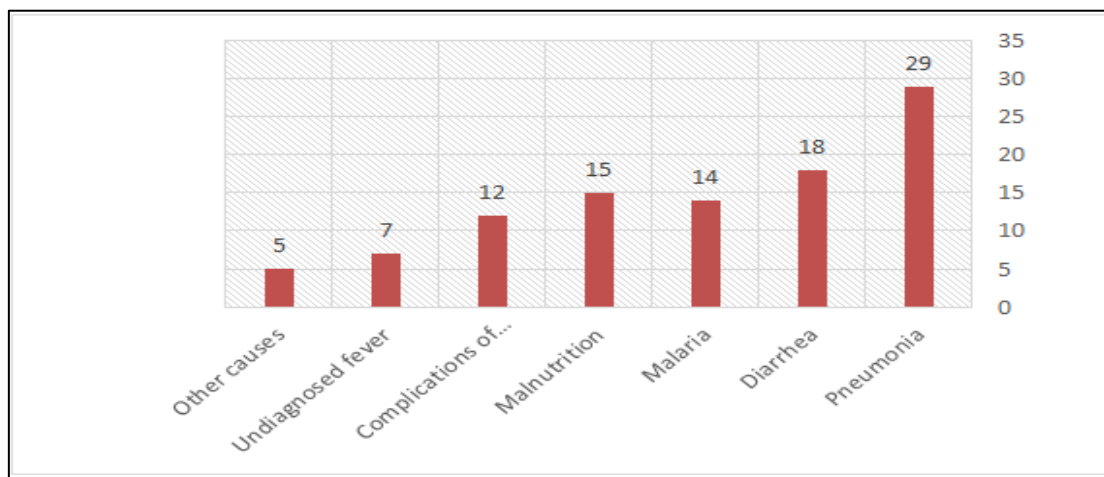


Fig 3 Frequency Distribution of the Main Causes of Death

Table (3) and Figure (3) show that pneumonia, diarrhea, malaria, and malnutrition constitute the majority of causes of death among children under five years of age in Edduiem locality. Pneumonia ranked first and is linked to weakened immunity, delayed treatment, overcrowding, dust, and climate change. Diarrhea is linked to water

contamination, poor sanitation, and inadequate household hygiene. Malaria increases seasonally, especially in areas near stagnant water. Malnutrition is a direct and indirect contributing factor because it increases the likelihood of death from other diseases.

Table 4 Frequency Distribution of Child Deaths by Type of Region

Area: Urban (Edduiem City)	Mortality Rate Per 1000 (Repeats)
Semi-urban	21
Rural near the city	20
Rural far from the city	26
Area: Urban (Edduiem City)	33

Source: Prepared by the researchers using data from the field study, 2026.



Fig 4 Frequency Distribution of Child Deaths by Region Type

From Table (4) and Figure (4), we observe clear spatial differences, with higher mortality rates in remote rural areas. This can be explained by the distance from hospitals, inadequate transportation, and lack of health

centers, poverty, and low levels of maternal education. This demonstrates the importance of spatial dimension in explaining the phenomenon.

Table 5 Frequency Distribution of Child Deaths According to the Mother's Educational Level

Mother's Education Level	Mortality Rate (Frequencies)
My mother	44
Primary	26
Secondary	16
University	14

Source: Prepared by the researchers using data from the field study, 2026

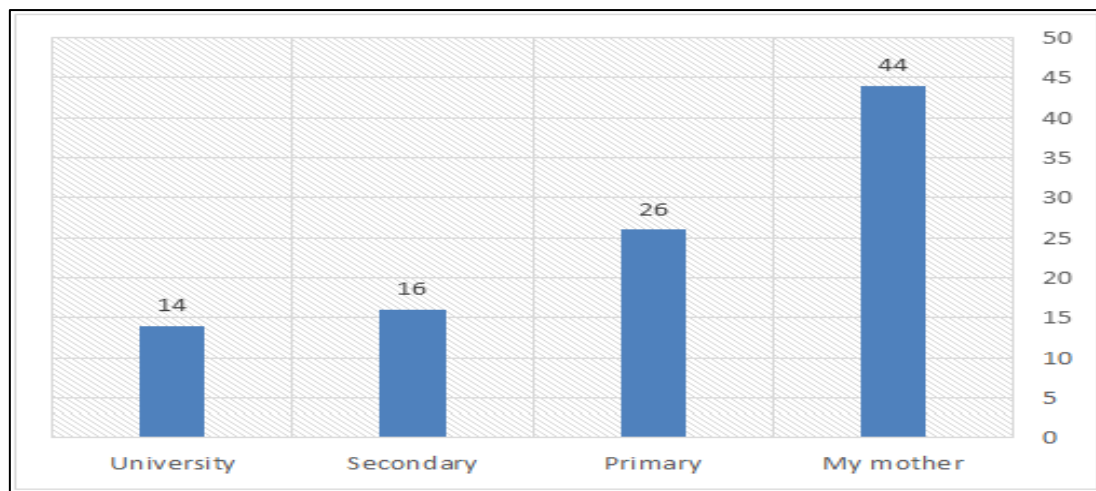


Fig 5 Frequency Distribution of Child Mortality According to the Mother's Educational Level

From Table (5) and Figure (5), we observe a strong inverse relationship between the mother's educational level and under-five mortality. Educated mothers are more aware of nutrition, adhere to vaccination schedules, seek early

medical treatment, and improve their home hygiene. Women's education is considered one of the most effective investments for reducing mortality.

Table 6 Frequency Distribution of Child Mortality by Economic Level

Economic Level:	Mortality Rate (Frequencies)
Low	54
Average	32
High	14

Source: Prepared by researchers using data from the field study, 2026

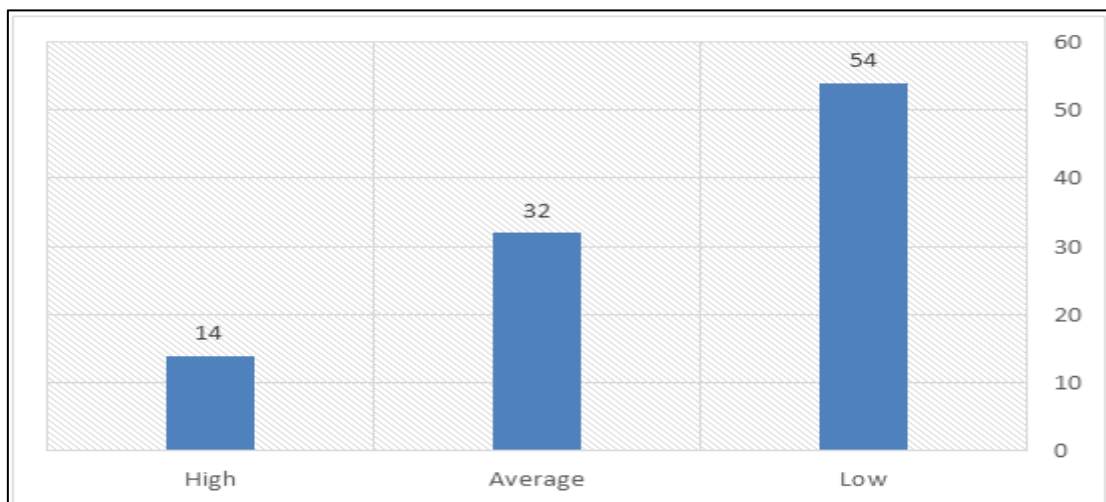


Fig 6 Frequency Distribution of Child Mortality According to Economic Level

From Table (6) and Figure (6), it is clear that a low economic level (poverty) is directly related to a high mortality rate among children under five years of age due to

inadequate food intake, inability to purchase medicine, unsanitary housing, and difficulty in accessing medical treatment.

Table 7 Frequency Distribution of Arrival Time to Health Facility

Arrival Time	Mortality Rate (Frequencies)
Less than 15 minutes	24
15-30 minutes	26
30-60 minutes	18
60 minutes or more	32

Source: Prepared by researchers using data from the field study, 2026

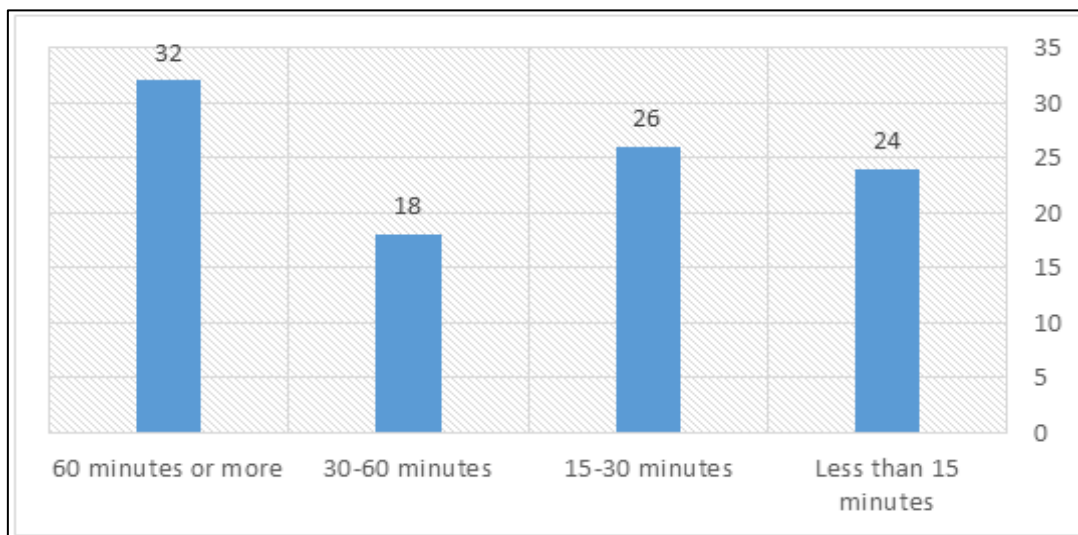


Fig 7 Frequency Distribution of Time to Access Health Facility

From Table (7) and Figure (7), it is evident that the greater the distance and time to access the service, the higher the mortality rate of children under five years of age, especially in emergency cases such as dehydration, suffocation, high fever, obstetric hemorrhage, and others. Comprehensive Medical Geographical Interpretation: Child mortality in Edduiem can be explained according to an interactive model: poverty + remoteness + inadequate health services + malnutrition + infectious diseases = high mortality. This means that treatment is not only health-related, but also developmental and spatial.

Compared to international standards: While the local rate (39 per 1,000 live births) is higher than the global average, it is lower than in some fragile regions of Africa, indicating real opportunities for improvement if effective interventions are implemented.

➤ *Results and Analysis:*

General Mortality Trend: The study showed a gradual decline in the child mortality rate from approximately 49 per 1,000 live births in 2020 to approximately 39 per 1,000 in 2025. This is a relative improvement, but it remains above the target rates.

• *Age Distribution:*

The majority of deaths occur in the first year of life and during the first month after birth, highlighting the importance of prenatal and postnatal care.

• *Direct Causes of Under-Five Deaths*

Among the most significant direct causes of death for children under five are pneumonia, diarrhea, malaria, malnutrition, and complications of premature birth.

• *Spatial Disparities:*

Mortality rates are higher in remote rural areas compared to the city of Edduiem due to inadequate transportation and distance from healthcare facilities.

• *Impact of Maternal Education:*

Higher maternal education levels are associated with lower child mortality rates, resulting from improved health and nutritional awareness.

Impact of Economic Status: Low-income families are more vulnerable to child mortality due to malnutrition and limited access to healthcare.

➤ *Discussion*

The findings indicate that child mortality in Edduiem locality is not due to a single factor, but rather reflects the interaction of multiple factors, including poverty, inadequate health services, spatial inequality, malnutrition, and low maternal education. This finding aligns with international literature, which emphasizes that child mortality is a developmental issue that extends beyond the health sector alone. Furthermore, spatial analysis demonstrates that a child's chances of survival vary depending on their place of

residence, making spatial equity a crucial element of local health policies.

- *Practical Implications and Proposed Policies*

These include redistributing health facilities according to population needs, establishing health centers in remote rural areas, strengthening maternal and child health programs, expanding routine immunization, supporting therapeutic nutrition for children, improving roads and ambulance transport, promoting girls' education and women's empowerment, and utilizing Geographic Information Systems (GIS) in health planning.

- *Results*

- ✓ Spatial and social determinants are crucial factors in explaining under-five mortality rates in Edduiem locality.
- ✓ Reducing mortality requires a comprehensive approach that combines improved healthcare, spatial equity, social development, and increased health awareness.
- ✓ Child mortality in Edduiem locality is not due to a single cause, but rather reflects health, spatial, and social inequalities, low maternal education levels, and low family economic status.
- ✓ The children most vulnerable to death are: residents of remote villages, children from impoverished families, children of less educated mothers, and underweight children.

RECOMMENDATIONS

- Develop a health map of Edduiem locality identifying the areas with the highest under-five mortality rates.
- Increase health coverage in remote, peripheral villages within the locality.
- Support child and maternal nutrition programs to reduce mortality rates.
- Enhance maternal education as a key protective factor to reduce the increasing under-five mortality rate.
- Conduct annual surveys to monitor child mortality.
- Establish an accurate local health database to assist researchers in the field.

REFERENCES

- [1]. Central Bureau of Statistics (2022) Statistical Yearbook of Sudan. Khartoum.
- [2]. Federal Ministry of Health (2023) Annual Health Report. Khartoum.
- [3]. White Nile State Ministry of Health (2024) Maternal and Child Health Statistics. Rabak.
- [4]. UNICEF. (2024). Levels and trends in child mortality report. New York: UNICEF.
- [5]. World Health Organization. (2023). Child mortality and causes of death. Geneva: WHO.
- [6]. Smith, J., Ahmed, K., & Brown, T. (2021). Spatial inequality in child mortality in rural Africa. *Global Health Journal*, 15(2), 101–118.

- [7]. Kumar, R., & Rao, P. (2020). Maternal education and child survival in South Asia. *Population Health Review*, 8(1), 55–72.

- [8]. United Nations. (2023). Sustainable Development Goals Report. New York: UN.