

Influence of environmental conditions on gestational age at delivery: a case-control study based on generalized linear models; North Kivu; June-October 2025

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Page | 1

Abstract

Introduction:

Premature births are a major public health problem, especially in developing countries. The main objective of this study was to examine the impact of environmental conditions on gestational age at delivery in North Kivu.

Methods:

This case-control study was conducted in five health zones of North Kivu from June to October 2025 using cluster sampling of 136 cases and 272 controls. The study population consisted of mother-newborn pairs. Data were analyzed using SPSS version 25. Tweedie's Generalized Linear Model with a logarithmic relationship function was used at a significance level of 5% to assess the adjusted influence of environmental conditions on gestational age at delivery.

Results:

In terms of living space, each 1.1% increase in room size was associated with a higher gestational age (aOR = 1.011; 95% CI: 1.001–1.017; p = 0.001). For terrain, when the residence and basic services were at the same elevation level as estimated by respondents, the likelihood of a higher gestational age increased by 11.3% (aOR = 1.113; 95% CI: 1.040–1.191; p = 0.002). For the living environment, the Kyondo health zone was associated with longer gestational ages, with a 78.5% increase (aOR = 1.785; 95% CI: 1.001–3.182; p = 0.049).

Conclusion:

These results suggest that a larger living space, less difficult terrain, and certain characteristics of the domestic environment could lead to a longer gestation period.

Recommendation:

To improve housing conditions, access to essential services, and the development of living environments while strengthening prenatal monitoring of vulnerable pregnant women.

Keywords: Gestational Age; Premature Birth; Housing Quality; Environmental Health; Pregnancy; Geographic Locations; North Kivu, DRC.

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Introduction

Representing the most significant problem in obstetric practice, preterm birth refers to any birth occurring before 37 weeks of gestation. It has a very serious impact, increasing perinatal mortality and morbidity (accounting for approximately 75% of neonatal mortality), in both developing and developed countries. Its incidence varies from 5% to 15% (Hounkponou et al., 2017). In France, the results of a study conducted in 2016 proved that inadequate housing conditions were implicated as being at the root of the occurrence of premature births. (Laurence, 2016)

A recent publication indicates that the prevalence of prematurity among women of reproductive age remains a major public health problem in sub-Saharan Africa. (Diakite et al., 2025; Alamneh et al., 2021). This means that prematurity is more frequent in disadvantaged areas with poor housing conditions, a lack of comfort, and especially a lack of elevators for women living on upper floors. This is compounded by the demands of professional or domestic work, particularly for large families. (Mabrouk et al., 2022) and by long commutes (from home to work or other basic services). Unwanted pregnancies, extreme maternal age, and pregnant women's lifestyle (Heroual et al., 2024; Maiga et al., 2024; Sebbani et al., 2020; Rouget et al., 2013; Prazuck et al., 1993).

Furthermore, research conducted in sub-Saharan Africa reveals that factors such as maternal infections (HIV and malaria) and gestational hypertension play a significant role in prematurity. (Akpovo et al., 2025). Improvements in socioeconomic status, the quality of women's education, and the provision of maternal health services should all be geared towards reducing prematurity rates in these regions. (Mabrouk et al., 2022).

In the Democratic Republic of Congo (DRC), the eastern part is not spared, where the number of births before 37 weeks of gestation continues to grow and has even doubled during the last decade, according to a survey carried out on the period from 2014 to 2024, where it went from 3.1% in 2014 to 6.9%, with an increase of about 0.3 cases of prematurity per 100 live births per year.

Furthermore, several studies that have addressed this topic generally simply split newborns into two groups and are less interested in studying them by considering the time spent in the intrauterine environment and taking into account geographical conditions such as living space, the effect of relief, etc. The present study focuses on these aspects in order to fill this perceived gap in the specific context of North Kivu.

The reason we chose to study prematurity based directly on gestational age is that numerical analysis of this variable allows for a more nuanced assessment. Such an approach deepens our understanding of pregnancy variability, thus broadening the possibilities for interpreting the data from

this analysis. (Ministerial Meeting on Population of the Non-Aligned Movement (1993: Bali), 1994).

In this sense, the questions that the present study attempted to answer were the following: What is the influence of poor environmental conditions on gestational age at delivery? In other words, what are the environmental factors associated with prematurity from a numerical point of view?

Thus, the main objective was to assess the influence of environmental conditions on gestational age at delivery in North Kivu. Specifically, it studies the link between different environmental conditions experienced by pregnant women and gestational age at delivery. The hypothesis formulated in this context stipulates that adverse environmental conditions, such as limited living space, a significant difference in elevation between the ecological niche (between the residential area and basic services), etc., have a negative influence on gestational age and therefore reduce fetal survival in the womb.

Materials and methods

Study design

This is a case-control study conducted from June to October 2025 to identify the determinants of premature births in the eastern part of the North Kivu Provincial Health Division. Such a design allows for the effective exploration of the influence of environmental conditions on gestational age by comparing women with full-term and preterm births. This facilitates the identification of environmental factors associated with variations in gestational age.

Study framework

The study was conducted in five health zones in North Kivu province due to their accessibility in terms of security and population density. These were: Beni, Butembo, Katwa, Kyondo, and Oicha, where we visited each general hospital for the initial contact with the women who had given birth. Furthermore, the province of North Kivu, located in eastern DRC, is distinguished by its rugged terrain, ranging from less than 800m to more than 5,000m in altitude. (CAID, 2025). It is home to Lake Kivu and overlooked by the Nyiragongo and Nyamulagira volcanoes. Its climate is temperate, with an average annual temperature of 18°C. (National Tourism Office DRC, 2025).

The province is rich in natural resources such as gold, coltan, and cassiterite. It is bordered to the East by Uganda and Rwanda, to the West by Tshopo province, to the Southwest by Maniema, to the North by Ituri province, and to the South by South Kivu. (Sadiki, 2023).

Population

For this study, the study population consisted of mother-child pairs in North Kivu throughout the study period. Thus,

all births occurring between June 1, 2025, and October 31, 2025, were considered the target population. Premature births constituted the cases, and full-term births, the controls.

Inclusion and exclusion criteria

The inclusion criteria for this study included women aged 15 to 49 years who had given birth in selected maternity hospitals in North Kivu between June and October 2025. Cases included preterm births occurring before 37 weeks of gestation, while controls were women who gave birth at term. Informed consent and residence in the targeted areas were also required.

In addition, these women would also have to agree to a home visit to measure or record their altitude, latitude, and longitude using the predefined geolocation data on the scanned form in KoboCollect, and to assess the estimated room size outside their homes. Due to the tense security situation and for reasons of privacy, the study team was unable to enter the respondents' rooms to measure their dimensions.

Sampling

Cluster sampling was chosen, justified by the need to obtain a representative sample while taking into account resource and access constraints in a challenging region. The primary units were the selected maternity wards.

The selection method consisted of identifying these maternity hospitals based on their capacity and the availability of archived data, thus allowing efficient collection, and then going down to the homes of the women who had given birth and who had agreed to this visit.

Sample size

The sample size for this study was calculated using OpenEpi software, which gave us a minimum size of 126 cases and 252 maternal controls at the 95% significance level with a power of 20%. To this, 10 cases and 20 controls were added to account for potential missing data, resulting in 136 cases and 272 controls.

Data collection techniques and tools

Data collection technique

The data were collected using the individual face-to-face structured interview technique for information not recorded in the pairs' files, coupled with document analysis for data not controllable by the mothers and the use of GPS integrated into the KoboCollect application for satellite data (altitude, latitude, and longitude) to achieve the objectives we set for ourselves.

Data collection tools

A document analysis grid and a structured questionnaire were used after being incorporated into the KoboToolbox software, where the collection was carried out using the KoboCollect application installed on the phone with an Android system.

Preliminary investigation

The data collection for this study was preceded by a preliminary survey designed to improve the efficiency and validity of the data collection tools. This allowed for training the interviewers in information gathering and for logical adjustments to the process, thereby improving the validity and relevance of the data subsequently collected. This was conducted with individuals other than the study participants.

Quality control

To ensure high data quality, controls were implemented, including double-checking. This reduced transcription errors and ensured data integrity. In addition, regular internal audits were conducted to ensure that the information collected during the study was consistent and valid. The maximum acceptable accuracy was 4.0 meters for data obtained using the KoboCollect app.

Managing biases

Three techniques were used to manage bias in this research. This process included random selection, validated questionnaires, and statistical adjustments for confounding variables. To improve the validity of the assessment of the collected data and reduce measurement bias, home visits were also conducted.

Data collection

Data collection took place in two stages. (i) At the maternity ward, we approached the new mothers, explained the purpose of the study, and requested their free and informed consent. Once obtained, we recorded their contact information and then, using their medical records, recorded the newborn's age.

(ii) at home, recorded the location point (altitude, latitude and longitude), asked questions relating to the differences felt between the level of the home and basic services, the estimated altitude and the size of the room in terms of length and width, which allowed us to deduce the area while observing from the outside the limits indicated to confirm the dimensions given by the respondents.

Variables of interest

The outcome variable was "gestational age." This study opted for this approach rather than considering the presence or absence of prematurity, since studying gestational age

numerically allows for a more nuanced analysis than the simple binary of prematurity. Gestational age is a key determinant of organ maturity. (Lattari Balest & Pekarsky, 2025) .

The independent variables consisted of the residential environment (ZS), living space (room size), and topography (house level relative to basic services, altitude, and latitude). Thus:

Table 1: Description of study variables

Variable	Description
Health Zone	Geographic classification of where the home is located, indicating access to health services.
Room dimensions	Room size, measured in m ² , influencing comfort and living conditions.
House level in relation to basic services	Assessment of the proximity or accessibility of essential services (market, FOSA, church, school, etc.).
Measured latitude	Geographic coordinate indicating north-south position and obtained using a device, influencing climate and environmental conditions.
Measured altitude	Element of the actual height of the site relative to sea level and obtained using a device, affecting living and health conditions.
Estimated altitude	Approximate height assessment based on respondents' assessment.

Data analysis

After collection, the data were exported from KoboToolbox to Microsoft Office Excel 2016 for file cleaning and analyzed using SPSS version 25 software. These data were described using frequencies for qualitative characteristics and median (IQR) for quantitative characteristics, for which the Kolmogorov-Smirnov normality test coupled with the graph method showed the abnormality of distributions and then the absence of homoscedasticity.

In univariate analysis, since normality and homogeneity of variance are not respected, Spearman's rank correlation, Mann-Whitney U test, and Kruskal-Wallis test were used to verify the relationship between the different quantitative variables, dichotomous, then polychotomous, and gestational age, respectively.

In multivariate analysis, after verifying collinearity and other prerequisites alongside normality and linearity as described above, generalized linear models, and especially the Tweedie approach with a log link, have been recommended. Generalized linear models based on the

Tweedie approach combine features of exponential distributions to model data where the variance is proportional to a power of the mean. With a log link, they are particularly well-suited for positive rather than negative responses. (Halder et al., 2023; Brooks et al., 2017) .

The Tweedie model with a logarithmic link function is ideal for studying the influence of environmental conditions on gestational age, as it handles positive data exhibiting variability, captures non-linear relationships, and allows for a relevant and accessible interpretation of the effects of environmental factors.

Furthermore, the model selected and presented in this study was obtained after three attempts in which the first included only the variables significant at the 0.05 level in univariate analysis, the second added those that were significant at the 0.1 level, and the third went up to the 0.5 level. The last model was selected based on its goodness of fit and performance, which were judged to be better after comparison with the first two models and with the empty model (see Table 2).

Table 2: Criteria for evaluating the goodness of fit of models

Quality indicators	Model 1	Model 2	Model 3
Predictors	House size and level of services	+ measured altitude	+ ZS, measured latitude and estimated altitude
Deviance	23,129	23,069	21.99
log of likelihood	-1072,612	-1072.09	-1062.52
AIC	2153,225	2154,178	2147,042
AICC	2153,326	2154,331	2147,725
BIC	2169.18	2174,123	2190,921
Likelihood ratio: approx	0.001	0.001	<0.001

Managing missing data

Missing data were addressed by excluding participants with a non-response rate exceeding 10%. This approach

minimized potential bias in the analysis and ensured that the results remained reliable and valid.

Ethical considerations

The protocol of this study was submitted to the ethics committee of ISTM/Kinshasa, and we obtained authorization No. 0008/CBE/ISTM/KIN/RDC/PMBB/2024 on March 27, 2024. Confidentiality and anonymity were respected, and the interview was conducted after obtaining free and informed consent from the respondents, who had the right to withdraw at any time they wished.

Results

Sample description and environmental conditions

The results show that the median room size of respondents was 6.2 (1.5) m² in cases and 7.5 (2.8) m² in controls. The majority of case respondents lived in the Katwa health zone (32.4%). More than half rated their home and basic services such as health facilities, markets, churches, etc., as equivalent (68.4%), and this at an average or normal altitude (75.0%). The median measured latitude was 0.132 (0.394)°, the median measured altitude was 1728 (667.7) meters, and the median gestational age was 38.0 (4.3) weeks.

Table 3: general characteristics

Features	n (%)		Median (IQR)**	
	Case	Witnesses	Case	Witnesses
Room size (n = 399)*			6.2 (1.5)	7.5 (2.8)
Health Zone				
Blessed	18 (13.2)	58 (21.3)		
Butembo	15 (11.0)	26 (9.6)		
Katwa	44 (32.4)	73 (26.8)		
Kyondo	30 (22.1)	48 (17.6)		
Oicha	29 (21.3)	67 (24.6)		
House level in relation to basic services				
The same	93 (68.4)	213 (78.3)		
Different (high or low)	43 (31.6)	59 (21.7)		
Measured latitude			0.09 (0.394)	0.145 (0.394)
Measured altitude			1745 (631)	1715 (667)
Estimated altitude				
High	34 (25.0)	54 (19.9)		
Average	102 (75.0)	218 (80.1)		
Gestational age			32.0 (4.3)	38.0 (1.0)

* There are 9 missing data points compared to the sample size of 408.

** IQR = Interquartile range

Exploration of the link between environmental conditions and gestational age in univariate analysis

Univariate analyses revealed a positive and significant correlation between the size of the maternity room and gestational age at delivery, and a significant difference based on estimated altitude ($p < 0.05$). However, health zone, latitude, and measured or estimated altitude were not statistically associated with gestational age at delivery ($p > 0.05$).

Table 4: Relationship between environmental conditions and gestational age in univariate analysis

Features	Spearman's rho (ddl)	Median (IQR)		p-value
		Case	Witnesses	
Room dimensions	0.122 (397)			0.014***
Measured latitude	0.045 (406)			0.368***
Measured altitude	-0.087 (406)			0.078***
Health Zone				
Blessed		33.0 (1.0)	38.0 (3.0)	0.486**
Butembo		28.0 (4.5)	38.0 (3.0)	
Katwa		34.0 (4.0)	38.0 (1.0)	
Kyondo		32.0 (6.0)	39.0 (1.0)	
Oicha		32.0 (1.0)	38.0 (3.0)	
House level in relation to basic services				
The same		33.0 (3.0)	38.0 (2.0)	0.029*
Different (high or low)		32.0 (5.0)	38.0 (1.0)	
Estimated altitude				
High		32.0 (6.0)	38.0 (1.0)	0.301*
Average		32.0 (4.0)	38.0 (2.0)	

*** Spearman correlation, Kruskal -Wallis Test

* Mann-Whitney U test

Influence of environmental conditions on gestational age in multivariate analysis

The results indicate that room size, the level of the home relative to basic services, and the area of study (AS) influence gestational age at delivery. For each 1 m² increase in room size, gestational age at delivery is associated with a

1.1% increase (aOR = 1.011 [1.001; 1.017]; p = 0.001). There is an 11.3% increase in the odds for gestational age when the home and the service are at the same level (aOR = 1.113 [1.040; 1.191]; p = 0.002). The Kyondo AS is also associated with prolonged gestational ages, with a 78.5% increase in the odds (aOR = 1.785 [1.001; 3.182]; p = 0.049).

Table 5: Relationship between environmental conditions and gestational age in multivariate analysis

Setting	B	approx.	Exp (B)	95% CI	
				Lower	Superior
(Constant)	2,998	0.000	20,051	11,135	36,111
Room dimensions	0.011	0.001	1,011	1.004	1,017
Home and basic services at the same level	0.107	0.002	1,113	1,040	1,191
Housing and basic services at different levels	0		1		
Measured altitude	-4.1E-05	0.101	1,000	1,000	1,000
ZS Beni	0.177	0.053	1,194	0.997	1,429
ZS Butembo	0.419	0.079	1,521	0.952	2,429
ZS Katwa	0.500	0.052	1,648	0.995	2,729
ZS Kyondo	0.579	0.049	1.785	1.001	3,182
ZS Oicha	0		1		
Measured latitude	0.760	0.071	2,139	0.936	4,883
Estimated "average" altitude	-0.071	0.057	0.931	0.865	1.002
Estimated altitude: high	0		1		

Discussion

Environmental conditions influencing gestational age at delivery

The results of this study indicate that living space, topography, and environment (ZS) influence gestational age at delivery.

Living space

This study shows that for every 1 m² increase in room size, gestational age at delivery is associated with a 1.1% increase in rib size (ORa = 1.011 [1.001; 1.017]; p = 0.001). This means that the larger the living space, the greater the chance of a full-term pregnancy. According to the theory of geographic space, a larger living space aids survival. (Fleuret & Séchet, 2006).

This reality demonstrates that a suitable living environment can reduce stress and improve access to resources, thereby contributing to improved gestational age and fetal maturation. (Dummer, 2008). This means that while an appropriate environment promotes optimal fetal development, a supportive environment can prevent fetal development and reduce the likelihood of preterm births. In such circumstances, there is also evidence that better housing conditions and a more accessible environment can be closely linked to positive effects on pregnancy.

The quality of living conditions for pregnant women, as well as the quality of pregnancy experiences, is also affected by an increasing number of available resources. (Nicholls-Dempsey et al., 2023). Improved health conditions associated with higher socioeconomic status, manifested by larger housing, which could mean more space to live and spend time, which in turn can make better nutrition and healthcare available, can lead to higher health status. (Morrison et al., 1989).

However, studies on the association between residential green spaces and pregnancy outcomes have yielded mixed results, as some studies have found no significant association between these green spaces and gestational age after adjusting for socioeconomic factors. (Glazer et al., 2018)

According to Nicholls-Dempsey et al. (2023), the association between living space and gestational age may be modulated by socioeconomic status, as studies that fully adjust for these factors may show a weaker or even nonexistent direct association. The impact of living space may vary depending on geographic location and access to healthcare services.

Relief

The study reveals an 11.3% increase in the odds of gestational age when the home and basic services are at the same level (ORa = 1.113 [1.040; 1.191]; p = 0.002). This

situation would reflect the effort pregnant women make traveling between their homes and everyday social services, such as the market, the FOSA (Family Support and Assistance Center), the church, etc., meaning that the less effort involved, the greater the chance of carrying the pregnancy to term.

Recent studies show that shorter walking distances increase the use of maternity services and reduce perinatal risks. Physiologically speaking, less effort to reach daily services would reduce the risk of preterm birth, given that moderate activity during pregnancy is safe and beneficial, potentially improving maternal well-being and reducing certain complications, according to ACOG 2020 guidelines and recent systematic reviews.

The relationship between physical exertion in pregnant women and prematurity was also found in a study carried out in Kinshasa, where the risk of premature birth was higher in the case of heavy work. (Atuba et al., 2023).

Living environment

The Kyondo health zone was associated with longer gestational ages, with a 78.5% increase in odds (ORa = 1.785 [1.001; 3.182]; p = 0.049). Compared to the Oicha health zone, pregnant women living in Kyondo have a higher chance of carrying their pregnancies to term. This could be explained by the fact that there is a relative improvement in security in this area compared to neighboring areas. Field observations show that victims of atrocities often seek refuge there. (Paluku, 2022; Kahotwa & Paluku, 2020).

Furthermore, the prolonged gestational ages observed likely reflect environmental or socioeconomic factors specific to Kyondo that affect the duration of pregnancy in this area to varying degrees compared to the Oicha health zone. These conditions may be a consequence of assistance provided by various national and international organizations in the region. However, this statistically significant difference could simply be due to the hospital as the primary point of selection, given that not all pregnant women typically go there.

Furthermore, some studies highlight that socio-economic status, access to prenatal health services, and the living conditions of pregnant women can influence the duration of pregnancy. (Yaméogo et al., 2022).

Integrated discussion of results

After multivariable analysis, the study noted that room size, house level relative to basic services, and environment (ZS) influence gestational age at delivery.

This favorable relationship between room size and gestational age at delivery can be explained by the geographical space hypothesis, which posits that space is

significantly relevant to the living conditions of a family community. (Dummer, 2008) . Larger living spaces may be a sign of higher socioeconomic status, which is conducive to a healthy pregnancy by reducing stress and promoting the well-being of the pregnant woman (Chen et al., 2024; Hasriantirisa et al., 2024).

According to Chan of Harvard, a well-located physical space promotes health and well-being, which in turn facilitates conditions that prolong pregnancy for pregnant women. More recent research shows that housing conditions can impact maternal and infant health and well-being (Harvard T.H. Chan School of Public Health, 2024).

This is physiologically important because a more comfortable and less stressful living environment can reduce maternal cortisol production (a stress hormone), which, if elevated, can negatively impact the duration of pregnancy. (Mustafa et al., 2019a) . Research has shown that maternal stress can compromise placental function and lead to pregnancy complications (Oancea et al., 2025; Loverro et al., 2022).

With its significantly greater difficulty of movement, the rugged landscape can lead to higher levels of fatigue and physical stress during pregnancy. The stresses of long distances, ups and downs, and intense physical exertion can lead to increased production of stress hormones as well as altered uterine blood flow, harming fetal development and the duration of gestation. (Jahan-Mihan et al., 2025; Glover, 2016) .

Finally, this association could be influenced by issues specific to this region, such as cultural practices, environmental factors, or adaptations to the physiological systems of life in the Kyondo ZS, which could also lead to longer gestational ages. The first is that Kyondo has previously hosted many internally displaced persons due to conflict, which could lead to physiological adjustments due to chronic stress and food insecurity. (Aldabbour et al., 2025; González-Fernández et al., 2020) .

Nevertheless, a thorough understanding of the underlying mechanisms of these observations is needed, and it is possible to identify future possible interventions to improve maternal and neonatal health in these contexts, which we need next (Behboudi-Gandevani et al., 2022; Mustafa et al., 2019b).

Generalizability

The results of this study can be generalized to women who gave birth in the five health zones studied Beni, Butembo, Katwa, Kyondo, and Oicha and have similar environmental and sociodemographic characteristics. This study has 136 cases and 272 controls recruited from selected maternity facilities and therefore can investigate the relationship

between residential environment, topography, and gestational age within this context.

But extrapolating findings to the whole North Kivu province should be considered carefully. The maternity facilities were chosen based on accessibility and capacity as well as data availability, and security limitations restricted access to certain mothers. This may have led to selection bias and reduced representation of women who live in less accessible areas or who suffer from different environmental conditions. Generalizing the results to other provinces of the DRC or to other settings is therefore very important, as geographical, socioeconomic, cultural, and health conditions may differ. Furthermore, data collected between June and October 2025 is not necessarily indicative of seasonal variation that could affect pregnancy outcomes. The results therefore serve as a context for North Kivu, which will need to be validated by multicenter studies over a longer period.

Implications of the study

The results obtained highlight the importance of raising awareness among pregnant women about the negative impact related to terrain, space and/or accommodation conditions as well as the living environment.

Therefore, it is essential to develop awareness programs at antenatal care centers (ANC) and within the community through the media. The effective involvement of political and administrative authorities, community leaders, and healthcare providers remains necessary to increase women's chances of carrying a pregnancy to term once they return to their respective natural living environments, while ensuring their access to adequate healthcare; this would help reduce the occurrence of premature births.

The results of this study encourage all health, political, and administrative actors to put in place mechanisms to reduce the frequency and associated consequences of prematurity.

Conclusion

This study reveals that environmental factors (a large living space, a less varied ecological niche topography, and moderate altitude) play a crucial role in fetal survival in utero, highlighting the influence of the environment on fetal growth. It also indicates that environmental factors contribute to perinatal health.

Limitations of the study

This study has some limitations. Security constraints in the region have restricted access for some mothers, which could introduce selection bias. Furthermore, data collection through self-reporting, particularly regarding room size, is susceptible to measurement bias. This measurement also did not consider room height, but only surface area in terms of length and width.

Although the questionnaires were pre-tested, specific cultural or linguistic factors still influence the understanding of the questions. Finally, the relatively short study period (June-October) did not capture significant seasonal variations that affect gestational age and its determinants.

Recommendations

Therefore, to ensure people's well-being, it is urgent to improve living standards for all through an integrated approach. This could include providing sufficient infrastructure, reproductive health education programs, and better access to high-quality maternal healthcare.

The environment must be adapted to support gestation through cooperation between local authorities, health professionals, and the community in order to achieve good health for mothers and newborns.

Abbreviations

AIC: Akaike Information Criterion

AICc: Akaike Information Criterion corrected

ANC: Antenatal Consultation

ACOG: American College of Obstetricians and Gynecologists

BIC: Bayesian Information Criterion

FOSA: Health Training

GPS: Global Positioning System

95% CI: 95% Confidence Interval

IQR: Interquartile range

m²: Square meter

OR_a : Adjusted Odds Ratio

DRC: Democratic Republic of the Congo

SPSS: Statistical Package for the Social Sciences

ZS: Health Zone

Author contributions

AKI: study conception, methodology, data curation, data visualization, and drafting of the initial manuscript. PAM: formal data analysis, interpretation of results, and critical revision of the manuscript. JPAO: contribution to methodology, interpretation of results, and critical revision of the manuscript. JPNKTN: scientific supervision, contribution to methodological design, and critical revision of the manuscript. FTK: scientific supervision, methodological contribution, interpretation of results, and critical revision of the manuscript. All authors: validation of the final version of the manuscript and agreement to its submission for publication. All authors assume responsibility for the integrity and content of the work.

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Declaration of conflict of interest

The authors declare that they have no conflict of interest of any kind.

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Data availability

The datasets generated and/or analyzed in this study are not publicly available due to ethical and confidentiality reasons, but can be obtained from the corresponding author on request if they are reasonable and comply with ethical and institutional requirements.

Author biographies

Kambale Isemighambo Anaclet is an academic scientist at ISTM Oicha in North Kivu and a health worker in the Democratic Republic of Congo whose research and community health work focus on field medicine and community health. Working within medical research networks in Central Africa, her work is situated in an academic field with a focus on improving local healthcare practices. Most of her work, carried out in collaboration with national universities, concerns the documentation of prevalent diseases and the development of medical practices in urban and rural areas. Currently, he is continuing his doctoral research at the ISTM Kinshasa doctoral school in Maternal and Child Health.

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