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RESEARCH ARTICLE

An assessment to inform programming for antenatal care services in six health facilities in Geita Region, Tanzania: a cross-sectional baseline survey

[version 1; peer review: 2 approved with reservations]

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Abstract

Background

Every two minutes, a woman dies from pregnancy or childbirth complications globally, with around 6,300 newborn deaths daily, most of which are preventable. Despite international efforts, maternal and neonatal mortality remain high. The World Health Organization (WHO) recommends at least eight antenatal care (ANC) contacts, beginning in the first trimester. This baseline assessment evaluated ANC service utilization and maternal complications at selected health facilities, guiding a future pilot intervention using digital solutions and machine learning for early detection and management of pregnancy complications.

Methods

A cross-sectional study analysed records of 657 women receiving ANC and delivery services across six health facilities from January to December 2022. Data were abstracted from ANC and Labor and Delivery registers, supplemented by District Health Information System 2 (DHIS2). Descriptive statistics summarized ANC practices, and multivariate logistic regression identified factors associated with anaemia (haemoglobin ≤ 11 g/dL).

Results

Of 599 women with complete ANC visit records, only 34% attended the recommended four or more ANC contacts, and just 19% initiated ANC during the first trimester. Nearly half (48.2%) of women with haemoglobin data (n=440) were anaemic. Iron supplementation coverage decreased significantly after the second dose. Women attending ≥ 4 ANC visits had 2.7 times higher odds of normal haemoglobin levels compared to those with fewer visits. Intermittent Preventive Treatment for Malaria (IPT) coverage was low at 43.3%. Postpartum haemorrhage (PPH) was notably common (n=147).

Conclusion

This baseline assessment revealed substantial gaps in ANC utilization and maternal health indicators, underscoring the need for innovative approaches. Our planned pilot intervention, integrating artificial intelligence, Group Antenatal Care (GANC), and community-level strategies, aims to increase early ANC initiation, improve attendance to recommended ANC visits, and facilitate early detection and management of pregnancy complications, ultimately enhancing maternal and foetal outcomes.

Keywords

Antenatal Care, Antenatal Risk Stratification, Digital Health in Maternal Care, Baseline Assessment, Group Antenatal Care



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Abbreviations

ANC: Antenatal care
 DHIS2: District Health Management System (Version 2)
 GANC: Group Antenatal Care
 Hb: Haemoglobin
 HMIS: Health Medical Information System
 IPTp3+: Intermittent Presumptive Therapy for Malaria (3 doses)
 LMICs: Low- and Middle-Income Countries
 MOH: Ministry of Health
 PPH: Postpartum Hemorrhage
 SDGs: Sustainable Development Goals
 TDHS: Tanzania Demographic Health Survey
 WHO: World Health Organization

Introduction

According to UNICEF, the number of maternal deaths declined by 35% between 2000 and 2017. However, over 800 women are still dying every day, majority of them in sub-Saharan Africa from preventable pregnancy or childbirth complications.¹ Despite continuous efforts to improve maternal health, Tanzania is still facing challenges in reducing maternal complications and fatalities to the desired levels. The current maternal mortality rate remains significantly high at 104 per 100,000 live births, which is still higher than the desired Sustainable Development Goal (SDG) target of 70 per 100,000 live births.² Maternal mortality in Tanzania has been reported to stem from a variety of causes, such as eclampsia, hemorrhage and sepsis.³ Child mortality is similarly high, at 24 deaths per 1,000 livebirths (TDHS 2022) double the SDG Target of <12 deaths per 1,000 livebirths.²

Antenatal care presents a unique opportunity for early detection and management of pregnancy-related complications, leading to improved pregnancy outcomes. WHO recommends a minimum of 8 contacts at the health facility during the antenatal period.⁴ Recent findings from the Tanzania Health and Demographic Survey (TDHS) show that about 65% of pregnant women had four or more ANC visits/contacts as recommended.² However, the high maternal mortality rate suggests that this improvement has not directly translated into reducing mortality. Worsening this situation is the fact that majority of the women, especially in rural settings in Tanzania, start ANC quite late.⁵ This emphasizes the urgent need to promote ANC attendance and enhance the quality of care provided during pregnancy and childbirth, both at healthcare facilities and within communities and households.

One significant contributing factor to the late identification of maternal complications during antenatal care is the inadequate health information systems in these settings.⁶ Lack of proper maternal health information and poor data quality at the primary health care level hinders health care providers from identifying complications early.^{6,7} Consequently, pregnant women face substantial risks of morbidity and mortality.

In such a challenging environment, digital health solutions have been identified to have the potential of contributing to early identification of complications in pregnancy.⁸ A recent meta-analysis done in Africa and other LMICs showed a steady growth of digital innovations for maternal health in these countries, providing a unique opportunity to employ digital health systems for maternal and newborn mortality reduction.⁹ However, there are also other limitations in the quality of the interventions provided in these settings due to weak health systems and other factors. One study in Rufiji, Tanzania¹⁰ reported that although ANC participants received basic clinical evaluations such as blood pressure measurements and abdominal examinations, more targeted and thorough investigations such as testing for albumin, hemoglobin or blood glucose, were rarely done. Implementing digital solutions, complemented by innovative care models, provides a unique opportunity to improve maternal and fetal outcomes by helping health providers link danger signs and clinical conditions, thus preventing adverse outcomes during pregnancy. This is where digital solutions such as artificial intelligence (AI) can play a vital role.

It has also been shown that early ANC attendance promotes utilization of preventive measures by pregnant mothers during the antenatal period.^{11,12} Women who start ANC services early and frequently are more likely to use key interventions such as intermittent preventive treatment for malaria and iron supplementation to prevent anemia.⁴ Improvement in maternal outcomes will be facilitated by innovative approaches that promote integrated, and high-impact interventions to address the high maternal mortality rate in Tanzania.

Prime Health Initiative Tanzania is a local non-governmental organization (NGO) that has received funding by the Bill and Melinda Gates Foundation to implement a 2-years project aiming at piloting an antenatal risk stratification system

using Artificial Intelligence (AI) technology. The primary objective is to promptly identify maternal risks among pregnant mothers in the Geita region of Tanzania. This will enable early interventions and management to prevent potential adverse maternal and fetal outcomes. If successful, this project has the potential to be scaled up in other health facilities in the region or elsewhere in Tanzania. The project will be implemented at six health facilities in two semi-urban/rural districts in Geita region.

Prior to the implementation of the proposed project, a comprehensive baseline assessment was conducted on to establish the status of ANC services in the targeted facilities. This paper presents the key findings derived from the assessment, with a specific focus on facility capacity, ANC attendance rates and patterns, maternal complications and other key practices related to antenatal care in the region. The baseline assessment provides vital information on the strengths, weaknesses, and gaps in the current ANC services. This critical exercise serves as a foundation for planning, refining, and tailoring the project interventions' design. It also sets grounds for future comparison to understand the impact of the project after its implementation.

The paper summarizes key baseline parameters for antenatal care in Geita region, including facility capacity, availability of electronic health management information systems (HMIS), ANC attendance and timing and the overall state of antenatal care in these facilities.

Methods

Study design

This was a cross-sectional study involving an analysis of records from women attending ANC visits in six selected health facilities during the assessment period (January to December 2022). We used data from HMIS registers – ANC and Labor and Delivery – to obtain information about pregnant mothers who attended ANC in the six facilities during the assessment period. Cut-off points on ANC and labor parameters (birth weight, hemoglobin concentration and age group categories) were based on the World Health Organization standards and other peer reviewed studies. Data from the District Health Information System 2 (DHIS2) from the same period was used to make comparisons on the proportions of maternal complications, anaemia and maternal & neonatal deaths.

Study location

The study facilities are located in 2 Districts and include Chato District Hospital, Bwanga Health Center, and Butengoromasa Dispensary (In Chato District Council) and, Nzera District Hospital, Katoro Health Center, and Nkome Dispensary (in Geita District Council) both within Geita region in Tanzania. The dispensary is the lowest level of health care delivery in the country with basic normal delivery services, while health centers and district hospitals are the subsequent level of care, with more infrastructure and human resources for labor and delivery, including Comprehensive Emergency Obstetric and Neonatal Care (CEmONC).

Sample size

We employed convenience sampling to examine all available records from the registers at each health facility during the review period. This encompassed antenatal care (ANC) registers and labor and delivery registers. To gather data on maternal complications, we extracted information from the District Health Information System 2 (DHIS2) for these facilities, reported during the same period.

Data collection methods

We trained data enumerators on data collection methods and tools. The data collectors visited each facility in person to gather information from the following sources: 1) NOH ANC Registers at the Antenatal Clinics and 2) MOH Labor and Delivery Registers at labor wards. Data from 657 women was extracted during this period from the ANC and labor registers. Additionally, data from the DHIS2 was retrieved online for the same period (January to December 2022) to analyze maternal and newborn complications reported in each study facility. Data was extracted manually from the registers into pre-designed data collection forms for analysis later. Regular supervision visits by the study lead and the project staff ensured adherence to data collection protocols.

The survey tool used in this study was developed specifically for the study and has not previously been published elsewhere. The online links to the survey tools are accessible at Kobo Toolbox, an open access online software (KoBoToolbox, 2024).^{13,14}

Data analysis

The final data set was transformed to excel 2019. For statistical analysis we used Stata (version 15.0) statistical for analysis. No additional copyright license was required to use this tool. Data was analyzed descriptively using frequency

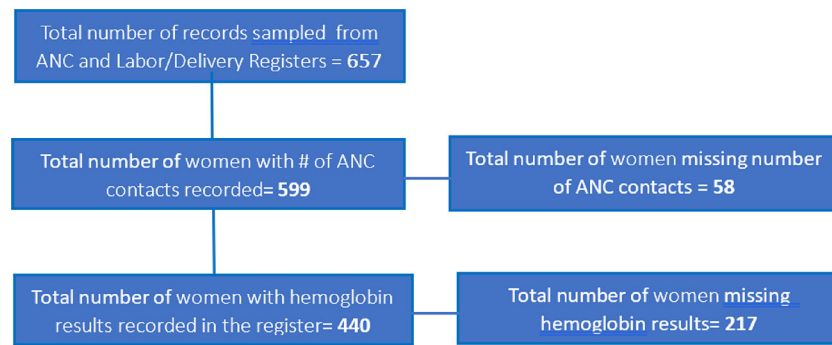


Figure 1. Flow chart of women who attended ANC services at the six health facilities. Women with missing records were excluded from the final analysis.

(percentages) and median (interquartile range [IQR]). Chi-square (χ^2) used to test for significance of the associations between outcome indicators and the independent variables. All statistical inferences were set to significance level of 5% ($\alpha=0.05$). Data was presented in tables, cross-tabulations (demonstrating relationships between independent and dependent variables), pie charts and histograms. A further description of the analysis is given in Figure 1.

Ethical considerations

The study team submitted the baseline study proposal and all data collection tools to the National Health Research Ethics Committee (NatHREC) as assurance that the study team was committed to protect the study participants and the data that would be generated as part of the baseline implementation. This study was approved with Ethical Clearance Certificate reference number NIMR/HQ/R.8a/Vol.IX/4194 dated 23rd January 2023.

This study was conducted according to CIOMS Guidelines on use of retrospective data and NatREC guidelines, the local ethical review board in Tanzania.

Results

Records from 657 women with ANC and labor and delivery records were reviewed. The results are shown in the tables and figures below:

The study was conducted in six public health facilities with varying levels of care and ANC attendance (Table 1).

Health Centers had the largest volume of women attending ANC services. None of the facilities was using an electronic health medical information system (HMIS).

ANC attendance

We analyzed data from the 657 women who attended ANC services and described various parameters such as age distribution, number of visits throughout pregnancy and gestation age during ANC initiation. 599 of them had complete records on the number of ANC visits they had made throughout their pregnancy period (See Figure 1).

Table 1. Facility characteristics.

Facility Name	Level	# of Beds	Monthly ANC Attendance	No of Doctors (MD)	Use of Electronic HMIS
Nzera	District Hospital	130	370	4	No
Chato	District Hospital	120	600	12	No
Bwanga	Health Center	100	1600	6	No
Katoro	Health Center	110	1400	3	No
Nkome	Dispensary	11	500	0	No
Butengorumasa	Dispensary	6	380	0	No

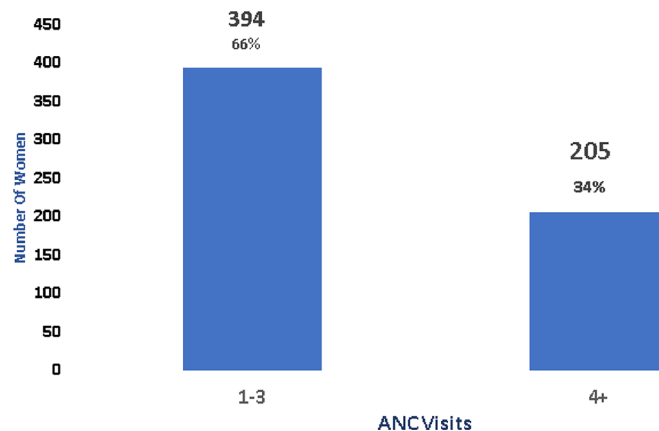


Figure 2. Number of ANC visits among women attending ANC services at the six project facilities from January to December 2022 (n = 599).

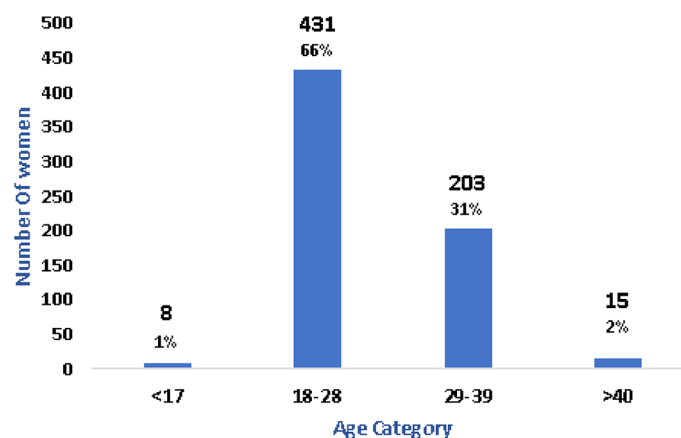


Figure 3. Age distribution of women attending ANC services at the six project facilities from January to December 2022 (n = 657).

Only 34% of the women who had ANC contacts records were found to have attended 4 or more ANC visits (Figure 2). Because the current Data registers at the facilities are still using the previous cut-off points for ANC visits, it was only possible to analyze those attending less than four contacts and those who has four contacts or more. Majority of women who attended ANC in these facilities were in the age group 18-28 years i.e. 65.4% (Figure 3).

Out of the 657 women who were reported in the study facilities, majority (54%) had initiated ANC between 13-24 weeks of gestation (Figure 4). Very few (19%) had initiated ANC at 12 weeks or below.

Majority of women (54%) initiated ANC visits during the second trimester of their pregnancy, with only 19% being seen during the first trimester.

ANC interventions

Key ANC interventions provided to mothers during ANC were assessed. These included hemoglobin checks for presence of anemia, iron and folic acid supplementation and intermittent preventive therapy (IPT) for malaria.

Almost half (48.2%) of the women (with hemoglobin results recorded) were recorded to have anemia (Table 2). 1% of them had severe anemia (Hb level below 7g/dl).

In the multivariate analysis, using logistic regression with hemoglobin level being a dependent variable, women with 4 or more ANC (4+) visits were 2.7 more likely to have normal Hb level above 11g/dl than those with less than 4 visits (OR = 2.75, p = 0.011) as shown in Table 3.

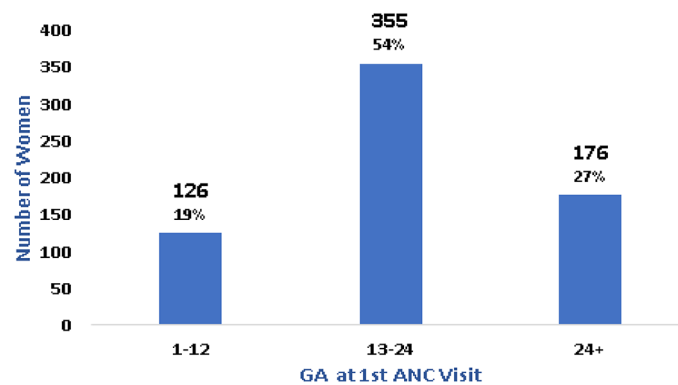


Figure 4. Gestational age at initiation of ANC at the six project facilities from January to December 2022 (n = 657).

Table 2. Prevalence of anemia reported among mothers attending ANC (n=440).

Normal (>11g/dl)	Mild (10.0-10.9 g/dl)	Moderate (7.0 – 9.9 g/dl)	Severe (<7g/dl)	Total
228 (51.8%)	110 (25%)	98 (22.2%)	4 (1%)	440 (100%)

Table 3. Multivariate logistic regression analysis of factors associated with Hb levels > 11g/dl.

Variable	Odds Ratio	95% Conf. Interval	p = value
ANC visits 4+	2.749114	5.977355	0.011
Mebendazole use	1.675982	4.100463	0.256
Iron supplementation	0.998055	10.24644	0.999
IPT use	1.158734	3.564585	0.797

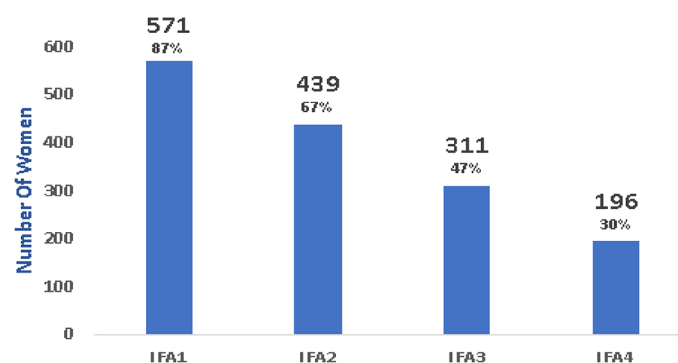


Figure 5. Iron and folic acid supplementation among women attending ANC at the six project facilities from January to December 2022 (n = 657).

We also analyzed Iron and Folic acid supplementation as reported in the HMIS registers. Out of the 657 women attending ANC, majority received the first and second dose of Iron and Folic Acid supplementation at 87% and 67% respectively (Figure 5). The trend shows a with a sharp decline in this proportion for the third and fourth doses.

Regarding the use of Intermittent Preventive Therapy for Malaria Prevention (IPT), less than half of the women (43.3%) received at least 3 doses of Intermittent Preventive Therapy for Malaria. Coverage of those getting only one does was 14% and those getting only 2 doses was 16% (Figure 6).

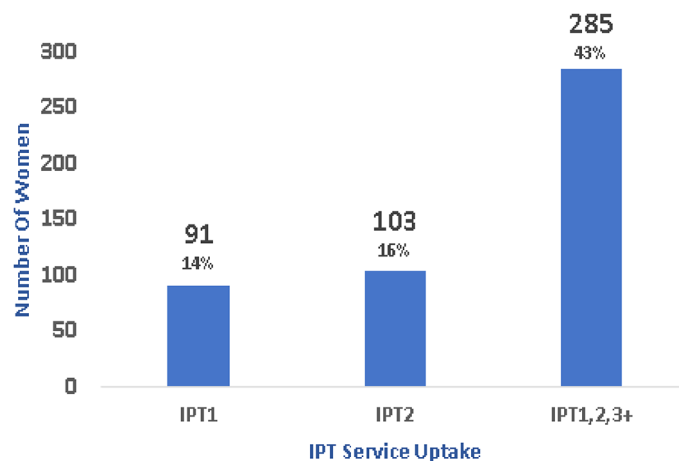


Figure 6. Use of intermittent preventive therapy for malaria prevention (IPTp) from January to December 2022.

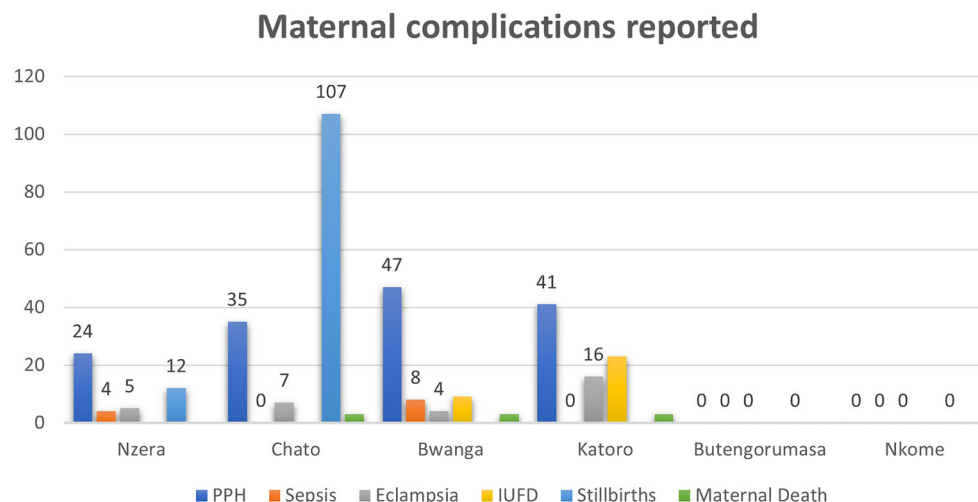


Figure 7. Number of maternal complications reported across project facilities during the assessment period.

Maternal and fetal complications during ANC, labor, and delivery

All maternal and fetal complications reported in the DHIS2 during the analysis were analyzed and categorized by type and facility as shown in Figure 7. All facilities reported a significant number of post-partum hemorrhage cases. Chato DH has a particularly high number of stillbirths reported. One of the facilities (Chato District Hospital), had a very high number of reported stillbirths in DHIS2 during the reporting period.

Discussion

The current study aimed to assess facility capacity, ANC coverage, occurrence of maternal complications and key ANC interventions in six healthcare facilities within Geita region. We describe key capacity parameters such as facility level, bed capacity, monthly ANC attendance, and availability of HMIS systems. We note that none of the facilities used electronic medical records before this assessment, implying that our project will need to strengthen this component before starting implementation.

Additional insights that will serve as a foundational understanding of the status of antenatal care in these facilities are further discussed below.

ANC attendance: Timing and frequency

The proportion of women receiving 4 or more ANC visits in this study was 34%. This is much lower than the proportion reported in the 2022 TDHS (65%) and from other literature in Tanzania.¹¹ This assessment was conducted

in a rural/semi-urban setting. Prior assessments have shown that the number of ANC visits tend to be lower in rural vs urban settings, as reported in the 2022 TDHS.² This finding is significant to our project, since it means that most women in the project area do not receive the WHO-recommended ANC contacts during pregnancy. Our intervention will therefore focus on exploring potential barriers to ANC attendance, such as accessibility, awareness, and cultural beliefs, and develop strategies to encourage and support regular ANC visits.

The study also examined demographics and ANC utilization factors among women attending ANC services. Most women were in the age group of 18-28 years, suggesting that the project will need to tailor ANC services to address the specific health needs and preferences of this age group.

Gestation age at initiation of ANC

The study found that most women, initiated ANC visits during the second trimester i.e., at 13-24 weeks of pregnancy. These findings are comparable to other studies that reported late initiation of ANC in Tanzania.^{12,15,16} WHO recommends at least one contact with the pregnant woman during the first trimester, highlighting the need for early ANC initiation.

From these findings, we recognize the need to analyze various barriers to early initiation of ANC in this community and thus tailor interventions to address them. Some of the barriers for late ANC initiation highlighted in other studies in Tanzania, include traditional and cultural beliefs, unpleasant experience in past pregnancies, shortage of health care workers and perceptions about inadequate quality of care.^{15,16} One study conducted in a similar setting in Rwanda recommended replacing traditional approaches with innovative models to enhance ANC seeking behavior¹⁷ and promote early initiation.

ANC interventions

The prevalence of anaemia in pregnancy in this study was found to be 48.2%. This is comparable to studies done elsewhere in Tanzania and elsewhere in Africa.¹⁸⁻²⁰ A study in a rural setting in Tanzania reported a much higher prevalence of anaemia in pregnancy, signifying the need for anaemia prevention measures in our setting.²¹ There is a need to find innovative approaches to enhance Iron and folic acid supplementation uptake, as recommended by WHO.

The multivariate analysis using logistic regression demonstrated that attending four or more ANC visits (OR = 2.74, p = 0.011) significantly increases the likelihood of having higher Hb levels (above 11). Other variables, including mebendazole use (OR = -1.67, p = 0.256), iron supplementation (OR = 0.99, p-value = 0.99), and IPT use (OR = 1.15, p = 0.797), did not show a statistically significant association with Hb levels in this analysis. Our findings are comparable to a study in Ghana that showed a similar association.²² These results, consistent with Table 3, underscore the positive impact of ANC attendance on anemia prevention.

During this baseline assessment, we observed a decline in the proportion of women receiving the third and fourth doses of Iron and Folic Acid supplementation. This signifies that there are potential barriers to consistent care. We plan to explore additional community level interventions, that can be implemented in the project facilities and promoted through peer-support and community health workers who will be part of our planned GANC model.

The coverage of 3 doses Intermittent Preventive Therapy for Malaria (IPTp3+) was reported 43.3%. This was comparable to other studies done elsewhere in Africa.^{23,24} It will be critical to analyze and address factors that may influence acceptability and uptake of IPTp3+ as outlined elsewhere in Tanzania.²⁵

Maternal complications

Maternal complications are a significant concern and were evident across all facilities during the assessment period. The assessment of maternal complications revealed important patterns across the project facilities. Postpartum hemorrhage (PPH) was the most frequently reported complication, affecting women across all facilities. This picture is similar to the findings from a 10-year mortality by Bwana et al in 24 public hospitals in the country.³ The finding highlights the need for targeted interventions to improve the management of PPH and its prevention through appropriate antenatal and postnatal care. Chato District Hospital reported a notably high number of stillbirths, signaling the necessity of focused efforts to address this issue.

Limitations

Several limitations are acknowledged in this study. Firstly, the data collected were based on the assessment period (January – December 2022), which may not fully represent the long-term performance of the facilities. Secondly, the study focused on a rural and semi-urban geographic area, that may limit the generalizability of the findings to urban

settings. Lastly, the reliance on reported maternal complications may be subject to underreporting or poor documentation in these health facilities.

Conclusion

Our findings shed light on the strengths and areas for improvement in the provision of ANC services in the project facilities. Efforts should be made to address common maternal complications such as PPH, and strategies to improve ANC attendance and early initiation of ANC should be prioritized. Targeted interventions, capacity-building, and quality improvement initiatives can collectively contribute to enhancing maternal and child health outcomes in the project area.

The proposed AI-powered antenatal risk stratification system holds promise in addressing these challenges. By leveraging advanced algorithms to analyze health data, this system can identify high-risk pregnancies promptly, enabling healthcare providers to intervene early and provide targeted care. Integration with the Group Antenatal Care (GANC) model presents a unique opportunity to facilitate peer support and education among pregnant women, potentially enhancing their engagement in care and health-seeking behaviors.

This study sets the stage for a transformative initiative that could reshape maternal healthcare in Geita region. By understanding the current state of antenatal care, the project can tailor interventions to address specific gaps and needs. The integration of digital health technology and innovative care models aligns with global efforts to leverage technology for improved healthcare outcomes. This initiative's success could serve as a model for other regions facing similar challenges, reducing maternal morbidity and mortality. As the project progresses, ongoing monitoring and evaluation will be critical to assess the impact and effectiveness of the AI-powered risk stratification system in improving maternal health outcomes.

This manuscript has been published as a preprint in the Research Square Platform.²⁶

Declarations

Ethics approval

We applied for and received permission from the local IRG- Board the National Health Research Ethics Committee (NatREC), with provided permission to collect the data, and the authority's permission to use secondary data which automatically waived the need for individual consents, provided we observe anonymity. Our Ethical Clearance Certificate reference number is NIMR/HQ/R.8a/Vol.IX/4194. Since this study was not a clinical trial, it did not require a clinical trial registration number.

This study was conducted according to CIOMS Guidelines on use of retrospective data and NatREC guidelines, the local ethical review board in Tanzania.

Consent to participate

This study was a cross-sectional survey that utilized de-identified secondary data extracted from Ministry of Health HMIS registers and the DHIS2 platform. As the dataset was fully anonymized and did not involve direct interaction with study participants, obtaining individual informed consent was not feasible nor required. The National Health Research Ethics Committee (NatREC) approved the study protocol and granted a waiver of individual consent. Ethical clearance was obtained under certificate number NIMR/HQ/R.8a/Vol.IX/4194 (23rd January 2023). All procedures were conducted in accordance with relevant national and institutional ethical guidelines.

Consent for publication

Not applicable.

Authors' contributions

AH, AK, and FP drafted the initial manuscript. FP, JH, and AK worked on data analysis. AH, AK, PS, FP, RB, YK, IL, HM, AM, EK, PS, FM, WK, CM, JT, OS, HA and NK provided inputs on the discussion and overall write-up. All authors read and critically reviewed the drafts of the manuscript for important intellectual content and approved the final version.

Availability of data and materials

The datasets generated during this baseline assessment are not publicly available due privacy and data protection reasons as guided by the Ministry of Health in Tanzania and the National Institute for Medical Research (NIMR) but are available from the corresponding author on request. Any requests for data access should be directed to the corresponding author (Dr. Augustino M. Hellar, email: Augustino.Hellar@phit.or.tz).

Anyone who wishes to use the data must ensure confidentiality and appropriate use of this study data. The authors will determine and decide to share any additional materials related to this assessment upon request.

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This baseline assessment was conducted as part of the preparation for an upcoming project in the Geita region of Tanzania. We extend our deepest gratitude and appreciation to the Ministry of Health and the President's Office of Regional Authorities and Local Governments for their unwavering support and contributions to this initiative. We also commend the leadership and dedication of the district and regional authorities and health facility leaders in the Geita region.

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Nwamekwe Charles Onyeka

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Review Report

This manuscript presents a cross-sectional baseline assessment of antenatal care (ANC) service utilization, maternal complications, and key ANC interventions in six health facilities in Geita Region, Tanzania. The study analysed 657 ANC records and DHIS2 data from 2022. Key findings include low ANC attendance (only 34% attended ≥ 4 visits), late ANC initiation (only 19% started in the first trimester), high anaemia prevalence (48.2%), declining iron supplementation uptake, low IPTp3+ coverage (43.3%), and notable maternal complications—particularly postpartum haemorrhage and a high concentration of stillbirths at one facility. The study aims to inform a forthcoming AI-driven antenatal risk stratification intervention.

Manuscript Evaluation and Points Needing Revision

1. Clarity and Accuracy of Presentation

Strengths:

1. Background and motivation are clearly articulated.
2. Results are well structured and visually supported by graphs and tables.

Issues requiring revision:

1. Some narrative sections repeat information already shown in tables/figures.
2. High stillbirth numbers at one facility require contextual explanation (coding issues, referral bias, documentation quality).

Required actions:

1. Reproduce the full logistic regression table with correct formatting, CIs, N values, and diagnostics. The regression output has to be complete, clean, properly structured, and include odds ratios, confidence intervals, p-values, the sample size used (N), and model-fit information,
2. Provide a methodological note explaining the outlier facility's stillbirths.

1. Technical Soundness and Study Design

The design is appropriate for a baseline assessment; however:

Major issues:

1. Temporality between ANC visits and Hb measurement is not established.
2. No adjustments were made for facility-level clustering despite multi-site data.
3. No missingness sensitivity analysis was performed.

Required actions:

1. Specify when Hb was measured relative to ANC visits.
2. Re-run regression using cluster-robust SEs or include facility fixed effects.
3. Provide a table summarizing missing data and differences between included vs excluded records.

1. Methods and Reproducibility

Strengths:

1. Data extraction process and ethical approvals are clearly described.
2. Use of DHIS2 provides credible facility-level indicators.

Limitations:

1. No variable definitions or coding schemes are provided.
2. Eligibility denominators for IPTp and iron doses are unclear.
3. No documentation of whether data collectors checked for inconsistencies across sources.

Required actions:

1. Provide variable dictionary and coding decisions.
2. Specify eligibility criteria for IPTp3+ and multi-dose supplementation.
3. Describe internal consistency checks performed (or not performed).

1. Statistical Analysis

Strengths: Descriptive statistics are appropriate and well presented.

Issues:

1. Regression table incorrectly formatted and incomplete.
2. Covariate selection is not justified.
3. No model diagnostics (Hosmer–Lemeshow test, pseudo- R^2 , etc.).
4. No assessment of multicollinearity or confounding.

Required actions:

1. Present full regression model details.
2. Justify covariate inclusion.
3. Report model diagnostics.
4. Consider re-estimating models with more granular ANC visit categories given WHO's 8-visit recommendation.

1. Source Data Availability

Concern: Data are not publicly available due to restrictions, limiting independent verification.

Recommended action: Upload a synthetic dataset or data dictionary to enhance transparency.

1. Support for Conclusions

Strengths:

1. Conclusions reflect core findings and align with descriptive results.
2. The rationale for an AI-based intervention is logical and well motivated.

Gaps:

1. Causal claims about ANC attendance and Hb improvement need stronger statistical evidence.
2. Interpretation of PPH and stillbirths requires facility-level audit information.

Required actions: Add contextual interpretation of maternal complications and possible facility-specific factors.

Overall Assessment

The manuscript presents valuable baseline data and addresses a highly relevant public health challenge. However, several methodological and statistical issues must be resolved to ensure scientific robustness and replicability. With these revisions, the paper will make a strong contribution to maternal health programming in Tanzania.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

No

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: I specialize in Industrial and Production Engineering, with focused research expertise in: Digital Manufacturing, Production Systems, ML/AL, Biomedical Engineering, ...

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 10 November 2025

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Nurul Raihen

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1. Table 3 appears corrupted. Please provide the full logistic regression output with proper 95% CIs (lower-upper), covariates, coding, N, missingness strategy, and model diagnostics. As written, the inferential claim is not verifiable.
2. When (median gestational week) was Hb measured, and how does that align with ANC visit count and iron dosing? Without temporality, the observed association may be confounded.
3. Confirm thresholds and any altitude/smoking adjustments. Were repeat Hb measures averaged or was a single value used?
4. Given your reliance on “ ≥ 4 visits,” how will baseline be comparable to post-intervention if the AI/GANC pilot targets the 8-contact guideline? Consider re-coding visits into finer categories or visit counts.
5. For IPTp3+ and iron dose completion, specify eligibility (e.g., book by ≥ 13 weeks for IPTp3+ feasibility) and present coverage among eligible women to avoid denominator bias.
6. Provide a short audit or sensitivity check on PPH and stillbirths comparing register vs DHIS2 entries by facility. The spike in stillbirths at one hospital needs context (coding, referral bias, audit results).
7. Re-estimate key associations with cluster-robust SEs or include facility fixed effects. Report intraclass correlation or between-facility variance to show how much outcomes vary by site.
8. Provide a variable-by-variable missingness table and compare characteristics of included vs excluded women (e.g., those lacking Hb or visit counts). Selection bias could inflate/deflate prevalence and associations.
9. Beyond counts, can you report stock-out logs, counselling notes, or distance to facility as potential determinants of dose completion? These programmatic levers would sharpen the forthcoming intervention.
10. Clarify case definitions for PPH and stillbirth used in DHIS2 during 2022, including any changes over time, and whether active management of third stage of labour was routine across facilities.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

No

Are all the source data underlying the results available to ensure full reproducibility?

No

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Mathematical Modeling, Applied mathematics, Numerical Simulation, Machine Learning, Statistics, and Data Science.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.
