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Feasibility of biochemical assessment of vitamin D status among pregnant women in Dodoma, Tanzania: a pilot study

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Abstract

Background

Vitamin D deficiency during pregnancy is associated with adverse maternal and neonatal outcomes. Despite abundant sunlight exposure in Tanzania, evidence regarding vitamin D status among pregnant women remains limited, particularly in central Tanzania. This pilot study assessed the feasibility of biochemical assessment of vitamin D status among pregnant women attending antenatal care services in Dodoma city and generated preliminary estimates of vitamin D status.

Methods

A facility-based pilot cross-sectional study was conducted among 60 pregnant women attending antenatal care services at the Makole Health Centre between July and August 2024. The feasibility outcomes included the recruitment rate, completion rate, questionnaire completeness, acceptability of venous blood sample collection, and logistical feasibility of sample handling and laboratory analysis. The data were collected via a structured electronic questionnaire, and the serum 25-hydroxyvitamin D concentrations were measured via chemiluminescent immunoassay. Exploratory analyses examined potential associations between selected factors and suboptimal vitamin D status (≤ 30 ng/mL).

Results

Of the 62 eligible pregnant women who were approached, 60 consented to participate, yielding a recruitment rate of 96.8%. All participants completed the study procedures, resulting in a completion rate of 100%. The level of questionnaire completeness and acceptance of blood sample collection were also 100%, with no reported adverse events or laboratory processing failures. Overall, 31.7% (95% CI: 20.3–45.0) of the participants had suboptimal vitamin D status, including 26.7% with vitamin D insufficiency and 5.0% with vitamin D deficiency. Exploratory analyses suggested potential associations between suboptimal vitamin D status and indoor occupation, lower household income, low physical activity, and higher prepregnancy body mass index.

Conclusions

Assessment of vitamin D status among pregnant women attending antenatal care services in Dodoma city was feasible and acceptable within a routine clinical setting. Larger adequately powered studies are needed to confirm these findings and better understand the determinants of vitamin D status during pregnancy in Tanzania.

Key feasibility messages

This pilot study was conducted to assess the feasibility of biochemical assessment of vitamin D status among pregnant women attending antenatal care services in Dodoma city, Tanzania. Specifically, the study evaluated participant recruitment, completion of study procedures, questionnaire completeness, acceptability of venous blood sample collection, and the logistical feasibility of sample transportation, storage, and laboratory analysis within a routine antenatal care setting.

The study demonstrated high feasibility across all assessed outcomes. Of the 62 eligible pregnant women approached, 60 consented to participate, yielding a recruitment rate of 96.8%. All enrolled participants completed the study procedures, resulting in a completion rate of 100%. Questionnaire completeness was 100%, all participants accepted venous blood sample collection, and no adverse events were reported. Furthermore, all serum samples were successfully transported, stored, processed, and analysed according to the study protocol without sample loss or laboratory processing failure.

These findings indicate that biochemical assessment of vitamin D status among pregnant women is feasible and acceptable within a routine antenatal care setting in Dodoma city. The study procedures, electronic data collection methods, and laboratory processes were successfully implemented and can be applied in a larger adequately powered study. Future studies should include a larger sample size, multiple health facilities, and data collection across different seasons to provide more precise estimates of vitamin D status and further investigate potential determinants of suboptimal vitamin D status during pregnancy.

Introduction

Vitamin D is a fat-soluble vitamin essential for calcium and phosphorus homeostasis, bone mineralisation, immune regulation, and cellular function (Ahmed et al. 2021; Alibrahim et al. 2024). In humans, vitamin D is obtained mainly through cutaneous synthesis following exposure to ultraviolet B radiation, with smaller contributions from dietary sources and supplements (Visuthranukul et al. 2023; Blbas et al. 2024). Serum 25-hydroxyvitamin D is widely recognised as the most reliable indicator of vitamin D status because of its stability and relatively long half-life (Cabaset et al. 2019).

During pregnancy, maternal vitamin D requirements increase to support fetal skeletal development and calcium metabolism (Moon et al. 2020). Inadequate vitamin D levels during pregnancy have been associated with adverse maternal outcomes, including preeclampsia, gestational diabetes mellitus, and caesarean delivery, as well as neonatal complications such as low birth weight, preterm birth, and impaired skeletal development (Elsori and Hammoud 2018; Tamblyn et al. 2022; Liu and Huang 2023; Lee et al. 2023).

Vitamin D deficiency during pregnancy is increasingly recognised as a global public health concern (Lee et al. 2023), with reported prevalence varying widely across settings depending on sunlight exposure, dietary practices, skin pigmentation, and diagnostic criteria (Zhang et al. 2022). Although Tanzania receives abundant sunlight throughout the year, studies conducted among different population groups have reported substantial levels of vitamin D insufficiency and deficiency (Mehta et al. 2009; Walli et al.

2016; Sudfeld et al. 2017; Muhihi et al. 2022). However, evidence among pregnant women remains limited, particularly in central Tanzania.

The vitamin D status during pregnancy may be influenced by several sociodemographic, behavioural, and environmental factors, including occupation, physical activity, obesity, socioeconomic status, dietary intake, and sunlight exposure (Quah et al. 2018; Santana et al. 2022; Lee et al. 2023). These factors may be particularly relevant in rapidly urbanising settings such as Dodoma city, where lifestyle patterns increasingly favour indoor activities and where access to vitamin D-rich foods such as fish may be limited due to the geographical disadvantage of the city (Mramba and Kahindi 2022).

Conducting large-scale studies involving biochemical assessment of vitamin D status in resource-limited settings can be financially and logistically challenging. Pilot studies are therefore important for evaluating the feasibility of recruitment procedures, data collection methods, laboratory analysis, and participant acceptability before the implementation of larger epidemiological investigations. Accordingly, this pilot study aimed to assess the feasibility of evaluating vitamin D status among pregnant women receiving antenatal care services in Dodoma city, Tanzania. In addition, the study sought to generate preliminary estimates of vitamin D status and explore potential associated factors to inform the design of a future adequately powered study.

Methods

Study design

This pilot study employed a facility-based cross-sectional design to assess the feasibility of evaluating vitamin D status among pregnant women receiving antenatal care (ANC) services in Dodoma city, Tanzania.

Study setting and population

The study was conducted at the Makole Health Centre between July and August 2024. The Makole Health Centre is a public primary-level health facility providing routine antenatal care (ANC) services to pregnant women in Dodoma city. The study population comprised pregnant women aged 18–45 years who were receiving ANC services at health facilities. Eligible participants included women with singleton pregnancies in the second or third trimester who provided written informed consent. Women in the first trimester were excluded because early pregnancy symptoms may influence dietary intake, physical activity, and sunlight exposure. Participants were excluded if they had albinism; multiple pregnancies; current use of vitamin D supplements; or chronic conditions known to affect vitamin D metabolism, including kidney, liver, thyroid, or heart disease; diabetes mellitus; or severe burns. Women using medications that could interfere with vitamin D metabolism, such as antiepileptic drugs, glucocorticoids, antituberculosis medications, antioestrogens, or antiretroviral therapy, were also excluded to minimise biological confounding.

Sample size and sampling procedure

As this was a pilot feasibility study, no formal sample size calculation was performed to estimate the prevalence or detect statistically significant associations (Kunselman 2024). The primary purpose of the study was to evaluate feasibility outcomes, including participant recruitment, acceptability of study procedures, and practicality of data collection and laboratory analysis. Methodological recommendations for pilot studies suggest that sample sizes ranging from 30 to 100 participants are generally adequate for evaluating study processes and generating preliminary estimates (Lancaster et al. 2004; Julious 2005). On the basis of these recommendations, a target sample size of 60 pregnant women was considered sufficient for assessing feasibility and obtaining preliminary estimates of vitamin D status. Eligible pregnant women attending ANC services during the study period were consecutively recruited until the target sample size was reached.

Data collection procedures

Data collection was conducted at the ANC outpatient clinic by trained research assistants, a nutritionist, and a clinical officer. Before data collection, the research team received training on the study protocol, ethical considerations, questionnaire administration, anthropometric measurements, and blood sample handling to ensure standardisation and consistency across data collectors. Eligible participants were informed about the purpose and procedures of the study, and written informed consent was obtained before enrolment. The interviews and anthropometric assessments were conducted in a private room to ensure confidentiality and participant comfort. Data were collected electronically via a structured questionnaire administered through the Kobo Collect Toolbox on Android devices.

Feasibility assessment

The feasibility outcomes assessed in this pilot study included the participant recruitment rate, completion rate, questionnaire completeness, acceptability of blood sample collection, and logistical feasibility of sample handling and laboratory analysis. The recruitment rate was defined as the proportion of eligible pregnant women who consented to participate, whereas the completion rate referred to the proportion of enrolled participants who completed all study procedures without withdrawal during data collection (Wu et al. 2025). Questionnaire completeness was assessed by the proportion of questionnaires with complete responses to key study variables. The acceptability of blood sample collection was evaluated by documenting participants' willingness to provide venous blood samples and the occurrence of adverse events during sample collection. Logistical feasibility was assessed by evaluating the successful transportation, storage, and laboratory processing of serum samples within the planned study procedures.

Progression criteria

To facilitate interpretation of the feasibility outcomes and inform the potential progression to a future larger study, progression criteria were applied for participant recruitment, completion of study procedures, questionnaire completeness, acceptability of venous blood sample collection, and successful transportation, storage, processing, and laboratory analysis of serum samples. The study was considered feasible if the recruitment rate was at least 80%, the completion rate was at least 90%, questionnaire completeness was at least 95%, acceptance of venous blood sample collection was at least 90%, and successful sample handling and laboratory analysis were achieved for at least 95% of collected serum samples. These criteria were informed by methodological recommendations for pilot and feasibility studies and were selected to reflect levels of performance considered necessary for successful implementation of a future larger study (Eldridge et al. 2016).

Dependent variable

The serum 25-hydroxyvitamin D concentration was used as the primary outcome variable. Approximately 2 mL of venous blood was collected from each participant by a certified laboratory technician via standard aseptic procedures (Woon et al. 2019). Blood samples were collected in red-top vacutainer tubes, allowed to clot for 45 minutes, and centrifuged at 3,500 rpm for 10 minutes (Miller et al. 2021). The serum was then separated, transferred into labelled tubes, stored in an icebox, and transported to the Lancet laboratory in Dodoma for storage at -20°C until analysis. Serum 25-hydroxyvitamin D levels were measured via the Maglumi 2000 chemiluminescent immunoassay analyser with the Maglumi 25-OH Vitamin D kit employing the chemiluminescent immunoassay (CLIA) method. The vitamin D status was classified according to the Endocrine Society guidelines as deficient (< 20 ng/mL), insufficient (20–30 ng/mL), or sufficient (> 30 ng/mL) (Jeyakumar et al. 2021). For exploratory analyses, vitamin D status was further categorised as suboptimal (≤ 30 ng/mL) or sufficient (> 30 ng/mL).

Independent variables

Independent variables included sociodemographic, obstetric, anthropometric, behavioural, and lifestyle factors previously reported to influence vitamin D status. Sociodemographic variables included maternal age, education level, occupation type (indoor or outdoor), monthly household income, and skin pigmentation. The obstetric variables included pregnancy trimester, gravidity, and history of caesarean section.

Maternal age was categorised into 18–25, 26–35, and 36–45 years. Education level was classified as nonformal, primary, secondary, or tertiary. Monthly household income was categorised as ≤ 250,000 TZS, > 250,000 to < 750,000 TZS, 750,000 to < 1,000,000 TZS, and ≥ 1,000,000 TZS. Gravidity was classified as first, second, third, fourth, or five or more pregnancies.

Skin pigmentation was assessed via the Fitzpatrick skin type classification (Cabaset et al. 2019). The participants identified their skin type via standardised images representing skin types I-VI, which were

supported by interviewer assessment to improve consistency, following approaches used in previous studies (Richard et al. 2017).

Anthropometric measurements included height and prepregnancy body mass index (BMI). Height was measured to the nearest 0.1 cm using a calibrated SECA stadiometer. Prepregnancy weight was self-reported because of the absence of routine preconception weight records. BMI was calculated and classified according to the World Health Organisation (WHO) criteria as underweight (< 18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0-29.9 kg/m²), or obese (≥ 30.0 kg/m²).

Physical activity was assessed via the short-form International Physical Activity Questionnaire (IPAQ). Physical activity levels were calculated in metabolic equivalent minutes per week (MET-minutes/week) and categorised as adequate (≥ 600 MET-minutes/week) or inadequate (< 600 MET-minutes/week) using standard IPAQ criteria (Aji et al. 2019; Anouti et al. 2022).

The dietary intake of vitamin D-rich foods was assessed via a brief checklist that captured the consumption of commonly available vitamin D-rich foods during the previous day. The assessment aimed to evaluate feasibility and general dietary patterns rather than estimate quantitative vitamin D intake (Woon et al. 2019; Haile et al. 2022; Polanek et al. 2024).

Sunlight exposure was assessed via a structured questionnaire adapted from previous studies (Woon et al. 2019; Urio et al. 2021; Liyanage et al. 2022). The participants reported the average daily sunlight exposure duration, categorised as < 15 minutes, 15–30 minutes, or > 30 minutes per day, and the usual timing of outdoor exposure was early morning, midday, or late afternoon/evening.

Data management and statistical analysis

Data collected electronically were exported from the Kobo Toolbox into Microsoft Excel for cleaning and quality checks before analysis via IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Feasibility outcomes, including recruitment rates, completion rates and questionnaire completeness, were summarised descriptively. Continuous variables were summarised using means and standard deviations, whereas categorical variables were presented as frequencies and percentages. Exploratory analyses were conducted to examine potential associations between selected independent variables and suboptimal vitamin D status (≤ 30 ng/mL). Chi-square tests or Fisher's exact tests were applied as appropriate on the basis of expected cell counts. Given the pilot nature of the study and the limited sample size, these analyses were intended for hypothesis generation only, and the findings were interpreted cautiously rather than as definitive statistical evidence.

Results

Feasibility outcomes

A total of 62 eligible pregnant women attending antenatal care services were approached during the study period, of whom 60 consented to participate, yielding a recruitment rate of 96.8%. All enrolled participants completed the questionnaire interview, anthropometric assessment, and venous blood sample collection, resulting in a completion rate of 100%.

The level of questionnaire completeness was high, with all 60 electronic questionnaires successfully submitted through the Kobo Collect Toolbox platform. No missing data were observed for key study variables, including serum vitamin D levels, maternal age, education level, occupation, household income, pregnancy trimester, body mass index, physical activity, and sunlight exposure variables.

The acceptance of venous blood sample collection was also high. All participants who consented agreed to provide blood samples for serum 25-hydroxyvitamin D analysis, resulting in a blood sample acceptance rate of 100%. No participants withdrew from the blood collection procedures, and no adverse events, such as fainting, excessive bleeding, or infection, were reported during or after sample collection.

For logistical feasibility, all 60 serum samples were successfully transported from the health facility to the Lancet Laboratory in Dodoma under cold-chain conditions according to the study protocol. All collected samples were adequately processed, stored at -20°C, and analysed successfully for their serum 25-hydroxyvitamin D concentration without sample loss, hemolysis, or laboratory processing failure.

The average duration of questionnaire administration and anthropometric assessment was approximately 30–40 minutes per participant, indicating acceptable participant burden and operational practicality within the routine antenatal care clinic setting.

The observed feasibility outcomes met all progression criteria. The participant recruitment rate (96.8%) exceeded the target of 80%, the completion rate (100%) exceeded the target of 90%, questionnaire completeness (100%) exceeded the target of 95%, and acceptance of venous blood sample collection (100%) exceeded the target of 90%. In addition, all collected serum samples were successfully transported, stored, processed, and analysed, exceeding the target of 95% for successful sample handling and laboratory analysis. (Table 1).

Table 1
Progression criteria and feasibility outcomes

Feasibility outcome	Progression criterion	Observed outcome
Participant recruitment rate	≥ 80%	96.8%
Completion rate	≥ 90%	100%
Questionnaire completeness	≥ 95%	100%
Acceptance of venous blood sample collection	≥ 90%	100%
Successful transportation, storage, processing, and laboratory analysis of serum samples	≥ 95%	100%

Sociodemographic and obstetric characteristics of pregnant women

A total of 60 pregnant women participated in the study. Half of the participants (50.0%) were aged 26–35 years, 43.3% were aged 18–25 years, and 6.7% were aged 36–45 years. With respect to education level, 38.3% had secondary education, 33.3% had primary education, 26.7% had tertiary education, and 1.7% had nonformal education. Most participants (80.0%) reported outdoor occupations, whereas 20.0% reported indoor occupations. More than half of the participants (60.0%) had a monthly household income of ≤ 250,000 TZS, followed by 28.3% earning > 250,000 to < 750,000 TZS. Most participants (63.3%) had moderate brown skin pigmentation, whereas 33.3% had dark brown skin and 3.3% had dark brown to black skin pigmentation. With respect to obstetric characteristics, 70.0% of the participants were in the third trimester, and 30.0% were in the second trimester. One-third of the participants (33.3%) were in their first pregnancy, another 33.3% were in their second pregnancy, 20.0% were in their third pregnancy, 10.0% were in their fourth pregnancy, and 3.3% had five or more pregnancies. The majority of participants (85.0%) reported no previous history of caesarean section. In terms of prepregnancy body mass index, 45.0% of the participants were normal weight, 31.7% were overweight, 15.0% were obese, and 8.3% were underweight. (Table 2).

Table 2
Sociodemographic and obstetric characteristics of pregnant women (n = 60)

Variable	*N* (%)
Age	
18–25 years	26 (43.3)
26–35 years	30 (50.0)
36–45 years	4 (6.7)
Education level	
Nonformal	1 (1.7)
Primary	20 (33.3)
Secondary	23 (38.3)
Tertiary	16 (26.7)
Occupation type	
Indoor	12 (20.0)
Outdoor	48 (80.0)
Monthly household income	
≤ 250,000 TZS	36 (60.0)
> 250,000 to < 750,000 TZS	17 (28.3)
750,000 to < 1,000,000 TZS	3 (5.0)
≥ 1,000,000 TZS	4 (6.7)
Skin pigmentation	
Moderate brown skin	38 (63.3)
Dark brown skin	20 (33.3)
Dark brown to black skin	2 (3.3)
Trimester	
Second trimester	18 (30.0)
Third trimester	42 (70.0)
Gravidity	
First pregnancy	20 (33.3)

Variable	*N* (%)
Age	
Second pregnancy	20 (33.3)
Third pregnancy	12 (20.0)
Fourth pregnancy	6 (10.0)
Five or more	2 (3.3)
History of caesarean section	
Yes	9 (15.0)
No	51 (85.0)
Body Mass Index	
Underweight	5 (8.3)
Normal weight	27 (45.0)
Overweight	19 (31.7)
Obesity	9 (15.0)

Vitamin D status among pregnant women

Among the 60 pregnant women included in the study, 68.3% (95% CI: 55.0-79.7) had sufficient vitamin D levels, while 26.7% (95% CI: 16.1–39.7) were vitamin D insufficient, and 5.0% (95% CI: 1.0-13.9) were vitamin D deficient. Overall, 31.7% (95% CI: 20.3–45.0) of the participants had suboptimal vitamin D status. (Table 3).

Table 3
Vitamin D status among pregnant women (n = 60)

Vitamin D status	*N* (%)	95% Confidence interval
Vitamin D sufficiency	41 (68.3)	55.0-79.7
Vitamin D insufficiency	16 (26.7)	16.1–39.7
Vitamin D deficiency	3 (5.0)	1.0-13.9
Suboptimal vitamin D status	19 (31.7)	20.3–45.0

Vitamin D-rich food consumption among pregnant women

The dietary intake assessment revealed that fortified cereal products were the most commonly consumed vitamin D-rich foods, reported by 63.3% of the participants, followed by fish and fish products, which were consumed by 43.3% of the participants. The consumption of other vitamin D-rich foods was

relatively low, with 36.7% reporting the intake of meat and meat products; 36.7% consuming other sources, such as mushrooms, fortified margarine, or fortified oils; 21.7% consuming fortified milk products; and 18.3% reporting egg consumption during the previous day.

Exploratory factors associated with suboptimal vitamin D status

Exploratory analysis revealed potential associations between selected maternal characteristics and suboptimal vitamin D status among pregnant women. Compared with those involved in outdoor occupations, a greater percentage of women in indoor occupations had suboptimal vitamin D status (52.6% vs. 47.4%, $p = 0.001$). Similarly, participants with lower monthly household income (≤ 250,000 TZS) constituted the majority of women with suboptimal vitamin D status (89.5%, $p = 0.013$). The physical activity level also appeared to be associated with vitamin D status. A greater proportion of pregnant women reporting low physical activity levels (< 600 MET-minutes/week) had suboptimal vitamin D status than did those with adequate physical activity levels (73.7% vs. 26.3%, $p = 0.001$). In addition, overweight and obese women had relatively greater proportions of women with suboptimal vitamin D status than women with a normal BMI ($p = 0.038$). However, these findings should be interpreted cautiously because the analysis was exploratory and based on a small pilot sample that was not powered to establish definitive statistical associations. The observed patterns are primarily useful for generating hypotheses and informing the design of future adequately powered studies. (Table 4)

Table 4
Exploratory factors associated with suboptimal vitamin D status among pregnant women (n = 60)

Age	***N* (%)**	**Vitamin D > 30 ng/mL**	**Vitamin D ≤ 30 ng/mL**	**p value**
18–25 years	26 (43.3)	18 (43.9)	8 (42.1)	0.716
26–35 years	30 (50.0)	21 (51.2)	9 (47.4)	
36–45 years	4 (6.7)	2 (4.8)	2 (10.5)	
Education level				
Nonformal	1 (1.7)	1 (2.4)	0 (0.0)	0.443
Primary	20 (33.3)	15 (36.6)	5 (26.3)	
Secondary	23 (38.3)	13 (31.7)	10 (52.6)	
Tertiary	16 (26.7)	12 (29.3)	4 (21.1)	
Occupation type				
Indoor	12 (20.0)	2 (4.9)	10 (52.6)	0.001*
Outdoor	48 (80.0)	39 (95.1)	9 (47.4)	
Monthly household income				
≤ 250,000 TZS	36 (60.0)	19 (46.3)	17 (89.4)	0.013*
> 250,000 to < 750,000 TZS	17 (28.3)	16 (39.0)	1 (5.3)	
750,000 to < 1,000,000 TZS	3 (5.0)	3 (7.3)	0 (0.0)	
> 1,000,000 TZS	4 (6.7)	3 (7.3)	1 (5.3)	
Trimester				
Second trimester	18 (30.0)	12 (29.3)	6 (31.6)	1.000
Third trimester	42 (70.0)	29 (70.7)	13 (68.4)	
History of caesarean section				
Yes	9 (15.0)	5 (12.2)	4 (21.1)	0.445
No	51 (85.0)	36 (87.8)	15 (78.9)	
Physical activity level				

Note: *This analysis is exploratory based on a small pilot sample. p values indicate potential associations to be investigated in a fully powered study and should not be interpreted as definitive.*

Age	*N* (%)	Vitamin D > 30 ng/mL	Vitamin D ≤ 30 ng/mL	p value
< 600 MET-minutes/week	18 (30.0)	4 (9.8)	14 (73.7)	0.001*
≥ 600 MET-minutes/week	42 (70.0)	37 (90.2)	5 (26.3)	
Body Mass Index				
Underweight	5 (8.3)	4 (9.8)	1 (5.3)	0.038*
Normal weight	27 (45.0)	23 (56.0)	4 (21.1)	
Overweight	19 (31.7)	9 (22.0)	10 (52.6)	
Obese	9 (15.0)	5 (12.2)	4 (21.1)	
Day time of sunlight exposure				
Early morning and late afternoon/evening	56 (93.3)	38 (92.7)	18 (94.7)	1.000
Mid-day	4 (6.7)	3 (7.3)	1 (5.3)	

Note: *This analysis is exploratory based on a small pilot sample. p values indicate potential associations to be investigated in a fully powered study and should not be interpreted as definitive.*

Discussion

This pilot study demonstrated that assessing vitamin D status among pregnant women attending antenatal care services in Dodoma city via questionnaire-based data collection and biochemical assessment of serum 25-hydroxyvitamin D is feasible within a routine clinical setting. The study achieved a high recruitment rate (96.8%) and full completion of study procedures among the enrolled participants, indicating strong participant acceptability and operational practicality. In addition, all the participants underwent venous blood sample collection, no adverse events were reported during sample collection, and all the serum samples were successfully transported, processed, stored, and analysed according to the study protocol. These findings suggest that the implementation of a larger facility-based study involving biochemical assessment of vitamin D status among pregnant women in this setting is operationally achievable.

The high degree of questionnaire completeness observed in this study further supports the feasibility of using electronic data collection platforms such as the Kobo Collect Toolbox within antenatal care settings. No missing data were identified for key study variables, including serum vitamin D levels, anthropometric measurements, and major sociodemographic characteristics. Together, these findings indicate that the study procedures, data collection tools, and laboratory logistics were acceptable and manageable within the available resource setting, as all progression criteria were met.

Preliminary findings from this pilot study revealed that 5.0% of participants were vitamin D deficient, whereas 26.7% were vitamin D insufficient. Overall, approximately one-third of the participants had suboptimal vitamin D status. Although these estimates should be interpreted cautiously because of the small sample size and pilot nature of the study, they suggest that suboptimal vitamin D status may exist among pregnant women in Dodoma despite abundant year-round sunlight exposure. Similar observations have been reported in other settings where environmental sunlight availability does not necessarily translate into adequate vitamin D status due to behavioural, occupational, dietary, and physiological factors (Walli et al. 2016; Urio et al. 2021; Sudfeld et al. 2022; Muhihi et al. 2022).

The prevalence of vitamin D deficiency observed in this study was lower than estimates reported in several studies conducted in low- and middle-income countries (Toko et al. 2016; Haile et al. 2022). Differences in prevalence across studies may reflect variations in geographical location, gestational age, laboratory methods, diagnostic cut-off points, season of data collection, and population characteristics. In addition, variation may partly reflect the instability of estimates generated from small pilot samples. These findings highlight the need for larger studies conducted across multiple seasons and health facilities to better characterise vitamin D status among pregnant women in Tanzania.

Exploratory analyses suggested potential associations between suboptimal vitamin D status and occupation, household income, physical activity, and prepregnancy body mass index. Compared with women involved in outdoor occupations, pregnant women engaged in indoor occupations appeared to be more likely to have suboptimal vitamin D status. This observation is biologically plausible because indoor work may reduce exposure to direct sunlight, which is the primary source of endogenous vitamin D synthesis (Haile et al. 2022). Similar findings have been reported in previous studies and systematic reviews examining vitamin D status among indoor workers and urban populations (Quah et al. 2018; Woon et al. 2019; Santana et al. 2022). Although this relationship should not be interpreted as definitive in the present pilot study, occupation may represent an important variable for further investigations in larger studies.

Low household income also appeared to be associated with suboptimal vitamin D status. This finding is consistent with evidence suggesting that socioeconomic disadvantage may reduce access to vitamin D-rich foods, health information, and health-promoting lifestyle practices (Lin et al. 2021; Stoica et al. 2024). In resource-limited settings, lower-income households may have limited dietary diversity and reduced consumption of foods such as fish, eggs, and fortified products, which contribute to vitamin D intake. However, because this analysis was exploratory and based on a small sample, further adequately powered studies are needed to clarify the relationship between socioeconomic status and vitamin D status during pregnancy.

Similarly, lower physical activity levels appeared to be associated with suboptimal vitamin D status. Physical activity may influence vitamin D status indirectly through increased outdoor exposure and reduced adiposity (Ceolin et al. 2022). Previous studies have also reported associations between physical inactivity and low vitamin D levels, although the magnitude and direction of this relationship

remain inconsistent across populations (Aji et al. 2019; Anouti et al. 2022). Given the exploratory nature of the present findings, future studies should incorporate a more detailed assessment of physical activity and outdoor exposure patterns.

Overweight and obesity were also associated with suboptimal vitamin D status in this study. This observation aligns with previous evidence suggesting that fat-soluble vitamin D may become sequestered in adipose tissue, thereby reducing circulating bioavailable vitamin D concentrations (Vranić et al. 2019). Although causal relationships cannot be established in this pilot study, these findings highlight the potential importance of maternal nutritional status and body composition in future investigations of vitamin D during pregnancy.

Overall, the exploratory associations identified in this study should be interpreted as hypothesis-generating rather than confirmatory. The primary contribution of this pilot study lies in demonstrating the feasibility and acceptability of conducting biochemical assessments of vitamin D status among pregnant women within routine antenatal care settings in Dodoma city while also identifying methodological considerations and potential variables of interest for future large-scale research.

Strengths and limitations

The main strength of this study is that it provides preliminary evidence of the feasibility of conducting biochemical assessments of vitamin D status among pregnant women within a routine antenatal care setting in Dodoma city. The study also demonstrated high participant acceptability, successful implementation of electronic data collection, and effective laboratory handling of serum samples. In addition, the use of standardised procedures for questionnaire administration, anthropometric assessment, and laboratory analysis strengthened methodological consistency.

However, several limitations should be acknowledged. The study involved a small sample size and was conducted at a single health facility, limiting the generalisability of the findings. The cross-sectional design precludes causal inference. Some variables, including prepregnancy weight, dietary intake, physical activity, and sunlight exposure, were self-reported and may therefore be subject to recall bias. In addition, data collection was conducted during a single season, preventing assessment of seasonal variation in vitamin D status. Finally, because this was a pilot feasibility study, the exploratory analyses were not adequately powered to establish definitive statistical associations.

Conclusion

Assessment of vitamin D status among pregnant women attending antenatal care services in Dodoma city was feasible and acceptable within a routine clinical setting, with all progression criteria achieved. Preliminary findings indicated the presence of suboptimal vitamin D status among some participants, with potential associations observed with occupation, household income, physical activity, and prepregnancy body mass index. Larger adequately powered studies are needed to confirm these findings and better understand the determinants of vitamin D status during pregnancy in Tanzania.

Abbreviations

ANC Antenatal care

BMI Body mass index

CI Confidence interval

IPAQ International Physical Activity Questionnaire

WHO World Health Organisation

Declarations

Ethics approval and consent to participate

Ethical approval for this study was granted by the Northern Tanzania Health Research Ethics Committee, approval number KNCHREC00016/01/2024, on 15 July 2024.

Consent for publication

Participants who were able to read and write provided written informed consent, whereas thumbprints were used for participants unable to read or write after verbal explanation of the study procedures. Participation was voluntary, and confidentiality was maintained throughout the study by excluding personal identifiers from the study records.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AA designed the research, conducted the research, analysed the data and wrote the manuscript; TA and CM supervised the research. All the authors read and approved the final manuscript.

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