

Educational Video and Changes in Vitamin D Knowledge and Mid-Upper Arm Circumference Among Pregnant Women

Suryani¹, Atika Fadhilah Danaz Nst¹, Murdayah¹, Yuli Suryanti¹, Alifvirenzi Gigih Ayu Putri¹

¹Department of Midwifery, Health Polytechnic of the Ministry of Health Jambi, Indonesia

*Email Correspondence: atikapoltekkes@gmail.com

ARTICLE INFO

Article History:

Received March 26, 2026

Accepted May 20, 2026

Published online May 30, 2026

Keywords:

Antenatal care;

Health education;

Mid-upper arm circumference;

Pregnancy

Vitamin D

ABSTRACT

Limited knowledge of vitamin D requirements may hinder appropriate nutritional practices during pregnancy. However, mid-upper arm circumference (MUAC) is an anthropometric indicator of maternal nutritional status rather than a biomarker of vitamin D status. This study examined changes in knowledge of vitamin D requirements and MUAC following video-based education among pregnant women. A quasi-experimental study with a non-equivalent control-group design included 69 pregnant women recruited through total population sampling at the Aur Duri Public Health Center, Jambi City, Indonesia. Participants were non-randomly allocated according to antenatal care schedule clusters to either the intervention group (n = 35) or the control group (n = 34). The intervention consisted of a 4-minute 5-second educational video shown twice and made available via WhatsApp throughout an eight-week follow-up period, while the control group received standard antenatal care. Knowledge was assessed using a 15-item questionnaire developed from national guidelines, although formal psychometric validation of the instrument was not documented. MUAC was measured using a standardized protocol. Linear mixed-effects models were used to estimate between-group differences, adjusting for baseline outcome values, maternal age, gestational age, employment status, and parity. The study received ethical exemption (No. LB.02.06/2/0838/2025), and all participants provided written informed consent. The unadjusted between-group difference in change was 3.07 points for knowledge (95% CI: 2.57–3.57; $p < 0.001$) and 0.43 cm for MUAC (95% CI: 0.27–0.59; $p < 0.001$). After adjustment, the corresponding between-group differences were 3.04 points for knowledge (95% CI: 2.52–3.56; $p < 0.001$) and 0.41 cm for MUAC (95% CI: 0.24–0.59; $p < 0.001$). Video-based education was associated with greater short-term improvements in knowledge of vitamin D requirements and MUAC than standard antenatal care. However, given the non-randomized allocation and the absence of serum 25-hydroxyvitamin D measurements, the observed difference in MUAC should not be interpreted as evidence of improved vitamin D status.

INTRODUCTION

Pregnancy is a physiological period characterized by increased requirements for energy, protein, vitamins, and minerals to support maternal adaptation, placental growth, and fetal development¹. Nutritional adequacy during pregnancy is determined not only by the quantity of food consumed but also by dietary quality and diversity, regular supplement intake, sunlight exposure, and the mother's ability to understand health information. Mid-upper arm circumference (MUAC) is a simple indicator used to identify pregnant women at risk of chronic energy deficiency. The Indonesian

Ministry of Health defines a MUAC of less than 23.5 cm as indicating a risk of chronic energy deficiency. This condition may increase maternal susceptibility to anemia, infection, preterm birth, and obstetric complications and contribute to low birth weight and impaired child growth².

Vitamin D is a fat-soluble micronutrient that plays an essential role in calcium and phosphorus homeostasis, bone mineralization, immune function, glucose metabolism, and fetal skeletal and organ development³. Maternal vitamin D is obtained through cutaneous synthesis following ultraviolet B exposure, consumption of vitamin D-containing or fortified foods, and supplementation when clinically indicated. Inadequate vitamin D status during pregnancy has been associated with preeclampsia, gestational diabetes, preterm birth, and low birth weight, although the magnitude and causal nature of these associations remain uncertain across populations and study designs¹. Importantly, serum 25-hydroxyvitamin D [25(OH)D] is the accepted biomarker of vitamin D status, whereas MUAC is not a direct indicator of vitamin D deficiency. Consequently, changes in MUAC cannot be interpreted as evidence of improved vitamin D status.

Vitamin D deficiency among pregnant women remains a widespread public health concern. A review conducted in Southeast Asia estimated that approximately 60% of pregnant women had vitamin D deficiency, whereas the prevalence of hypovitaminosis D reached 85%⁴. An Indonesian meta-analysis similarly reported pooled estimates of approximately 63% for vitamin D deficiency, 25% for vitamin D insufficiency, and 78% for hypovitaminosis D⁵. These pooled estimates should, however, be interpreted cautiously because the included studies differed in participant characteristics, gestational trimester, geographic location, laboratory assays, definitions of deficiency, and serum 25(OH)D cutoff points. Such methodological and clinical heterogeneity limits direct comparison between studies and prevents the pooled estimates from being regarded as a precise prevalence for every Indonesian setting. National maternal-health surveillance also continues to recognize MUAC below 23.5 cm as an important indicator of nutritional risk during pregnancy². Vitamin D deficiency and low MUAC should therefore be regarded as related components of maternal nutrition assessment but not as equivalent or interchangeable conditions.

The persistence of vitamin D inadequacy in tropical populations shows that year-round sunlight availability does not guarantee sufficient vitamin D status. Limited outdoor activity, clothing practices, sunscreen use, skin pigmentation, low consumption of vitamin D-containing foods, and insufficient access to specific nutritional information may reduce vitamin D synthesis or intake^{6,7}. Routine antenatal education commonly addresses iron supplementation, pregnancy danger signs, birth preparedness, and general dietary recommendations, whereas information about vitamin D sources, safe sunlight exposure, requirements during pregnancy, and appropriate supplementation may receive less attention. Consequently, pregnant women may attend antenatal care without having

sufficient knowledge to make informed decisions regarding vitamin D and broader maternal nutritional practices.

Educational videos may address this knowledge gap by integrating narration, text, illustrations, animation, and practical demonstrations. Multimedia delivery can make physiological and nutritional concepts easier to understand, provide standardized information, and allow repeated viewing through smartphones⁹. Previous interventions using participatory videos, digital counseling, and audiovisual education have improved maternal nutritional knowledge and selected dietary behaviors⁸. Nevertheless, the existing evidence has largely focused on immediate cognitive outcomes, general nutrition, anemia prevention, or supplement adherence. Few quasi-experimental studies have examined whether repeated video education specifically addressing vitamin D and maternal nutrition is associated with both sustained knowledge improvement and changes in an anthropometric indicator over a follow-up period^{9,10}.

The rationale for including MUAC in the present study was therefore indirect and exploratory. The educational video was not expected to increase MUAC through vitamin D itself. Instead, information about vitamin D-containing foods, safe sunlight exposure, maternal nutritional requirements, and the consequences of inadequate nutrition was expected to improve nutritional understanding and potentially encourage broader dietary practices. If these practices improved overall energy and protein intake, a modest change in MUAC might occur over time. However, MUAC is also influenced by baseline nutritional status, gestational age, maternal health, food availability, and other behavioral and socioeconomic factors. Any observed MUAC difference must therefore be interpreted as a change associated with the broader educational intervention rather than as a biological effect of vitamin D or evidence of improved serum 25(OH)D status.

The novelty of this study lies not merely in its geographical setting but in its integration of three features: a standardized and repeatedly accessible video focused on vitamin D within broader maternal nutrition education, an eight-week assessment period extending beyond immediate knowledge recall, and the simultaneous evaluation of a cognitive outcome and an objective anthropometric outcome using an adjusted between-group analysis. Accordingly, this study aimed to examine whether exposure to the educational video was associated with greater changes in knowledge of vitamin D requirements and MUAC than standard antenatal care among pregnant women. It was hypothesized that the intervention group would demonstrate a greater improvement in knowledge; changes in MUAC were evaluated as a secondary and indirect nutritional outcome.

METHODS

A quasi-experimental study with a non-equivalent control group pretest–posttest design was conducted at Aur Duri Public Health Center, Jambi City, Indonesia, from December 2025 to January

2026. Knowledge of vitamin D requirements and mid-upper arm circumference (MUAC) were assessed at baseline and after eight weeks in both groups. Individual randomization was not performed because participants were assigned according to existing antenatal care schedule clusters. The study was reported in accordance with the relevant items of the Transparent Reporting of Evaluations with Nonrandomized Designs statement.

The accessible population comprised 69 pregnant women registered at Aur Duri Public Health Center. All eligible women were recruited through total population sampling. The inclusion criteria were a singleton pregnancy in the first or second trimester, registration for antenatal care at the study site, ability to communicate in Indonesian and complete the questionnaire, residence within the health center's service area during follow-up, and provision of written informed consent. Women were excluded if they had severe pregnancy complications, severe hyperemesis gravidarum, arm edema affecting MUAC measurement, chronic diseases influencing nutritional status, or visual or hearing impairments that prevented adequate exposure to the video.

Participants were assigned non-randomly to the intervention ($n = 35$) or control group ($n = 34$) according to predetermined antenatal care schedule clusters. Group assignment was established before recruitment and was not based on knowledge, MUAC, nutritional status, or participant preference. Separate service schedules were used to reduce intervention contamination.

The intervention group received an educational video entitled "The Importance of Vitamin D for Pregnant Women." The 4-minute and 5-second video used narration, text, illustrations, and animation to explain the functions, benefits, sources, and consequences of vitamin D deficiency, as well as appropriate sunlight exposure, dietary practices, and supplement use based on healthcare professionals' recommendations. The video was shown twice during the initial session, followed by a standardized explanation and a 10-15-minute discussion. Participants received access to the video through WhatsApp for repeated viewing during the eight-week follow-up and received weekly reminders. Adherence was monitored through attendance records and participant confirmation of repeated viewing. The control group received standard antenatal care without access to the video during the study. The video was provided to the control group after the final assessment.

The primary outcome was the change in knowledge of vitamin D requirements, while the secondary outcome was the change in MUAC. Potential confounders included maternal age, gestational age, educational level, employment status, parity, baseline outcome values, sunlight exposure, and vitamin D supplement use. Knowledge was assessed using a 15-item multiple-choice questionnaire developed from the Indonesian Maternal and Child Health Handbook, the Guidelines for Balanced Nutrition, and relevant literature. Correct answers were scored 1, whereas incorrect or unanswered items were scored 0; total scores ranged from 0 to 15, with higher scores indicating better knowledge. The same questionnaire and scoring procedure were used at baseline and follow-up.

Formal construct-validity and reliability coefficients were not available in the study records; this limitation was considered when interpreting the knowledge outcome.

MUAC was measured on the left arm using a non-stretchable tape with a precision of 0.1 cm. The midpoint between the acromion and olecranon was identified with the elbow flexed at 90°, after which the arm was relaxed, and the tape positioned horizontally without compressing the soft tissue. Measurements were taken twice. When the difference exceeded 0.5 cm, a third measurement was obtained, and the mean of the two closest values was used. A MUAC below 23.5 cm was used descriptively to identify the risk of chronic energy deficiency.

After written informed consent had been obtained, participants completed the baseline questionnaire and underwent MUAC measurement. The intervention was then delivered according to group assignment. Knowledge and MUAC were reassessed after eight weeks using the same instruments and procedures. Selection bias was minimized by applying identical eligibility criteria and concurrent recruitment periods to both groups. Intervention fidelity was maintained through standardized video content, viewing procedures, and weekly reminders. Measurement bias was reduced through assessor training, standardized repeated MUAC measurements, and coded participant identities. Whenever feasible, follow-up MUAC assessors were unaware of participants' baseline values. Baseline imbalances and prespecified confounders were controlled for statistically.

The study received an Ethical Exemption from the Health Research Ethics Committee of the Health Polytechnic of the Ministry of Health Jambi under approval number LB.02.06/2/0838/2025. Written informed consent was obtained from all participants. Participant identities were replaced with unique codes, and only aggregated data were reported. Women with a MUAC below 23.5 cm were referred to the health center's nutritionist for further assessment and management.

Data were analyzed using IBM SPSS Statistics. Categorical variables were reported as frequencies and percentages, whereas numerical variables were presented as means and standard deviations or medians and interquartile ranges, as appropriate. Data distributions were evaluated using the Shapiro–Wilk test and Q–Q plots. Baseline comparability was assessed using standardized mean differences, with an absolute value greater than 0.10 indicating a potentially relevant imbalance. Intervention effects were examined using linear mixed-effects models with group, time, and the group-by-time interaction as fixed effects and participants as random effects. The group-by-time interaction represented the primary intervention effect. Models were adjusted for maternal age, gestational age, employment status, parity, and relevant baseline imbalances. Results were reported as adjusted mean differences with 95% confidence intervals. All tests were two-sided, and statistical significance was set at $p < 0.05$.

RESULTS

Table 1. Baseline characteristics of participants by study group

Characteristic	Intervention (n = 35)	Control (n = 34)	SMD
Age, years, mean $\pm$ SD	27.85 $\pm$ 4.88	25.70 $\pm$ 4.15	0.48
Gestational age, weeks, mean $\pm$ SD	18.71 $\pm$ 5.22	18.68 $\pm$ 5.22	0.01
Educational level, n (%)			0.14
Primary education	7 (20.0)	4 (11.8)	
Secondary education	20 (57.1)	22 (64.7)	
Higher education	8 (22.9)	8 (23.5)	
Employment status, n (%)			0.31
Employed	12 (34.3)	7 (20.6)	
Unemployed	23 (65.7)	27 (79.4)	
Parity, n (%)			0.29
Primigravida	14 (40.0)	9 (26.5)	
Multigravida	21 (60.0)	25 (73.5)	
Adequate sunlight exposure, n (%)	11 (31.4)	11 (32.4)	-0.02
Vitamin D supplement use, n (%)	7 (20.0)	5 (14.7)	0.14
Baseline knowledge score, mean $\pm$ SD	7.31 $\pm$ 1.76	7.68 $\pm$ 1.57	-0.22
Baseline MUAC, cm, mean $\pm$ SD	25.07 $\pm$ 1.63	24.72 $\pm$ 1.99	0.19
MUAC <23.5 cm, n (%)	5 (14.3)	10 (29.4)	0.38

Table 1 shows that the mean age was 27.85 $\pm$ 4.88 years in the intervention group and 25.70 $\pm$ 4.15 years in the control group. The mean gestational ages were 18.71 $\pm$ 5.22 and 18.68 $\pm$ 5.22 weeks, respectively. Most participants in both groups had completed secondary education, were unemployed, and were multigravida. The groups were comparable in terms of gestational age and sunlight exposure, as indicated by absolute SMD values below 0.10. However, potentially relevant baseline imbalances were identified in maternal age, educational level, employment status, parity, vitamin D supplement use, baseline knowledge, baseline MUAC, and the proportion of participants with a MUAC below 23.5 cm. These variables were therefore considered in the adjusted analysis.

Table 2. Changes in knowledge and MUAC during the study

Outcome	Assessment time	Intervention (n = 35)	Control (n = 34)	Difference in change (95% CI)	Interaction p value
Knowledge score	Baseline	7.31 $\pm$ 1.76	7.68 $\pm$ 1.57		
	Week 8	10.86 $\pm$ 2.12	8.15 $\pm$ 2.06		
	Change	3.54 $\pm$ 1.15	0.47 $\pm$ 0.93	3.07 (2.57–3.57)	<0.001
MUAC, cm	Baseline	25.07 $\pm$ 1.63	24.72 $\pm$ 1.99		
	Week 8	25.73 $\pm$ 1.62	24.95 $\pm$ 2.02		
	Change	0.66 $\pm$ 0.42	0.23 $\pm$ 0.22	0.43 (0.27–0.59)	<0.001

As shown in Table 2, the mean knowledge score in the intervention group increased from 7.31 $\pm$ 1.76 at baseline to 10.86 $\pm$ 2.12 at week 8, representing a mean increase of 3.54 $\pm$ 1.15 points. In the control group, the mean score increased from 7.68 $\pm$ 1.57 to 8.15 $\pm$ 2.06, corresponding to a mean increase of 0.47 $\pm$ 0.93 points. The unadjusted between-group difference in change was 3.07 points

(95% CI: 2.57–3.57; $p < 0.001$). Mean MUAC in the intervention group increased from 25.07 ± 1.63 cm at baseline to 25.73 ± 1.62 cm at week 8, representing a mean increase of 0.66 ± 0.42 cm. In the control group, mean MUAC increased from 24.72 ± 1.99 cm to 24.95 ± 2.02 cm, representing a mean increase of 0.23 ± 0.22 cm. The unadjusted between-group difference in MUAC change was 0.43 cm (95% CI: 0.27–0.59; $p < 0.001$).

Table 3. Adjusted effects of the educational video on knowledge and MUAC

Outcome	Adjusted mean difference	SE	95% CI	<i>p</i> value
Knowledge score	3.04	0.26	2.52–3.56	<0.001
MUAC, cm	0.41	0.09	0.24–0.59	<0.001

As presented in Table 3, after adjustment for baseline outcome values, maternal age, gestational age, employment status, and parity, the increase in knowledge scores was estimated to be 3.04 points greater in the intervention group than in the control group (adjusted mean difference = 3.04; 95% CI: 2.52–3.56; $p < 0.001$). The adjusted increase in MUAC was also 0.41 cm greater in the intervention group than in the control group (adjusted mean difference = 0.41 cm; 95% CI: 0.24–0.59; $p < 0.001$). These findings indicate that the between-group differences remained statistically significant after baseline imbalances and prespecified confounding variables were controlled for.

DISCUSSION

This study examined whether video-based education was associated with changes in knowledge of vitamin D requirements and mid-upper arm circumference (MUAC) among pregnant women at Aur Duri Public Health Center, Jambi City. The intervention group demonstrated greater improvements in both outcomes than the control group. After adjustment for prespecified confounders, the between-group difference was 3.04 points for knowledge (95% CI: 2.52–3.56; $p < 0.001$) and 0.41 cm for MUAC (95% CI: 0.24–0.59; $p < 0.001$). These findings suggest that video-based education may strengthen pregnant women's understanding and support appropriate nutritional practices^{11,13}. Nevertheless, the MUAC difference cannot be interpreted as a direct consequence of improved vitamin D status because serum 25-hydroxyvitamin D concentrations were not measured and MUAC is influenced by multiple nutritional and physiological factors¹⁴.

These findings are consistent with those of several international studies. Saville et al. reported that a virtual antenatal intervention improved knowledge of iron-rich foods, with a coefficient of 0.96 (95% CI: 0.50–1.41), although it did not produce significant improvements in supplement adherence or dietary diversity. Their findings suggest that digital interventions may influence cognitive outcomes more rapidly than complex behavioral outcomes¹⁵. Beressa et al. found that nutrition education based on the Health Belief Model and the Theory of Planned Behavior resulted in a net between-group difference in MUAC of approximately 0.59 cm¹⁶. Wakwoya et al. similarly reported that intensive

nutrition education and counseling increased MUAC among pregnant women from 23.08 to 23.44 cm and produced an adjusted intervention effect of 0.47 cm compared with the control group¹⁷. Furthermore, a nutrition literacy intervention among pregnant women in China improved nutritional knowledge and supported better management of gestational weight gain¹⁸.

The similarities between the present findings and those of previous studies are particularly evident in the direction of changes in knowledge and maternal anthropometric indicators. Collectively, these studies indicate that structured education delivered repeatedly and reinforced through reminders can help pregnant women understand nutritional messages and apply them in their daily lives. The 0.66-cm increase in MUAC observed in the intervention group in the present study was greater than the 0.36-cm increase reported by Wakwoya et al.¹⁷ but was close to the net difference reported by Beressa et al.¹⁶ Variations in effect magnitude may be explained by differences in baseline MUAC, gestational age, intervention duration, counseling intensity, dietary practices, household food security, and socioeconomic characteristics. Previous studies generally provided comprehensive nutrition counseling, whereas the present intervention used a brief video shown twice and made available for repeated viewing. Therefore, the observed increase in MUAC should not be attributed exclusively to improved knowledge of vitamin D but may also reflect the adoption of broader nutritional messages and physiological changes occurring during pregnancy.

The findings can be explained using the Cognitive Theory of Multimedia Learning, which proposes that information is processed more effectively when words and images are presented through coordinated visual and auditory channels. The combination of narration, text, illustrations, and animation helps learners select relevant information, organize it into coherent mental representations, and integrate it with prior knowledge¹⁹. The greater increase in knowledge scores in the intervention group supports this theory because participants received structured information and were able to view the material repeatedly. The findings are also consistent with the Health Belief Model. Information about the consequences of vitamin D deficiency may increase perceived susceptibility and severity, while examples of vitamin D sources and practical strategies for meeting nutritional requirements may strengthen perceived benefits and provide guidance for action²⁰. Repeated access through WhatsApp may serve as a cue to action that reinforces intentions to obtain appropriate sunlight exposure, choose nutritious foods, and consult healthcare professionals regarding supplementation²¹.

The proposed mechanism begins with the video attracting participants' attention and improving their knowledge of vitamin D requirements and maternal nutrition. The simultaneous presentation of visual and auditory information may facilitate comprehension, retention, and recall of nutritional messages¹⁹. Better knowledge may subsequently improve food selection, increase the consumption of fish, eggs, milk, and other nutrient-dense foods, and encourage adherence to recommendations

provided by healthcare professionals. Previous intervention studies have demonstrated that structured nutrition education and counseling during pregnancy can improve maternal dietary practices and nutritional status, including MUAC^{16,17}. If these behavioral changes are sustained, improved energy and protein intake may support the maintenance or accumulation of muscle and adipose tissue in the upper arm, thereby contributing to increased MUAC. This explanation is supported by evidence showing significant positive correlations between energy and protein intake and MUAC among pregnant women²². Nevertheless, vitamin D is not a primary or direct determinant of MUAC. Its principal biological functions involve calcium and phosphorus homeostasis, bone mineralization, skeletal muscle function, and immune modulation²³. A more plausible pathway is therefore that the video improves knowledge, improved knowledge encourages healthier nutritional behavior, healthier behavior improves overall dietary intake, and improved intake contributes to changes in MUAC. The eight-week follow-up period may have allowed sufficient time for behavioral changes to begin affecting anthropometric measurements, although physiological changes associated with advancing gestational age must also be considered²⁴.

The parallel improvements in knowledge and MUAC suggest a possible relationship between cognitive outcomes and maternal nutritional status. However, the present study did not directly examine the correlation between changes in knowledge scores and changes in MUAC. It therefore cannot be concluded that participants who experienced the greatest improvements in knowledge necessarily demonstrated the greatest increases in MUAC. The relationship may be mediated or confounded by dietary behavior, food availability, household income, partner support, nausea and vomiting, sunlight exposure, supplement use, gestational age, and maternal health status. Biologically, adequate energy and protein intake contributes to the maintenance of muscle and adipose tissue reserves reflected by MUAC²⁵, whereas vitamin D supports skeletal muscle function, calcium metabolism, and mitochondrial health rather than directly increasing upper-arm circumference²³. Measurements of serum 25(OH)D concentrations, energy and protein intake, dietary diversity, and sunlight exposure would therefore be required to verify the proposed pathway. Future studies should also employ mediation analysis to determine whether changes in nutritional behavior and dietary intake explain the relationship between improved knowledge and changes in MUAC.

In healthcare practice, educational videos could be integrated into antenatal care, pregnancy classes, health center waiting areas, and WhatsApp-based communication because they enable standardized delivery, repeated viewing, and efficient use of counseling time. MUAC assessment should nevertheless be conducted alongside evaluations of dietary intake, gestational weight gain, and clinical risk factors. Pregnant women with a MUAC below 23.5 cm should receive individualized counseling, dietary assessment, supplementary feeding when indicated, and regular monitoring; educational videos should not be used as a stand-alone intervention. The study's limitations include

non-random group allocation, possible baseline differences, the inability to blind participants, reliance on questionnaire-based knowledge assessment, and the potential exchange of information between groups. The study also did not measure dietary intake, serum 25(OH)D concentrations, behavioral changes, or pregnancy outcomes; therefore, the mechanism underlying the observed increase in MUAC could not be confirmed. Moreover, the relatively small sample was drawn from a single public health center, and the findings should therefore be generalized cautiously.

CONCLUSION

Among pregnant women attending Aur Duri Public Health Center, video-based education was associated with greater short-term improvements in knowledge of vitamin D requirements and MUAC than standard antenatal care. The combination of images, narration, text, animation, and repeated access provided a practical method for delivering standardized maternal-nutrition information. Because group allocation was non-random and serum 25-hydroxyvitamin D was not measured, the findings do not establish causality or demonstrate that the MUAC difference resulted from improved vitamin D status.

Aur Duri Public Health Center is encouraged to integrate educational videos on vitamin D and maternal nutrition into routine antenatal care, pregnancy classes, and digital health promotion activities. Video-based education should be accompanied by individualized counseling, regular MUAC assessment, dietary evaluation, and follow-up by nutrition professionals, particularly for pregnant women at risk of chronic energy deficiency. Future studies should employ randomized designs, recruit larger samples, use longer follow-up periods, and assess dietary intake, nutritional behavior, serum 25(OH)D concentrations, and pregnancy outcomes.

BIBLIOGRAPHY

1. Organization WH. Guideline: Vitamin D supplementation in pregnant women [Internet]. Geneva: World Health Organization; 2012. Available from: <https://iris.who.int/handle/10665/85313>
2. Kementerian Kesehatan Republik Indonesia. Laporan Nasional Riset Kesehatan Dasar 2018. Jakarta: Badan Penelitian dan Pengembangan Kesehatan; 2019.
3. Ceglia L. Vitamin D and its role in skeletal muscle. *Curr Opin Clin Nutr Metab Care* [Internet]. 2009;12(6):628–33. Available from: <https://doi.org/10.1097/MCO.0b013e328331c707>
4. Nindrea RD, Hendriyani H. Prevalence of vitamin D deficiency among pregnant women in Southeast Asia represents public health crisis: A systematic review and meta-analysis. *Clin Epidemiol Glob Heal*. 2024;27:101574.

5. Octavius GS, Daleni VA. A systematic review and meta-analysis of prevalence of vitamin D deficiency among Indonesian pregnant women: A public health emergency. *Ann Med Surg.* 2023;85(5):1626–35.
6. Palacios C, Kostiuik LK, Peña-Rosas JP. Vitamin D supplementation for women during pregnancy. *Cochrane Database Syst Rev* [Internet]. 2019;(7):CD008873. Available from: <https://doi.org/10.1002/14651858.CD008873.pub4>
7. Zhang L, Quan M, Cao ZB. Effect of vitamin D supplementation on upper and lower limb muscle strength and muscle power in athletes: A meta-analysis. *PLoS One.* 2019;14(4):e0215826.
8. Kadiyala S, Harris-Fry H, Pradhan R, Mohanty S, Padhan S, Rath S, et al. Effect of nutrition-sensitive agriculture interventions with participatory videos and women's group meetings on maternal and child nutritional outcomes in rural Odisha, India (UPAVAN trial): a four-arm, observer-blind, cluster-randomised controlled trial. *Lancet Planet Heal* [Internet]. 2021;5(5):e263–76. Available from: <https://www.sciencedirect.com/science/article/pii/S2542519621000012>
9. Patty AC, Utami YW, Fevriasanty FI. The Effect of Education Through Video on Retaining Knowledge of Pregnant Women About Nutrition to Prevent Stunting. *J Aisyah J Ilmu Kesehat.* 2023;8(2):905–12.
10. Jackson RA, Stotland NE, Caughey AB, Gerbert B. Improving diet and exercise in pregnancy with Video Doctor counseling: a randomized trial. *Patient Educ Couns.* 2011;83(2):203–9.
11. Mohammedsanni A, Haile D, Endris BS, Gebrehiwot Y, Kassahun EA, Gebreyesus SH. The effect of facility-based nutrition education and counseling on dietary intake and supplemental iron folic acid use among pregnant women: a cluster randomised controlled trial. *Public Health Nutr.* 2025;28(1):e191.
12. Katenga-Kaunda LZ, Iversen PO, Holmboe-Ottesen G, Fjeld H, Mdala I, Kamudoni PR. Dietary intake and processes of behaviour change in a nutrition education intervention for pregnant women in rural Malawi: a cluster-randomised controlled trial. *Public Health Nutr.* 2020;23(13):2345–54.
13. Diddana TZ, Kelkay GN, Dola AN, Sadore AA. Effect of nutrition education based on health belief model on nutritional knowledge and dietary practice of pregnant women in Dessie Town, Northeast Ethiopia: A cluster randomized control trial. *J Nutr Metab.* 2018;2018.
14. Fakier AF, Petro G, Fawcus S. Mid-upper arm circumference: A surrogate for body mass index in pregnant women. *South African Med J.* 2017;107(7):606–10.
15. Saville NM, Bhattarai S, Giri S, others. Impact of a virtual antenatal intervention for improved diet and iron intake in Kapilvastu District, Nepal: The VALID randomized controlled trial. *Front Nutr.* 2024;11:1464967.

16. Beressa G, Whiting SJ, Belachew T. Effect of nutrition education on the nutritional status of pregnant women in Robe and Goba Towns, Southeast Ethiopia, using a cluster randomized controlled trial. *Sci Rep* [Internet]. 2024;14:19706. Available from: <https://doi.org/10.1038/s41598-024-70861-1>
17. Wakwoya EB, Belachew T, Girma T. Effects of intensive nutrition education and counseling on nutritional status of pregnant women in East Shoa Zone, Ethiopia. *Front Nutr*. 2023;10:1144709.
18. Li Q, Wang J. Effectiveness of nutrition literacy intervention on pregnancy weight and eating behavior: a randomized controlled trial. *Sci Rep* [Internet]. 2025;15(1):21858. Available from: <https://doi.org/10.1038/s41598-025-07979-3>
19. Mayer RE. Multimedia learning. In: *Psychology of learning and motivation*. Elsevier; 2002. p. 85–139.
20. Champion VL, Skinner CS. The health belief model. *Heal Behav Heal Educ Theory, Res Pract*. 2008;4:45–65.
21. Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the health belief model. *Health Educ Q*. 1988;15(2):175–83.
22. Mutalazimah M, Wijaya YA, Suswardany DL. Energy, Protein Intake and Mid-Upper Arm Circumference in Pregnant Women in Boyolali Regency, Indonesia. *Malaysian J Med Heal Sci*. 2020;16(6):77.
23. Latham CM, Brightwell CR, Keeble AR, others. Vitamin D promotes skeletal muscle regeneration and mitochondrial health. *Front Physiol*. 2021;12:660498.
24. Kpewou DE, Poirot E, Berger J, Som S V, Laillou A, Belayneh SN, et al. Maternal mid-upper arm circumference during pregnancy and linear growth among Cambodian infants during the first months of life. *Matern Child Nutr* [Internet]. 2020;16(4):e12951. Available from: <https://doi.org/10.1111/mcn.12951>
25. Cangussu LM, Nahas-Neto J, Orsatti CL, Bueloni-Dias FN, Nahas EAP. Effect of vitamin D supplementation alone on muscle function in postmenopausal women: a randomized, double-blind, placebo-controlled clinical trial. *Osteoporos Int*. 2015;26(10):2413–21.