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What factors influences dietary and non-dietary vitamin D intake among pregnant women in an African population?

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ABSTRACT

Objective: Data on dietary vitamin D (vitD) intake, sunlight exposure, and the associated determinants are lacking in Africa. The aim of this study was to establish the factors influencing vitD intake and sunlight exposure among pregnant women in an African population with the goal of improving maternal vitD nutrition.
Methods: A population-based cross-sectional study was conducted among 703 mother–infant pairs accessing postnatal care at the five main health facilities in Cape Coast, Ghana in 2016. Information on sociodemographic characteristics and sunlight exposure practices during pregnancy were collected using a structured questionnaire. A semiquantitative food frequency questionnaire was used to estimate vitD intake during pregnancy.
Results: VitD nutrition awareness during pregnancy was low in the study area. Education, occupation, ethnicity, and marital status influenced vitD intake in this population. In a multivariable linear regression adjusting for potential confounders, lack of information on essential nutrients needed in pregnancy, and infrequent consumption of recommended foods resulted in 10.51 µg (95% confidence interval [CI], –19.59 to –1.42) and 26.18 µg (95% CI, –47.18 to –5.17) reduction in vitD intake, respectively. Lack of information on the importance of vitD in pregnancy, and on their dietary and non-dietary sources resulted in 11.76 µg (95% CI, –21.53 to –2.00) and 26.34 µg (95% CI, –52.47 to –0.21) reduction in vitD intake, respectively. Employment status of mothers was associated with statistically significant higher sunlight exposure.
Conclusions: The study findings call for rolling out literacy and nutrition education programs targeted at women in sub-Saharan African countries to help improve maternal nutrition.

Introduction

Vitamin D (vitD) is a prehormone with its concentration in the body determined primarily by two factors: exposure of the skin to sunlight [1] and dietary consumption of vitD-rich food such as mushrooms (shiitake and sun-exposed), tuna and other oily fishes, and cooked egg [2]. The reliance on dietary sources of vitD, however, is insufficient to meet the body's requirements, hence it is recommended that individuals get maximum sunlight exposure [3]. This is particularly important for pregnant women because decreased vitD concentration during pregnancy has been associated with adverse pregnancy outcomes including low birthweight, preterm birth, small for gestational age, stillbirth, and spontaneous abortion [4–8]. Pregnancy-related conditions such as gestational diabetes, preeclampsia, and bacterial vaginosis also have been associated with decreased vitD concentration during pregnancy [5,8,9].

Neonatal vitD status is directly related to maternal vitD status through transplacental transfer of vitD [10]. The concentration of vitD in umbilical cord blood is between 50% and 80% of the maternal blood [11]. VitD intake during pregnancy is important for fetal bone development [12,13]. Insufficient vitD intake during pregnancy will thus have adverse implications for fetal and neonatal health.

There is a lack of consensus on the definition of optimal vitD status during pregnancy and the amount of vitD needed to

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maintain adequate levels [14]. The Endocrine Society [15] and a committee of vitD experts [16] recommended serum 25-hydroxyvitamin D [25(OH)D] concentration of >75 nmol/L and recommended a daily vitD intake of 37.5 to 50 µg. However, vitD recommendations vary from country to country. In Scandinavian countries, for instance, where there is limited sunlight, it has been recommended that all pregnant women consume 10 µg/d of vitD to optimize vitD status [17]. This is to ensure circulating 25[OH]D concentration of ≥25 nmol/L [17,18]. In the United States and Canada, a dietary allowance of 15 µg/d is recommended for pregnant and lactating women to achieve the Institute of Medicine–targeted serum 25(OH)D concentration of 50 nmol/L [19]. In Australia and New Zealand, the recommended intake for pregnant women is 5 µg/d and a supplement intake of 10 µg/d with insufficient sunlight exposure [20]. In the United Kingdom, 10 µg/d is recommended [21], whereas in Germany, Austria, and Switzerland, 20 µg/d is recommended [22].

In Africa, where there is plentiful sunlight year-round, vitD deficiency is considered a major public health problem. Studies conducted in Tunisia [23], Tanzania [24], Ethiopia [25], and Nigeria [26,27] have reported a high prevalence of vitD deficiency among women, including pregnant mothers. The study conducted in Tanzania recommends a mean serum 25(OH)D concentration of 115 and 139 nmol/L in non-pregnant and pregnant women, respectively [24].

Available evidence suggests that the contribution of dietary sources to vitD nutrition in the Africa region is minimal owing to limited consumption of vitD-rich food such as oily fish, egg yolk, mushrooms, and fortified dairy products [28–30]. Additionally, data on the contribution of sunlight exposure in the region is nonexistent. Dietary practices of pregnant women in Africa and other developing regions have been documented to be poor as a result of poverty, socioeconomic constraints, and ignorance [31–33]. A systematic review reported the usual dietary intake of pregnant women in Africa to be predominantly plant based [32], a situation that could lead to deficiency of important micronutrients needed in pregnancy including vitD [34].

This study, therefore, sought to establish the factors influencing vitD intake and sunlight exposure in pregnant women in Cape Coast, Ghana. The results will provide a better understanding of the factors related to dietary and non-dietary vitD intake and create awareness among pregnant women in Ghana and other sub-Saharan African countries for improved vitD nutrition.

Methods

Study design and site

A population-based cross-sectional study was conducted among mothers and their newborns at the postnatal clinic of the five main health facilities in the Cape Coast metropolis: Teaching Hospital, Metropolitan Hospital, University Hospital, Ewim Polyclinic, and Adisadel Urban Health Centre. Cape Coast covers an area of 122 km^2 with an estimated population of 169 894, according to the 2010 census. Cape Coast is the capital city of the Central Region of Ghana and the smallest of the country's six metropolitan areas.

Study population and data collection

The source population comprised of all nursing mothers residing in Cape Coast and accessing postnatal services at the selected health facilities. Eight hundred mothers who had singleton births with no gross anatomic deformities were randomly sampled and interviewed at the facility. Of the study population, 301 (42.8%) were from the Teaching Hospital, 50 (7.1%) from the Metropolitan Hospital, 150 (21.3%) from the University Hospital, 100 (14.2%) from Ewim Polyclinic, and 102 (14.5%) from the Adisadel Urban Health Centre. The study population included 703 mothers (87.9% response rate).

Assessment of sunlight exposure

Information on mothers' exposure to sunlight was collected using a structured questionnaire. The following information was collected:

- Working or spending time outdoors during pregnancy;
- Period of pregnancy when most outdoor visits were made;
- Frequency of work or time spent outdoors;
- Amount of time spent outdoors during each visit or working activity; and
- Participant's rating of sunlight exposure during their outdoor visits/activities.

The level of exposure to sunlight was defined as follows:

Step 1

1. Classify the following as high sunlight exposure practices: visiting outdoors throughout the duration of pregnancy, visiting outdoors daily or four to five times per week, spending ≥7 h outdoors during each visit, and respondent sunlight exposure rating of high and moderate; and
2. Classify the following as low sunlight exposure practices: visiting outdoors during either the first, second, or third trimester of pregnancy, visiting outdoors two or three times per week, once per week or occasionally, spending ≤6 h outdoors during each visit, and respondent sunlight exposure rating of low and no. A score of 1 and 2 was respectively assigned to the low and high sunlight exposure practices.

Step 2

1. Classify all four high-exposure practices (score of 8) as very high sunlight exposure;
2. Classify any three high-exposure practices and any one low exposure practice (score of 7) as high sunlight exposure;
3. Classify any two high-exposure practices and any two low-exposure practices (score of 6) as moderate sunlight exposure;
4. Classify any one high-exposure practice and any three low-exposure practices (score of 5) as low sunlight exposure;
5. Classify all four low-exposure practices (score of 4) as very low sunlight exposure; and
6. Classify mothers who indicated that they did not spend time or worked outdoors during pregnancy as no exposure (score of 0).

Assessment of vitamin D nutritional status

A semiquantitative food frequency questionnaire (FFQ) was used to establish the frequency of consumption of eight vitD-rich foods together with the usual portion size during the period of pregnancy. In the FFQ, frequency of consumption was assessed on a scale ranging from 0 (*never*) to 8 (*>3 times per day*). Portion sizes (g) were estimated from color photographs of the listed food items. This information was used to estimate vitD intake (µg) of mothers.

Step 1 involved assigning a score to the frequency of consumption of each of the listed food items. The score ranged from 0 to 8 and were assigned to *never, once per month, 2 to 3 times per month, once per week, 2 to 3 times per week, 4 to 5 times per week, once per day, 2 to 3 times per day,* and *more than 3 times per day,* respectively. Step 2 involved multiplying the frequency scores assigned in step 1 with their portion sizes to obtain for each of the listed food items, the quantity consumed. Step 3 involved estimating the amount of vitD intake in each of the foods consumed based on vitamin D content of the food photographs shown to the participants. Step 4 involved summing up the estimates from step 3 to obtain daily vitD intake of the participants.

The listed vitD-rich foods were salmon, mackerel, tuna, sardine, herring, mushrooms (sun-exposed), pork (raised outdoors), and cooked egg yolk.

Ethical considerations

The Institutional Review Board of the University of Cape Coast, Cape Coast, Ghana approved the study (Ethical clearance ID No: UCCIRB/CANS/2015/03). Approval was also sought from the management of the selected health facilities. An informed consent form attached to the questionnaires was used to seek the consent of all participants before inclusion in the study.

Statistical analysis

We compared average vitD intake and sunlight exposure score, according to categories of the sociodemographic characteristics, and nutritional awareness and practices of the participants using *t* test and one-way analysis of variance (ANOVA) to assess the role of chance. With regard to the ANOVA, Tukey's post hoc test was applied to examine the difference in mean concentrations between groups that statistical significance was noted. Linear regression modeling was used to

Table 1
Sociodemographic characteristics of respondents (N = 703)

Characteristic	n (%)
Age group, y	
<20	55 (7.8)
20–29	368 (52.3)
30–39*	260 (37)
>39*	17 (2.4)
Missing	3 (0.4)
Education	
None/Primary	55 (7.8)
Junior high school	278 (39.5)
Senior high school/secondary/technical	177 (25.2)
University/tertiary*	191 (27.2)
Missing	2 (0.3)
Occupation	
Employed*	534 (76.0)
Hairdresser/seamstress	138 (25.8)
Office worker	44 (8.2)
Trader/street vendor/fish monger	178 (33.3)
Other	174 (32.6)
Student	49 (7)
Housewife/unemployed	119 (16.9)
Missing	1 (0.1)
Religion	
Christian*	612 (87.1)
Muslims	86 (12.2)
Other	2 (0.3)
Missing	1 (0.1)
Ethnic group	
Akan*	520 (74)
Ewe	41 (5.8)
Ga	11 (1.6)
Hausa and other northern tribe	80 (11.4)
Other southern tribe	47 (6.7)
Foreigner	4 (0.6)
Marital status	
Single	99 (14.1)
Married	522 (74.3)
Cohabitation	78 (11.1)
Divorced	3 (0.4)
Missing	1 (0.1)
Monthly income, GH¢	
None	115 (16.4)
<200	210 (35.7)
201–500	208 (35.4)
501–1000	114 (19.4)
>1000*	56 (8)

* Covariates served as reference.

estimate the effect of nutritional characteristics on vitD intake, and sunlight exposure. All models were adjusted for age, education, religion, ethnic group, occupation, and mothers' monthly income. The criteria for statistical significance were based on recording $P < 0.05$. Stata version 13 (Stata Corp., College Station, TX, USA) was used to perform all the analysis.

Results

Table 1 presents the sociodemographic characteristics of the respondents. About 52% of the respondents were within the 20 to 29 y age group. About 27% of the respondents had university/tertiary education whereas ~8% had no formal education. Seventy-six percent of the respondents were employed. About 17% were either housewives or unemployed. Approximately 87% were Christians; Muslims made up 12%. Akans constituted 74% of the respondents. The proportion of married respondents was 74.3%. Only 8% of the respondents reported earning a monthly income of more than GH¢1000 (US $222).

Table 2 presents the nutrition awareness and practices of the study respondents. About 89% of the respondents reported receiving nutritional information or counseling during pregnancy.

Table 2
Nutrition awareness and practices of respondents (N = 703)

Characteristic	n (%)
Receipt of nutritional education or information during pregnancy (n = 703)	
Yes	623 (88.6)
No	78 (11.1)
Missing	2 (0.3)
Source of nutritional information (n = 623)	
Health facility	566 (90.9)
TV/radio	5 (0.8)
Newspapers/books	12 (1.9)
Internet	4 (0.6)
Family/friends	14 (2.3)
Multiple sources	22 (3.5)
Provision of information on essential nutrients in pregnancy (n = 623)	
Yes	419 (67.3)
No	189 (30.3)
Missing	15 (2.4)
Essential nutrients indicated (n = 419)	
Vitamins	199 (47.5)
Minerals	9 (2.1)
Vitamins and minerals	138 (32.9)
Vitamins and proteins	8 (1.9)
Fruits and vegetables	9 (2.1)
Proteins	3 (0.7)
Various foods	38 (9.1)
Missing	15 (3.6)
Provision of information on food sources of the essential nutrients (n = 419)	
Yes	391 (93.3)
No	22 (5.3)
Missing	6 (1.4)
Regular consumption of foods indicated (n = 391)	
Yes	356 (91)
No	28 (7.2)
Missing	7 (1.8)
Frequency of food intake (n = 356)	
Daily	164 (46.1)
4–5×/wk	73 (20.5)
2–3×/wk	88 (24.7)
1×/wk	10 (2.8)
Occasionally	18 (5.1)
Missing	3 (0.8)
Provision of information on importance of vitamin D (n = 623)	
Yes	140 (22.5)
No	471 (75.6)
Missing	12 (1.9)
Provision of information on dietary and non-dietary sources of vitamin D (n = 140)	
Yes	111 (79.3)
No	27 (19.3)
Missing	2 (1.4)
Sources of vitamin D indicated (n = 111)	
Sunlight only	25 (22.5)
Foods (fish, milk, egg, mushroom, fruits, vegetables, cereals) only	23 (20.7)
Sunlight and foods	59 (53.2)
Missing	4 (3.6)
Regular consumption of vitamin D rich foods indicated (n = 82)	
Yes	71 (86.6)
No	11 (13.4)
Frequency of vitamin D rich food intake (n = 71)	
Daily	28 (39.4)
4–5×/wk	6 (8.5)
2–3×/wk	30 (42.3)
1×/wk	3 (4.2)
Occasionally	4 (5.6)
Attempts to obtain vitamin D from non-dietary source (n = 84)	
Yes	69 (82.1)
No	15 (17.9)
Efforts made to obtain vitamin D from non-dietary source (n = 69)	
Spending time outside	18 (26.1)
Working outside	11 (15.9)
Walking to work, school, church, market; visit friends and other places	25 (36.2)
Sitting or walking in the morning sun	15 (21.7)

Table 3
Sociodemographic differences in maternal vitamin D intake

Characteristic	Mean (µg)	SD (µg)	*F* value	*P* value	Post hoc *P* value
Age group (y)					
<20	70.37	52.79	0.02	0.9957	
20–29	71.64	49.25			
30–39	71.05	53.37			
>39	69.41	32.80			
Education					
None/primary	63.05	38.13	3.18	0.0235	0.031*
Junior high school*	66.30	48.72			
Senior high school/secondary/technical*	79.68	55.77			
University/tertiary	73.88	51.15			
Occupation					
Employed	70.62	49.46			
Hairdresser/seamstress*	63.44	41.68	2.36	0.0389	0.014*
Office worker*	92.03	59.01			
Trader/street vendor/fish monger	72.07	52.83			
Other	69.42	47.73			
Student	71.37	54.83			
Housewife/unemployed	75.34	54.81			
Religion					
Christian	71.14	50.63	0.10	0.9040	
Muslims	73.25	52.10			
Other	61.82	12.71			
Ethnic group					
Akan	71.29	50.68	2.38	0.0375	0.022*
Ewe*	56.62	38.21			
Ga	53.40	31.64			
Hausa and other northern tribe	70.43	50.94			
Other southern tribe*	90.48	59.21			
Foreigner	83.31	55.27			
Marital status					
Single	73.04	51.60	4.00	0.0077	0.007*
Married*	73.63	51.39			
Cohabitation*	53.74	42.04			
Divorced	104.93	29.98			
Monthly income, GH¢					
None	74.60	55.02	0.51	0.7295	
<200	69.03	52.32			
201–500	69.95	45.99			
501–1000	72.00	51.47			
>1000	77.96	51.79			

* Subgroups for which statistically significant differences in mean vitD intake was observed in the Post hoc test.

Of these respondents, 67% indicated being provided with information on essential nutrients needed in pregnancy. About 33% indicated that the importance of both vitamins and minerals were mentioned to them. About 11% of these respondents incorrectly identified the essential nutrients mentioned to them as fruits and vegetables, and various foods. The majority of these respondents (93.3%) indicated that they were provided with information on the food sources of the essential nutrients mentioned to them. Of these respondents, 91% indicated that they consumed the foods mentioned regularly, with 46.1% consuming the mentioned foods on a daily basis.

Of the respondents who indicated being provided with information on essential nutrients needed in pregnancy, only 22.5% said they were provided with information on the importance of vitD in pregnancy. About 79% reported being provided with information on the dietary and non-dietary source of vitD. Of these respondents, ~ 53% indicated that both sunlight and foods (such as fish, milk, egg, mushroom, fruits, vegetables, and cereals) were mentioned as sources of vitD. Of the respondents who received information on food sources of vitD, ~ 87% indicated consuming the vitD-rich foods mentioned regularly. However, some of the vitD food sources mentioned by the participants such as fruits and vegetables do not naturally contain vitD. Also, some of the foods mentioned, such as milk and cereals, contain vitD only when fortified and it is not clear whether the participants were referring to fortified products. Of the respondents who reported being provided with information on the non-dietary sources of vitD, 82.1% indicated making an effort to obtain vitamins from this source including spending time outside; sitting or walking in the morning sun; and walking to work, school, church, market and other places.

The sociodemographic differences in maternal vitD intake are presented in Table 3. Mean vitD intake among the study population was 71.41 µg (SD 50.74 µg). Respondents 20 to 29 y of age recorded the highest vitD intake. The difference in mean vitD intake with respect to age group of the respondents was not statistically significant ($P = 0.9957$). Respondents with senior high school/secondary/technical education recorded the highest vitD intake. The difference in mean vitD intake with respect to educational attainment of the respondents was statistically significant ($P = 0.0235$). The post hoc analysis revealed the differences in mean vitD intake among senior high school/secondary/technical-educated mothers and their junior high school-educated counterparts to be statistically significant (79.68 versus 66.30 µg; $P = 0.031$).

Office workers recorded the highest vitD intake. The difference in mean vitD intake defined by occupation of the respondents was statistically significant ($P = 0.0389$). The post hoc analysis

Table 4
Differences in maternal vitamin D intake according to respondents' nutrition awareness and practices

Characteristic	Mean (µg)	SD (µg)	*t*/*F* statistic	*P* value	Post hoc *P* value
Receipt of nutritional information or counseling during pregnancy					
Yes	71.23	50.47	–0.0040	0.9968	
No	71.24	51.71			
Provision of information on essential nutrients in pregnancy					
Yes	74.26	51.23	2.40	0.0165	
No	63.68	47.83			
Provision of information on food sources of the essential nutrients					
Yes	74.59	51.84	–0.17	0.8677	
No	76.48	47.09			
Regular consumption of foods indicated					
Yes	77.23	52.56	2.77	0.0059	
No	49.30	32.07			
Frequency of food intake					
Daily	77.96	53.04	0.53	0.7109	
4–5×/wk	71.97	55.97			
2–3×/wk	75.06	44.85			
1×/wk	90.31	41.39			
Occasionally	86.94	69.33			
Provision of information on importance of vitamin D					
Yes	82.14	54.61	2.93	0.0035	
No	68.17	47.81			
Provision of information on dietary and non-dietary sources of vitamin D					
Yes	85.12	58.45	1.40	0.1650	
No	68.71	35.06			
Regular consumption of vitamin D-rich foods indicated					
Yes	87.77	67.02	0.74	0.4624	
No	72.37	41.09			
Frequency of vitamin D-rich food intake					
Daily	92.77	67.13	0.47	0.7569	
4–5×/wk	62.81	79.52			
2–3×/wk	89.26	68.79			
1×/wk	110.45	66.58			
Occasionally	61.91	45.78			

revealed the differences in mean vitD intake among office workers and hairdressers/seamstresses to be statistically significant (92.03 versus 63.44 µg; $P = 0.014$). Respondents of other southern tribes recorded the highest vitD intake. The difference in mean vitD intake with respect to ethnicity of the respondents was statistically significant ($P = 0.0375$). Respondents with no monthly income and those earning the highest monthly income (more than GH¢1000) recorded the highest vitD intake. However, the difference in mean vitD intake with respect to income level of the respondents was not statistically significant ($P = 0.7295$).

The differences in vitD intake with respect to the nutrition awareness and practices of the respondents are presented in Table 4. The mean vitD intake among women who reported to have received information on nutrition during pregnancy was 71.23 µg. However, there was no difference in mean vitD intake between women who did or did not receive nutritional information ($P = 0.9968$). Women who reported being provided with information on essential nutrients needed during pregnancy recorded higher vitD intake compared with their counterparts ($P = 0.0165$). Respondents who indicated regularly consuming the food sources of the essential nutrients mentioned to them recorded higher vitD intake compared with non-regular consumers ($P = 0.0059$).

The respondents who reported receiving information on the importance of vitD intake during pregnancy recorded higher vitD intake than their counterparts ($P = 0.0035$). Additionally, respondents who were provided with information on dietary and non-dietary sources of vitD recorded higher vitD intake than their counterparts ($P = 0.1650$). Women who indicated regularly consuming the vitD-rich foods recommended recorded higher vitD intake than those who did not regularly consume the recommended foods ($P = 0.4624$).

Table 5 presents the differences in sunlight exposure with respect to employment status of respondents, and their nutrition awareness and practices. Mean sunlight exposure score among the study population was 5.71 (SD 2.36). Respondents who were employed recorded the highest sunlight exposure score. The difference in mean sunlight exposure score defined by employment status of the respondents was statistically significant ($P < 0.0001$). The post hoc analysis revealed housewives and unemployed respondents had lower sunlight exposure than employed respondents ($P < 0.0001$). The respondents who reported being provided with information on the importance of vitD during pregnancy had higher sunlight exposure score than their counterparts ($P = 0.5977$).

Women who reported working outside during pregnancy had the highest sunlight exposure score. The difference in mean sunlight exposure score with regard to efforts made by mothers to obtain vitD from the non-dietary source was statistically significant ($P = 0.0071$). The post hoc analysis revealed that mothers who indicated spending some time outside their homes had lower sunlight exposure than mothers who were working outside ($P = 0.015$) or sitting/walking in the morning sun ($P = 0.019$).

The effects of nutritional characteristics on maternal vitamin D intake and sunlight exposure are reported in Table 6. The estimated decrease in vitD intake among mothers who reported not receiving information on essential nutrients needed in pregnancy and those not consuming the recommended foods regularly were 10.51 (95% confidence interval [CI], –19.59 to –1.42) and 26.18 µg (95% CI, –47.18 to –5.17), respectively. The estimated

Table 5
Differences in sunlight exposure according to respondents' employment status, and nutrition awareness and practices

Characteristic	Mean	SD	t/F-statistic	P value	Post hoc P value
Employment status					
Employed*	5.92	2.20	12.23	<0.0001	<0.0001*
Student	5.67	2.55			
Housewife/unemployed*	4.75	2.72			
Provision of information on importance of vitamin D					
Yes	5.71	2.32	0.53	0.5977	
No	5.59	2.45			
Provision of information on dietary and non-dietary sources of vitamin D					
Yes	5.68	2.37	–0.18	0.8536	
No	5.78	2.22			
Attempts to obtain vitamin D from non-dietary source					
Yes	5.71	2.36	1.01	0.3148	
No	5.00	2.93			
Efforts made to obtain vitamin D from non-dietary source					
Spending time outside*	4.22	2.94	4.39	0.0071	0.015*
Working outside*	6.82	1.33			0.019*
Walking to work, school, church, market, visit friends and other places‡	5.80	2.38			
Sitting or walking in the morning sun*	6.53	0.99			

* Subgroups for which statistically significant differences in mean sunlight exposure score was observed in the Post hoc test.

decrease in vitD intake among mothers who reported not being provided with information on importance of vitD, and on their dietary and non-dietary sources were 11.76 (95% CI, –21.53 to –2.00) and 26.34 µg (95% CI, –52.47 to –0.21), respectively.

Sunlight exposure score among mothers who reported not making an effort to obtain vitD from the non-dietary source decreased by 1.07 units (95% CI, –2.66 to 0.50). However, the association was not statistically significant. Additionally, sunlight exposure score among mothers who reported sitting or walking in the morning sun increased by 2.27 units (95% CI, 0.33–4.22). Furthermore, among mothers who reported working outside (1.97; 95% CI, –0.14 to 4.07) and those walking to work, school, church, etc. (1.15; 95% CI, –0.55 to 2.86), the estimated increase in sunlight exposure score was not statistically significant.

Discussion

Validity issues

The population-based nature of the present study together with the high response rate achieved (87.9%) minimized selection bias. The potential for selection bias from excluding mothers who do not seek postnatal care also was minimized. According to Amegah et al. [35], in Cape Coast and other urban settings of Ghana, patronage of postnatal services is high owing to the high level of awareness of Reproductive and Child Health (RCH) service provision and benefits among urban dwellers and the ease of access to these services. The authors also added that mothers residing in several urban areas of Ghana have easy access to RCH services due to shorter traveling distances. The selection bias arising from mothers giving birth at home and not accessing postnatal care should not be a concern in the present study. This is because, in Ghana, only very few mothers deliver at home in urban areas compared with rural areas [35]. Moreover, the small number of home deliveries in urban areas usually occurs by accident with most mothers immediately taken to the nearest health facility owing to ease of access to health facilities.

On the issue of missing data, for all the variables measured, the proportion of respondents with missing data was low (<4%). Of all the variables measured, only three (provision of information on essential nutrients in pregnancy, essential nutrients recommended, and sources of vitD indicated) recorded a proportion of ≥2.4%.

We used a semiquantitative FFQ to establish the frequency of consumption of vitD-rich foods as well as the portion sizes with the amount of vitD intake derived from the information collected. There are certainly limitations with the use of FFQ for estimating the usual food and nutrient intake of study participants. As with all retrospective data collection, recall bias is a particular concern and could lead to either under or overestimation of vitD intake. However, despite the limitations, FFQ is widely accepted as the standard tool for measuring diet in epidemiologic research owing to its many practical advantages. According to Kristal et al. [36], from a statistical standpoint, FFQ is the only dietary measure that minimizes the very high intraindividual, day-to-day variability in nutrient intake without relying on multiple-day assessments of actual foods consumed. Additionally, in case–control and cross-sectional studies, where the usual food intake is ascertained retrospectively, FFQ is the only feasible approach [36]. We collected information on consumption of milk and breakfast cereals in the FFQ, but had to exclude these foods from the estimation of vitD intake because the participants were unable to inform us as to whether the brands they consumed were fortified with vitD. We collected information on the consumption of mushrooms and pork meat, and included them in the estimation of vitamin intake of participants. In Ghana, mushrooms are cultivated outdoors and sold on the open market exposed to sunlight and as a result could be considered as a good dietary source of vitD in the present study population. Additionally, pigs are raised outdoors and also could be considered an important dietary source of vitD both in pregnant women and in the general population living in tropical countries like Ghana.

In the present study, the information collected on sunlight exposure practices of mothers during pregnancy and quantification into an exposure index reflects reasonably well mothers' sunlight exposure conditions. However, exposure misclassification is possible in the study but likely to be reduced due to the several types of information collected from the mothers and summarized for the quantitative assessment of sunlight exposure. We could not factor the clothing style of Muslim participants (i.e., whether they normally cover the entire skin with clothing) into their sunlight exposure score as we did not collect such information. Also, we did not collect information on the use of

Table 6
Linear regression of maternal vitamin D intake and sunlight exposure on nutritional characteristics

Characteristic	Vitamin D intake		Sunlight exposure	
	Unadjusted β (95% CI)	Adjusted β (95% CI)*	Unadjusted β (95% CI)	Adjusted β (95% CI)†
Receipt of nutritional information or counseling during pregnancy				
No	0.02 (−11.91 to 11.96)	0.61 (−11.49 to 12.72)		
Yes	Reference	Reference		
Provision of information on essential nutrients in pregnancy				
No	−10.58 (−19.21 to −1.94)	−10.51 (−19.59 to −1.42)		
Yes	Reference	Reference		
Provision of information on food sources of the essential nutrients				
No	1.89 (−20.34 to 24.11)	1.84 (−20.64 to 24.33)		
Yes	Reference	Reference		
Regular consumption of foods indicated				
No	−27.93 (−47.76 to −8.10)	−26.18 (−47.18 to −5.17)		
Yes	Reference	Reference		
Frequency of food intake				
4–5×/wk	−5.99 (−20.50 to 8.51)	−5.19 (−20.22 to 9.85)		
2–3×/wk	−2.90 (−16.52 to 10.72)	−2.86 (−17.09 to 11.38)		
1×/wk	12.35 (−21.23 to 45.93)	4.06 (−30.75 to 38.87)		
Occasionally	8.98 (−16.62 to 34.58)	1.04 (−25.69 to 27.77)		
Daily	Reference	Reference		
Provision of information on importance of vitamin D				
No	−13.97 (−23.31 to −4.62)	−11.76 (−21.53 to −2.00)	−0.12 (−0.58 to 0.34)	0.03 (−0.44 to 0.50)
Yes	Reference	Reference	Reference	Reference
Provision of information on dietary and non-dietary sources of vitamin D				
No	−16.40 (−39.64 to 6.83)	−26.34 (−52.47 to −0.21)	0.09 (−0.90 to 1.09)	0.29 (−0.78 to 1.37)
Yes	Reference	Reference	Reference	Reference
Regular consumption of vitamin D-rich foods indicated				
No	−15.40 (−56.89 to 26.10)	0.03 (−46.20 to 46.27)		
Yes	Reference	Reference		
Frequency of vitamin D-rich food intake				
4–5×/wk	−29.97 (−91.09 to 31.16)	−8.13 (−84.19 to 67.93)		
2–3×/wk	−3.51 (−39.21 to 32.20)	−7.80 (−47.87 to 32.27)		
1×/wk	17.67 (−64.87 to 100.22)	30.90 (−57.42 to 119.22)		
Occasionally	−30.86 (−103.49 to 41.77)	−16.15 (−114.38 to 82.09)		
Daily	Reference	Reference		
Attempts to obtain vitamin D from non-dietary source				
No			−0.71 (−2.11 to 0.69)	−1.07 (−2.66 to 0.52)
Yes			Reference	Reference
Efforts made to obtain vitamin D from nonfood source				
Spending time outside			−0.78 (−2.41 to 0.85)	−0.32 (−2.11 to 1.48)
Working outside			1.82 (−0.03 to 3.67)	1.97 (−0.14 to 4.07)
Walking to work, school, church, market, visit friends and other places			0.80 (−0.72 to 2.32)	1.15 (−0.55 to 2.86)
Sitting or walking in the morning sun			1.53 (−0.17 to 3.24)	2.27 (0.33–4.22)
No			Reference	Reference

* Covariates were age, education, religion, ethnic group, and monthly income.
† Covariates were age, education, religion, ethnic group, and employment status.

sunscreen in the present study as it is not widely used among Ghanaians.

Synthesis with previous evidence

Nutrition awareness among pregnant women in the study area was found to be very high and translated into regular consumption of recommended nutrient-rich foods during pregnancy. A study conducted in Kano, Nigeria [37] found nutritional awareness among pregnant women to be very high with associated high intake of meat, fish, fruit, vegetable and red palm oil during pregnancy. However, another study conducted in Ethiopia [38] found nutritional knowledge among pregnant women to be low. The high nutritional awareness during pregnancy observed in our study area was mainly achieved through women's antenatal care (ANC) visit to health facilities. This finding, however, is contrary to studies conducted in Kenya [39] and Tanzania [40], which suggest a lack of effective nutrition counseling at ANC clinics. Birungi and Onyango-Ouma [39] observed that the ANC package has suboptimal nutrition counseling with only one third of women attending ANC clinics for the first time receiving nutritional counseling. Magoma et al. [40] reported that delivery of health information including nutrition counseling at ANC clinics was among the components of the ANC package least likely to be effectively implemented.

Awareness of the importance of vitD nutrition during pregnancy in the study area was low. To date, only the study conducted by Toher et al. [41] has investigated vitD status and nutrition awareness among pregnant women of various ethnicities including sub-Saharan Africa. The study reported poor awareness of vitD nutrition among all the ethnic groups examined. The authors indicated that the poor vitD status among pregnant women might be a reflection of vitD nutrition not being promoted during pregnancy in the same manner as other nutrients such as iron and folic acid [41]. Additionally, studies conducted in various countries reported poor awareness about vitD and its sources among primary health care patients, middle-aged and elderly women, and urban office workers [42–44]. Despite the low vitD nutrition awareness in the present study area, the majority of the mothers who received information on essential nutrients during pregnancy regularly consumed recommended nutrient-rich foods and also made an effort to obtain vitD naturally from exposure to the sun. A randomized controlled trial by Hollis et al. [45], recommended 4000 IU/d (100 µg) of vitD intake for pregnant women of all ethnic backgrounds to achieve sufficient vitD status throughout pregnancy. In comparison with this recommendation, the average vitD intake of pregnant women in the present study area could be considered insufficient.

VitD intake was influenced by the participants' educational and employment status. SHS/secondary/technical- and university/tertiary-educated mothers, and office workers recorded the highest vitD intake. However, no consistent relationship was observed between mother's monthly income and vitD intake. Studies have reported pregnant and lactating women of low socioeconomic status (SES) to be at greater risk for insufficient vitamin and mineral intake [46,47]. A community-based study conducted in Geneva canton [48] reported vitD intake to be lower among lower educational and occupational groups. Additionally, a study conducted in southern Thailand [49] found pregnant women with higher family income and higher levels of formal education to consume nutritious diets with greater frequency compared with poorer SES groups. The findings of lower vitD intake with low SES are according to Darmon and Drewnowski [50] consistent with the low consumption of fish by lower SES groups.

Receipt of information on the essential nutrients needed during pregnancy, and regular consumption of recommended food sources was associated with higher vitD intake in the present study. Receipt of information on the importance of vitD intake during pregnancy, and on the dietary and non-dietary sources was also associated with statistically significant higher vitD intake. Similar observations were found from a previous study [41], which reported awareness of vitD nutrition to have a positive influence on dietary practice, with informed participants consuming higher amounts of fortified milks than uninformed participants did. Additionally, the study emphasized the importance of awareness for the promotion of positive dietary behaviors during pregnancy. This is especially true among pregnant women who are generally viewed as a receptive audience for nutrition education and are motivated to improve their diets to optimize the health of themselves and their babies [51,52]. It also has been suggested that increasing nutrition knowledge of individuals is likely to evoke changes in attitude and subsequently result in improvements in dietary behavior [53,54].

Employment was associated with higher sunlight exposure score in the present study. On efforts made by mothers to obtain vitD from sunlight, those who indicated working outside during pregnancy had the highest sunlight exposure score. Walking in the morning sun to the workplace and involvement in occupational activities such as street vending, which entails extended walking in the sun could account for the high sunlight exposure score among employed respondents compared with housewives and unemployed respondents who are mostly indoors. Sunlight exposure is the main source of vitD but exactly how much ultraviolent radiation is required for healthy individuals to maintain normal serum 25(OH)D concentration is unclear. However, it has been suggested that exposure to sunlight for 5 to 15 min between the hours of 1000 and 1500 during the spring, summer, and autumn is usually enough to synthesize vitD in all individuals [55–57]. The recommended sunlight exposure for pregnant women is the same as for the general population and can be achieved with a daily walk or some other form of outdoor physical activity in the early morning or in the late afternoon [58].

Conclusions

The results from the present study showed a high level of nutrition awareness among pregnant women in Cape Coast and did influence the vitD intake of mothers. However, knowledge and awareness about vitD importance, and their sources was found to be low in the study area. Educational and occupational attainment influenced vitD intake with employment status determining sunlight exposure patterns of mothers. Information on safe sun exposure to obtain vitD naturally could be promoted to maintain optimal vitD concentrations in pregnant women. Additionally, housewives and unemployed pregnant women who are indoors during the day could be encouraged to synthesize vitD naturally.

Considering the low literacy rate in many sub-Saharan African countries, especially among women, literacy and education programs targeted at women and with a strong nutrition component should be rolled out in these countries. This should enhance receipt of nutrition education by less educated mothers during prenatal care and lead to changes in dietary practices for improved maternal and fetal health.

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