



# Clinical practice of vitamin D screening and supplementation in pregnancy in Asia-pacific countries: A cross-sectional study

Ryan Wai Kheong Lee, Alicia Li Bin Chng, Kok Hian Tan<sup>\*</sup>, IPRAMHO International Study Group<sup>1</sup>

## ARTICLE INFO

**Keywords:**  
Vitamin D  
Asia-pacific  
Screening  
Supplementation  
Pregnancy

## ABSTRACT

**Background:** Vitamin D deficiency is common in pregnant women. There is scarce information in the Asia-Pacific region on the understanding of vitamin D screening and supplementation in pregnancy among health care professionals.

**Methods:** We performed a cross-sectional study among health care professionals who are part of the Integrated Platform for Research in Advancing Metabolic Health outcomes of Women and Children (IPRAMHO) international study group on their understanding and perception of Vitamin D screening and supplementation in pregnancy. The cross-sectional survey comprised 4 main sections: demographics, existing policies, nutrient supplementation in pregnancy and various practices on screening, treatment and perceptions, with a total of 22 questions. A total of 15 responses were obtained from attendees from distinct health facilities across eleven participating Asia-Pacific countries.

**Results:** Majority of the surveyed hospitals (11/15, 78.6 %) did not have a national policy or regional guideline regarding Vitamin D screening and supplementation in pregnancy. More than half of respondents were (9/14, 64.3 %) were unsure of the percentage of women seen with Vitamin D deficiencies each year and were unsure of Vitamin D dosage prescribed to pregnant women with (8/15, 53.3 %) or without (6/14, 42.9 %) Vitamin D deficiency. Vitamin D was rarely prescribed in pregnancy when compared to other nutrient supplements such as folic acid and iron. Majority of respondents (9/11, 72.7 %) indicated that their hospital did not screen for Vitamin D deficiencies in pregnancy, even amongst high risk pregnant women. Nevertheless, majority of respondents indicated a need (12/15, 80.0 %) for a guideline or consensus regarding Vitamin D screening and supplementation in pregnancy.

**Conclusion:** While majority of the surveyed hospitals did not have a national policy or regional guideline regarding Vitamin D screening and supplementation in pregnancy, majority of respondents indicated a need for the policy or guideline. There were varying clinical knowledge gaps and different perceptions on Vitamin D screening and supplementation in pregnancy among healthcare professionals.

<sup>\*</sup> Corresponding author. Department of Maternal Fetal Medicine, KK Women's and Children's Hospital, Singapore, 229899, Singapore.

E-mail address: [tan.kok.hian@singhealth.com.sg](mailto:tan.kok.hian@singhealth.com.sg) (K.H. Tan).

<sup>1</sup> Integrated Platform for Research in Advancing Metabolic Health Outcomes of Women and Children (IPRAMHO) International Study Group for Vitamin D in Pregnancy include the listed members.

<https://doi.org/10.1016/j.heliyon.2023.e21186>

Received 23 February 2023; Received in revised form 16 October 2023; Accepted 18 October 2023

Available online 4 November 2023

2405-8440/© 2023 Published by Elsevier Ltd.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Introduction

Vitamin D deficiency is common in pregnant women and has become a global public health problem [1,2]. The definition of vitamin D deficiency in pregnancy is debatable with no clear consensus; serum 25-hydroxyvitamin D levels cut offs ranging from <25 to 30 nmol/L [1,3]. The prevalence of vitamin D deficiency in pregnancy is wide ranging from 9 % in the United States of America [4] to 59 % in India [5]. Stark differences in prevalence rates varies according to latitude [6], skin-colour, sun-exposure, race-ethnicity, clothing patterns [7,8], Body Mass Index (BMI) [9]. The high prevalence of vitamin D inadequacy in the Asia-Pacific region can be observed in women with darker skin colour [7] and excessive clothing with limited sun exposure [8]. This increasing prevalence of vitamin D deficiency can also be attributed by increasing awareness and objective measurements of serum vitamin D levels in high-risk women with darker skin tone, reduced sunlight exposure or obese women [8].

Several meta-analyses conducted associate low vitamin D status in pregnancy with adverse maternal and neonate outcomes such as reduced fertility [10], pre-eclampsia [11,12], gestational diabetes [13,14], low birth weight [15,16] and preterm birth [17,18], neonatal late hypocalcemia [19] and nutritional rickets [20].

Additionally, vitamin D supplementation during pregnancy was reported to improve maternal vitamin D and calcium status. This may thereby protect skeletal health in both mother and neonate with reduced risk of fractures and improvements on bone mineralization [21] and may contribute to reduced risk of preeclampsia. Furthermore, vitamin D supplementation was also reported to reduce the risk of preterm birth [22].

The main source of vitamin D is obtained by direct synthesis from sunlight to the skin and stimulation of pre-vitamin D3 development. However, dietary intake only provides 10 % of vitamin D requirements as very few foods contain a high amount of vitamin D. Hence vitamin D supplementation could be considered as a way of meeting such requirements [23]. Meta-analyses of randomized controlled trials have showed that vitamin D supplementation during pregnancy with doses  $\leq 2000$  IU daily had positive effects on minimizing the risk for small for gestational age babies and enhancing the infant's growth, in absence of an increased risk of congenital abnormalities or mortality [24,25].

Guidelines on vitamin D recommendations vary among different countries and organisations. The Royal College of Obstetricians and Gynaecologists (RCOG) recommends routine vitamin D supplementation to all pregnant women in the United Kingdom [26]. In contrast, the World Health Organisation (WHO) does not recommend routine antenatal supplementation [27]. Conflicting evidence [28] exists on the value of routine supplementation to improve maternal and fetal outcomes [29].

Currently, there are scarce information on clinical knowledge gaps and on perceptions of screening for vitamin D deficiency in pregnancy among health-care professionals in the Asia-Pacific region. Similarly, screening tools and treatment regimens on vitamin D supplementation may also vary in the Asia-Pacific region. These reasons include racial, cultural differences to environmental factors such as sunlight exposure, diet and resources available such as measuring serum vitamin D levels before treatment.

There is no current survey being published comparing healthcare professionals' views and practices on the screening and treatment of vitamin D deficiency in pregnancy, in Asia-Pacific region. Hence, this survey is timely to assess and understand, our knowledge, perceptions on screening and treatment of vitamin D screening and supplementation in pregnancy in the Asia-Pacific region. It is important to understand the attitudes and perceptions of approaches to vitamin D screening and supplementation in pregnancy in Asia-Pacific countries, since vitamin D deficiency is becoming increasingly prevalent in Asia-Pacific countries. This study review would enable professionals to collaborate and enhance our understanding of global health perspectives on the effects of vitamin D supplementation in pregnancy in the Asia-Pacific.

## 2. Methods

We conducted an electronic online survey on hospitals from various Asia-Pacific countries during the Integrated Platform for

**Table 1**  
Survey respondent's characteristics and representative hospitals and countries (N = 15).

Demographics				
Survey Respondent	Country	Country income level	Hospital	No of Deliveries per year
No. 1	Bangladesh	Lower-middle	LABAID Specialized Hospital	360
No. 2	China	Upper-middle	Chengdu Women's and Children's Central Hospital	15,000
No. 3	India	Lower-middle	Naval Maternity & Nursing Home	600
No. 4	Indonesia	Lower-middle	Dr. Hasan Sadikin Central General Hospital	2000
No. 5	Malaysia	Upper-middle	Hospital Tuanku Ja'afar Seremban	11,000
No. 6	Malaysia	Upper-middle	Universiti Putra Malaysia Teaching Hospital	10,000
No. 7	Myanmar	Lower-middle	Yangon Central Women's Hospital	1000
No. 8	Singapore	High Lower-middle	Mount Alvernia Hospital	4000
No. 9	Singapore	High	KK Women's and Children's Hospital	12,000
No. 10	Thailand	Upper-middle	Siriraj Hospital	7000
No. 11	Australia	High	Mercy Hospital for Women	5800
No. 12	Philippines	Lower-middle	Veterans Memorial Medical Centre	1000
No. 13	Philippines	Lower-middle	Bicol Regional General Hospital & Geriatric Medical Centre	1280
No. 14	Philippines	Lower-middle	Medical Centre Taguig	500
No. 15	Sri Lanka	Lower-middle	Colombo North Teaching Hospital-Ragama	3000

Research in Advancing Metabolic Health Outcomes of Women and Children (IPRAMHO) Asia-Pacific online workshop which was held in January 2022. The purpose of the survey was to provide insights of Vitamin D screening and supplementation practices in the Asia-Pacific countries.

An electronic survey was sent to clinicians and academic attendees from 15 healthcare facilities in 11 participating Asia-Pacific countries, namely Singapore, Bangladesh, China, Malaysia, Myanmar, India, Indonesia, Sri Lanka, Philippines and Australia. The respondents for the survey were chosen from country representatives of the IPRAMHO Asia-Pacific workshop. The response rate for the survey was 100 % with active participations from the IPRAMHO group members and timely reminders to complete the survey. These survey responses were then collated and analyzed.

The surveys comprised 4 main sections with a total of 22 questions, which sought to gather information regarding demographics, existing policies in their clinical practice, perspectives on nutrient supplements in pregnancy and practices on screening, treatment and perceptions. All respondents participated voluntarily and the study was approved by SingHealth Ethical Board CIRB Ref 2022/2004.

### 3. Results

The respondent's characteristics, hospitals from 11 countries are summarized in Table 1. There were varying number of deliveries in various hospitals ranging from less than 1000 to more than 10,000 deliveries per year. The 11 Countries were classified into higher, upper-middle, lower-middle and low-income countries according to the World Bank open data [30].

Majority of respondents (12/15, 80.0 %) indicated that their hospital does not screen for vitamin D deficiencies in pregnancy even amongst high-risk pregnant women (Table 2, 2A-2C). Moreover, for pregnant women diagnosed with vitamin D deficiency, there was no common ground on follow-up tests for vitamin D levels amongst respondents, with answers varying from repeating each trimester (2/15, 13.3 %) to no follow-up (4/15, 26.7 %) (Tables 2 and 2D). There was no consensus regarding the cut off value to determine vitamin D deficiency ranging from 10 to 50 nmol/L (Tables 2 and 2E). An overwhelming number of respondents indicated a need (14/15, 93.3 %) for a guideline or consensus regarding vitamin D screening and supplementation in pregnancy (Table 2, 2F).

Majority of respondents (10/15, 66.7 %) responded that they did not have a national policy or regional guideline regarding vitamin D screening and supplementation in pregnancy with only a minority (3/15, 20.0 %) indicating that their institution has a policy which they refer to (Tables 3 and 3A). Majority of respondents expressed that their own centres did not have any written protocol on vitamin D screening and supplementation (11/14, 66.7 %) or were unsure if a protocol existed (2/14, 14.3 %) (Tables 3 and 3B).

More than half of all respondents were (9/14, 64.3 %) either unsure or did not know the percentage of women with vitamin D deficiency that their hospital sees each year (Tables 3 and 3C). Approximately half of all respondents were also unsure of vitamin D dose prescribed to pregnant women with (8/15, 53.3 %) or without (6/14, 42.9 %) vitamin D deficiencies (Table 3, 3D-3E).

**Table 2**  
Existing practices regarding vitamin D screening, treatments and perceptions.

Practices on screening, treatment and perceptions	
Question (Response)	Number of responses (%)
<b>2A. Does your hospital screen for vitamin D deficiency in pregnancy?</b>	
Yes	0/15 (0.0 %)
No	12/15 (80.0 %)
Sometimes	3/15 (20.0 %)
<b>2B. Does your hospital screen for vitamin D deficiency in specific group of patients based on risk profile?</b>	
Yes	3/15 (20.0 %)
No	10/15 (66.7 %)
Sometimes	2/15 (13.3 %)
<b>2C. What is your hospital policy on screening for vitamin D deficiency in pregnancy?</b>	
Assessment of patient risk profile	3/15 (20.0 %)
Measurement of serum vitamin D levels based on risk profile	1/15 (6.7 %)
Research purpose, affordability	2/15 (14.3 %)
Leave it for physicians to decide	4/15 (26.7 %)
No screening for vitamin D	10/15 (66.7 %)
<b>2D. How does your hospital follow up on vitamin D levels in pregnancy women with vitamin D deficiency?</b>	
No need to repeat routinely	4/15 (26.7 %)
Repeat only if symptomatic	3/15 (20.0 %)
Repeat every trimester	2/15 (13.3 %)
Not sure	6/15 (40.0 %)
<b>2E. What do you think is the cut-off value to determine vitamin D deficiency (nmol/L) in pregnant women?</b>	
10 nmol/L	1/15 (6.7 %)
20 nmol/L	2/15 (13.3 %)
30 nmol/L	3/15 (20.0 %)
40 nmol/L	1/15 (6.7 %)
50 nmol/L	4/15 (26.7 %)
Not sure	4/15 (26.7 %)
<b>2F. Do you think that there is a need for a guideline and/or consensus on vitamin D screening and supplementation in pregnancy?</b>	
Yes	14/15 (93.3 %)
Not sure	1/15 (6.7 %)

**Table 3**  
Existing policies regarding vitamin D screening and supplementation.

Existing Policies	
Question (Response)	Number of responses (%)
<b>3A. Is there a national policy and/or regional guideline which your hospital refers to for vitamin D screening and supplementation in pregnancy?</b>	
Yes	3/15 (20.0 %)
No	10/15 (66.7 %)
Not sure	2/15 (13.3 %)
<b>3B. Does your hospital have a written protocol on vitamin D screening and supplementation deficiency in pregnancy?</b>	
Yes	1/14 (14.3 %)
No	11/14 (78.6 %)
Not sure	1/14 (7.1 %)
<b>3C. What percentage of pregnant women does your hospital see have vitamin D deficiency?</b>	
>80 %	2/14 (14.3 %)
40–60 %	2/14 (14.3 %)
<40 %	1/14 (7.1 %)
Not sure	9/14 (64.3 %)
<b>3D. What dose of vitamin D does your hospital prescribe in pregnant women WITHOUT vitamin D deficiency?</b>	
400IU	5/14 (40.0 %)
800IU	0/15 (0.0 %)
1,000IU	1/14 (7.1 %)
1,500IU	1/14 (7.1 %)
2,000IU	1/14 (7.1 %)
Not sure	6/14 (42.9 %)
<b>3E. What dose of vitamin D does your hospital prescribe in pregnant women WITH vitamin D deficiency ?</b>	
400IU	0/15 (0.0 %)
800IU	0/15 (0.0 %)
1,000IU	4/15 (25.0 %)
1,500IU	0/15 (0.0 %)
2,000IU	3/15 (20.0 %)
Not Sure	8/15 (53.3 %)

#### 4. Discussion

This survey seeks to evaluate the role of vitamin D screening and supplements in the Asia-Pacific region. We acknowledge that there has been a general lack of studies evaluating vitamin D screening and supplementation in the region. For It is also challenging to compare the prevalence among countries or regions with different diagnostic guidelines.

Our cross-sectional study showed that there is currently no widely accepted role regarding vitamin D screening or supplementation in pregnancy. This observation could be largely due to the fact that there is a general lack of evidence worldwide regarding screening recommendations and recommended dosage for supplementation [26]. This is also evidenced by a recent Cochrane review done in 2019 which showed that while there were poorer outcomes for infants born to women with vitamin D deficiencies, there was no overwhelming evidence as to whether supplementation would enhance outcomes for this group of infants [31]. Furthermore, a systematic review on vitamin D supplementation published in the BMJ in 2017 found that there was a general lack of evidence to guide clinical and policy recommendations [32].

It is of paramount concern that the prevalence of vitamin D deficiency in the Asia-Pacific region such as India and Malaysia [5,42] is higher than in Europe [33] or the United States [4]. The high prevalence of vitamin D inadequacy in the Asia-Pacific region can be attributed to women with darker skin colour in contrast to women of white race with lighter skin colour [7]. In addition, women in the Asia-Pacific like India often wear excessive clothing due to cultural and religious differences with limited sun exposure compared to European women [8].

We acknowledge that there are potential differences in the need for vitamin D screening in the Asia-Pacific region due to environmental factors and government resources. For example, the need for vitamin D screening in Australia is likely lower than in India or Bangladesh due to the geographical position of Australia being closer to the equator and increased sun exposure. As most of the vitamin D we obtain is from sun exposure, several factors such as skin pigmentation and sun protection behaviors have been shown to affect the skin's production of vitamin D. Firstly, individuals with darker skin are shown to obtain less adequate vitamin D levels from sun exposure as compared to lighter skin individuals. Secondly, in heavily polluted Asia-Pacific cities, the prevalence of large amounts of pollutants in the atmosphere effectively reduces sunlight exposure as these pollutants tend to absorb and reduce the amount of light reaching the earth's surface. Thirdly, in certain countries, a large proportion of the female population tend to wear long sleeves, long skirts and veils due to religious purposes, which reduce their exposure to sunlight

Interestingly, we have identified that while most doctors would almost always prescribe folic acid supplements in pregnancy, only a small proportion would actively prescribe vitamin D supplements to their patients. This can perhaps be attributed to a lack of policies surrounding vitamin D supplementation as compared to policies surrounding nutrient supplementation with folic acid and iron supplements in pregnant women. Routine folic acid and iron supplementation are beneficial and adverse effects of folate deficiencies [34,35] and iron deficiency anaemia in pregnancy well studied [36,37].

More importantly, in many Southeast Asian countries with limited government resources and funding, vitamin D screening and

supplementation is costly for the general population. For example, in India, a single vitamin D test cost approximately INR1500 [38] and the price of cholecalciferol (vitamin D3) supplements is INR4.76 per unit [39]. This, when compared to the GDP per capita of INR2277 [40] is too costly for most. Similarly, this issue applies to many less developed countries in the region where majority live below the poverty line and may not be able to afford vitamin D tests or supplements. This could also account for why screening for and supplementing vitamin D is much less common as compared to established supplements like folic acid or iron.

There are many approaches and practices regarding vitamin D screening and supplementation, which includes universal screening for vitamin D deficiency and supplementing high-risk profile individuals with, darker skin tone, reduced sunlight exposure or obese women. Currently, universal screening as a part of routine antenatal care is debatable and controversial with more robust evidence required to evaluate the effects of vitamin D supplementation in pregnancy to the risk of maternal adverse events [31].

Amongst our respondents, the most preferred option for a policy regarding vitamin D was to give supplementation to those proven to have low serum vitamin D and a high-risk profile. This was followed by supplementing pregnant women with low serum vitamin D without assessing risk-profile and thirdly, by supplementing those with high-risk profile. The preference amongst respondents for supplementation based on risk profile was due to the high prevalence of vitamin D deficiency amongst the Asia-Pacific population and that screening and supplementing those with low serum vitamin D levels would be most evidence-based and objective. This is also in line with the existing recommendations by Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) published in 2014, which recommended testing and supplementation to those at high risk of vitamin D deficiency [41]. More research is needed to compare the effect of vitamin D screening and supplementation for Asian ethnic groups. Studying the associations of vitamin D supplementation on maternal and fetal outcomes will provide greater clinical utility and guide decisions on the use of vitamin D guidelines most appropriate for each country.

The strengths of this review include comprehensive information regarding screening and supplementation approaches in pregnancy in countries whose clinical practice was still unknown, and an excellent response rate of 100 %. However, our review is not without limitations. Firstly, with a sample size of only eleven countries, our conclusions may not be truly representative of the wider Asia-Pacific region. Secondly, since only clinicians or researchers participated in the survey, there might be information bias while completing the survey. Thirdly, there is no currently validated survey on vitamin D screening and supplementation which may result in response bias.

In summary, we found that our surveyed hospitals in the Asia-Pacific region differ in policies and practices on vitamin D supplementation and screening in pregnancy. We also found that there were varying clinical knowledge gaps and different perceptions on vitamin D screening and supplementation in pregnancy among healthcare professionals. Further research needs to be undertaken regarding the benefits and risks of universal screening and supplementation of vitamin D in Asia-Pacific region. This study review promotes collaboration among international healthcare professionals and enhances our understanding of global health perspectives on the effects of Vitamin D screening and supplementation in pregnancy for the benefit of pregnant women in the Asia-Pacific.

## Research funding

The study was funded by National Medical Research Council (NMRC)- Integrated Platform for Research in Advancing Metabolic Health Outcomes of Women and Children (IPRAMHO) Centre Grant (NMRC CGAug16C008).

## Informed consent

Informed consent was obtained from all individuals included in this study.

## Ethical approval

The study is approved by SingHealth Ethical Board CIRB Ref 2022/2004.

## Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

## 2. Policy

- A. Is there a national policy and/or regional guideline which your hospital refers to for women with vitamin D deficiency?
  - Yes, what is the national policy/guideline?
  - No
  - Not sure
- B. Does your Centre have a written protocol on the management of Vitamin D deficiency in pregnant women?
  - Yes
  - No
  - Not sure
- C. What percentage of pregnant women does your Centre see have vitamin D deficiency?

- Approximately \_\_\_\_\_ %
- Not sure

### 3. Nutrient supplements in pregnancy

A. How often does your Centre prescribe folic acid during pregnancy?

- Always
- Often
- Occasionally
- Rarely
- None

B. How often does your Centre prescribe multi-vitamins during pregnancy?

- Always
- Often
- Occasionally
- Rarely
- None

C. How often does your Centre prescribe iron tablets during pregnancy?

- Always
- Often
- Occasionally
- Rarely
- None

D. How often does your Centre prescribe omega 3 fatty acids/Docosahexaenoic acid during pregnancy?

- Always
- Often
- Occasionally
- Rarely
- None

E. How often do your Centre prescribe Vitamin D during pregnancy?

- Always
- Often
- Occasionally
- Rarely
- None

F. What dose of Vitamin D does your centre prescribe in pregnant women WITHOUT vitamin D deficiency ?

- 400IU
- 800IU
- 1000IU
- 1500IU
- 2000IU
- Unsure

G. What dose of Vitamin D does your centre prescribe in pregnant women WITH vitamin D deficiency ?

- 400IU
- 800IU
- 1000IU
- 1500IU
- 2000IU
- Unsure

H. Does your centre routinely prescribe calcium supplements during pregnancy?

- Always
- Often
- Occasionally
- Rarely
- None

I. What dose of calcium does your centre usually prescribe?

- 400IU
- 800IU
- 1000IU
- 1500IU
- 2000IU

## 4. Practice

### 4.1. Screening for vitamin D deficiency

- A. Does your Centre screen for vitamin D deficiency in pregnancy?
- Yes
  - No
  - Sometimes
  - Not sure
- B. What is your Centre policy on screening for vitamin D deficiency in pregnancy? (More than one answer can be chosen, if applicable.)
- My Centre does not screen for vitamin D deficiency
  - Leave it for the physicians to decide
  - Assessment of patient risk profile
  - Measurement of serum vitamin D levels based on risk profile
  - Measurement of serum vitamin D levels routinely for all patients
  - Others, please specify:
- C. Does your Centre screen for vitamin D deficiency in specific group of patients based on risk profile?
- Yes
  - No
  - Sometimes
  - Not sure
- D. What risk factors does your centre use when doing an assessment of risk profile ? (More than one answer can be chosen, if applicable.)
- Age
  - Body mass index (BMI)
  - History of Vitamin D deficiency
  - Physical activity
  - Race and ethnicity
  - Exposure to sunlight
  - Others: \_\_\_\_\_
  - NA

### 4.2. Treatment

- A. What treatments are available at your centre for women diagnosed with Vitamin D deficiency during pregnancy? (More than one answer can be chosen, if applicable.)
- Referral to Endocrine for follow up
  - Referral to see a Dietician
  - Prescribe Vitamin D in pregnancy
  - None of the above
  - Others please indicate:
- B. How does your centre follow up on vitamin D levels in pregnant women with Vitamin D deficiency?
- No need to repeat routinely
  - Repeat only if symptomatic (lethargy, muscle aches, depression)
  - Repeat every trimester
  - Not sure

### 4.3. Perceptions/opinions

- A. What do you think is the prevalence of Vitamin D deficiency in pregnant women in your country?
- < 19 %
  - 20–39 %
  - 40–59 %
  - 60–79 %
  - > 80 %
  - Unsure
- B. What do you think is the cut-off value to determine Vitamin D deficiency (nmol/L) in pregnant women?
- 10
  - 20
  - 30
  - 40

- 50
  - Unsure
- C. Do you think that there is a need for a guideline and/or consensus on vitamin D screening in pregnancy?
- Yes
  - No
  - Not sure
- D. Do you think that there is a need for a guideline and/or consensus on vitamin D supplementation in pregnancy?
- Yes
  - No
  - Not sure
- E. Do you think that there is a need for a guideline and/or consensus on vitamin D treatment in pregnancy?
- Yes
  - No
  - Not sure
- F. What is your opinion on Vitamin D screening and supplementation in pregnancy? Please rank the options in order of preference from 1 to 5 (1 being most preferred to 5 least preferred)
- Routinely give Vitamin D to all pregnant women without screening
  - Give Vitamin D based on high risk profile screening only
  - Give Women screened with low serum low serum Vitamin D levels without assessing risk profile
  - Give women screened with low serum Vitamin D levels and high risk profile
  - Not to screen and supplement Vitamin D at all

### CRedit authorship contribution statement

**Ryan Wai Kheong Lee:** Methodology, Conceptualization, Data curation, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Alicia Li Bin Chng:** Methodology, Writing – original draft, Writing – review & editing. **Kok Hian Tan:** Conceptualization, Investigation, Methodology, Formal analysis, Funding acquisition, Project administration, Resources, Supervision, Writing - original draft, Writing - review & editing. **Alexis Shub:** Conceptualization, Data curation, Formal analysis, Methodology, Writing - review & editing.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Appendix A

#### 1. Demographics.

- A. Country
- B. Hospital
- C. Designation
- D. Centre
- University Hospital
  - Non-university/Government Related Training Hospital
  - Community-based Hospital
  - Private Hospital
  - Others
- E. Average number of obstetricians working in the healthcare facilities
- F. Average number of deliveries per year in the healthcare facilities

### References

- [1] C Palacios, L Gonzalez, Is vitamin D deficiency a major global public health problem? *J Steroid Biochem Mol Biol* 144 (Pt A) (Oct 2014) 138–145, <https://doi.org/10.1016/j.jsbmb.2013.11.003>. Epub 2013 Nov 12.
- [2] J. Lepsch, I. Eshriqui, Farias DR Association between early pregnancy vitamin D status and changes in serum lipid profiles throughout pregnancy, *Metabolism* 70 (2017) 85–97.
- [3] M.F. Holick, N.C. Binkley, H.A. Bischoff-Ferrari, C.M. Gordon, D.A. Hanley, R.P. Heaney, M.H. Murad, C.M. Weaver, Evaluation, treatment, and prevention of vitamin D deficiency: an endocrine society clinical practice guideline, *J. Clin. Endocrinol. Metab.* 96 (2011) 1911–1930.



- [4] R. Saraf, S.M. Morton, C.A. Camargo Jr., C.C. Grant, Global summary of maternal and newborn vitamin D status - a systematic review, *Matern. Child Nutr.* 12 (4) (2016 Oct) 647–668.
- [5] S. Sharma, A. Kumar, S. Prasad, S. Sharma, Current scenario of vitamin D status during pregnancy in North Indian population, *J. Obstet. Gynaecol. India* 66 (2) (2016), 93–100.
- [6] T. Karlsson, L. Andersson, A. Hussain, M. Bosaeus, N. Jansson, A. Osmancevic, L. Hulthén, A. Holmäng, I. Larsson, Lower vitamin D status in obese compared with normal-weight women despite higher vitamin D intake in early pregnancy, *Clin. Nutr.* 34 (5) (2015 Oct) 892–898.
- [7] S. Karras, S.A. Paschou, E. Kandaraki, P. Anagnostis, C. Annweiler, B.C. Tarlatzis, B.W. Hollis, W.B. Grant, D.G. Goulis, Hypovitaminosis D in pregnancy in the Mediterranean region: a systematic review, *Eur. J. Clin. Nutr.* 70 (9) (2016 Sep) 979–986.
- [8] American College of Obstetrics and Gynecology. ACOG committee: opinion number 495: vitamin D: screening and supplementation during pregnancy, *Obstet. Gynecol.* 118 (1) (2011) 197–198, <https://doi.org/10.1097/AOG.0b013e318227f06b>.
- [9] S.L. Loy, N. Lek, F. Yap, S.E. Soh, N. Padmapriya, K.H. Tan, A. Biswas, G.S. Yeo, K. Kwek, P.D. Gluckman, K.M. Godfrey, S.M. Saw, F. Müller-Riemenschneider, Y. S. Chong, M.F. Chong, J.K. Chan, Growing up in Singapore towards healthy outcomes (GUSTO) study group. Association of maternal vitamin D status with glucose tolerance and caesarean section in a multi-ethnic asian cohort: the growing up in Singapore towards healthy outcomes study, *PLoS One* 10 (11) (2015 Nov 16), e0142239, <https://doi.org/10.1371/journal.pone.0142239>.
- [10] S. Pilz, A. Zittermann, R. Obeid, A. Hahn, P. Pludowski, C. Trummer, E. Lerchbaum, F.R. Pérez-López, S.N. Karras, W. März, The role of vitamin D in fertility and during pregnancy and lactation: a review of clinical data, *Int. J. Environ. Res. Publ. Health* 15 (10) (2018 Oct 12) 2241, <https://doi.org/10.3390/ijerph15102241>.
- [11] M. Karamali, E. Beihaghi, A.A. Mohammadi, Z. Asemi, Effects of high-dose vitamin D supplementation on metabolic status and pregnancy outcomes in pregnant women at risk for pre-eclampsia, *Horm. Metab. Res.* 47 (12) (2015), 867–82.
- [12] M. Mojibian, S. Soheilykhah, M.A. Fallah Zadeh, M. Jannati Moghadam, The effects of vitamin D supplementation on maternal and neonatal outcome: a randomized clinical trial, *Iran. J. Reproductive Med.* 13 (11) (2015), 687–96.
- [13] S. Hashemipour, A. Ziaee, A. Javadi, F. Movahed, K. Elmizadeh, E.H. Javadi, et al., Effect of treatment of vitamin D deficiency and insufficiency during pregnancy on fetal growth indices and maternal weight gain: a randomized clinical trial, *Eur. J. Obstet. Gynecol. Reprod. Biol.* 172 (2014), 15–9.
- [14] C. Yap, N.W. Cheung, J.E. Gunton, N. Athayde, C.F. Munns, A. Duke, et al., Vitamin D supplementation and the effects on glucose metabolism during pregnancy: a randomized controlled trial, *Diabetes Care* 37 (7) (2014), 1837–44.
- [15] N. Khalessi, M. Kalani, M. Araghi, Z. Farahani, The relationship between maternal vitamin D deficiency and low birth weight neonates, *J. Fam. Reprod. Health* 9 (3) (2015 Sep) 113–117.
- [16] N.C. Harvey, C. Holroyd, G. Ntani, K. Javadi, P. Cooper, R. Moon, et al., Vitamin D supplementation in pregnancy: a systematic review, *Health Technol. Assess.* 18 (45) (2014) 1–190.
- [17] J. Woo, C. Giurgescu, C.L. Wagner, Evidence of an association between vitamin D deficiency and preterm birth and preeclampsia: a critical review, *J. Midwifery Wom. Health* 64 (5) (2019 Sep) 613–629.
- [18] H.T. Christesen, T. Falkenberg, R.F. Lamont, J.S. Jorgensen, The impact of vitamin D on pregnancy: a systematic review, *Acta Obstet. Gynecol. Scand.* 91 (2012) 1357–1367.
- [19] J.L. Mansur, B. Oliveri, E. Giacoia, D. Fusaro, P.R. Costanzo, Vitamin D: before, during and after pregnancy: effect on neonates and children, *Nutrients* 14 (2022) 1900.
- [20] M. Zerofsky, M. Ryder, S. Bhatia, C.B. Stephensen, J. King, E.B. Fung, Effects of early vitamin D deficiency rickets on bone and dental health, growth and immunity, *Matern. Child Nutr.* 12 (2016) 898–907.
- [21] N. Brustad, B.L. Chawes, J. Thorsen, M. Krakauer, J. Lasky-Su, S.T. Weiss, J. Stokholm, K. Bønnelykke, H. Bisgaard, High-dose vitamin D supplementation in pregnancy and 25(OH)D sufficiency in childhood reduce the risk of fractures and improve bone mineralization in childhood: follow-up of a randomized clinical trial, *EClinicalMedicine* 43 (2021 Dec 24), 101254.
- [22] C.L. Wagner, C. Baggerly, S. McDonnell, K.A. Baggerly, C.B. French, L. Baggerly, S.A. Hamilton, B.W. Hollis, Post-hoc analysis of vitamin D status and reduced risk of preterm birth in two vitamin D pregnancy cohorts compared with South Carolina March of Dimes 2009–2011 rates, *J. Steroid Biochem. Mol. Biol.* 155 (Pt B) (2016 Jan) 245–251.
- [23] F. Huang, Z. Wang, J. Zhang, W. Du, C. Su, H. Jiang, X. Jia, Y. Ouyang, Y. Wang, L. Li, B. Zhang, H. Wang, Dietary calcium intake and food sources among Chinese adults in CNTCS, *PLoS One* 13 (10) (2018 Oct 1), e0205045.
- [24] Y. Liu, C. Ding, R. Xu, K. Wang, D. Zhang, W. Pang, W. Tu, Y. Chen, Effects of vitamin D supplementation during pregnancy on offspring health at birth: a meta-analysis of randomized controlled trials, *Clin. Nutr.* 41 (7) (2022 Jul) 1532–1540.
- [25] W.G. Bi, A.M. Nuyt, H. Weiler, L. Leduc, C. Santamaria, S.Q. Wei, Association between vitamin D supplementation during pregnancy and offspring growth, morbidity, and mortality: a systematic review and meta-analysis, *JAMA Pediatr.* 172 (7) (2018 Jul 1) 635–645.
- [26] Royal College of obstetricians and Gynaecologists. Vitamin D in pregnancy. Scientific impact paper number 43. [https://www.maternofetal.net/wpcontent/uploads/2020/08/vitamin\\_d\\_sip43\\_june14.pdf](https://www.maternofetal.net/wpcontent/uploads/2020/08/vitamin_d_sip43_june14.pdf), June 2014. (Accessed 25 May 2023).
- [27] World Health Organization, WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience, World Health Organization, Geneva, 2016.
- [28] D.E. Roth, S.A. Abrams, J. Aloia, G. Bergeron, M.W. Bourassa, K.H. Brown, et al., Global prevalence and disease burden of vitamin D deficiency: a roadmap for action in low- and middle-income countries, *Ann. N. Y. Acad. Sci.* 1430 (1) (2018), 44–79.
- [29] L.M. De-Regil, C. Palacios, L.K. Lombardo, J.P. Peña-Rosas, Vitamin D supplementation for women during pregnancy, *Cochrane Database Syst Rev* 14 (1) (2016), CD008873, <https://doi.org/10.1002/14651858.CD008873.pub3>. Update in: *Cochrane Database Syst Rev.* 2019 Jul 26;7:CD008873.
- [30] The world bank. <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>. (Accessed 25 May 2023).
- [31] C. Palacios, L.K. Kostiuik, J.P. Peña-Rosas, Vitamin D supplementation for women during pregnancy, *Cochrane Database Syst. Rev.* 7 (7) (2019 Jul 26) CD008873.
- [32] D.E. Roth, M. Leung, E. Mesfin, H. Qamar, J. Watterworth, E. Papp, Vitamin D supplementation during pregnancy: state of the evidence from a systematic review of randomised trials, *BMJ* 359 (2017 Nov 29) j5237.
- [33] A. Rodriguez, L. Santa Marina, A.M. Jimenez, A. Esplugues, F. Ballester, M. Espada, et al., Vitamin D status in pregnancy and determinants in a Southern European cohort study, *Paediatr. Perinat. Epidemiol.* 30 (3) (2016) 207–228.
- [34] Folate deficiency in pregnancy, *Nutr. Rev.* 25 (6) (1967 Jun) 166–168.
- [35] A.M. Molloy, P.N. Kirke, L.C. Brody, J.M. Scott, J.L. Mills, Effects of folate and vitamin B12 deficiencies during pregnancy on fetal, infant, and child development, *Food Nutr. Bull.* 29 (2 Suppl) (2008 Jun) S101–S111. ; discussion S112–5.
- [36] M.K. Georgieff, N.F. Krebs, S.E. Cusick, The benefits and risks of iron supplementation in pregnancy and childhood, *Annu. Rev. Nutr.* 39 (2019 Aug 21) 121–146.
- [37] A.E. Benson, J.J. Shatzel, K.S. Ryan, M.A. Hedges, K. Martens, J.E. Aslan, J.O. Lo, The incidence, complications, and treatment of iron deficiency in pregnancy, *Eur. J. Haematol.* 109 (6) (2022 Dec) 633–642.
- [38] G. R, A. Gupta, Vitamin D deficiency in India: prevalence, causalities and interventions, *Nutrients* 6 (2) (2014 Feb 21) 729–775, <https://doi.org/10.3390/nu6020729>.
- [39] P.K. Chugh, A. Dabas, Price dispersion of vitamin D supplements over time: an initiative for prescriber education, *Indian J Endocrinol Metab* 25 (2) (2021 Mar-Apr) 142–147, [https://doi.org/10.4103/ijem.ijem\\_159\\_21](https://doi.org/10.4103/ijem.ijem_159_21).

- [40] GDP per capita (current US\$) - India. Data. (n.d.). <https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=IN>.
- [41] Royal Australian and New Zealand College of obstetricians and Gynaecologists. Vitamin and mineral supplementation and pregnancy. <https://www.hps.com.au/wp-content/uploads/2019/04/Vitamin-and-mineral-supplementation-in-pregnancy-C-Obs-25-Review-Nov-2014-Amended-May-2015.pdf>, 2014. (Accessed 25 May 2023).
- [42] F.C. Woon, Y.S. Chin, I.H. Ismail, M. Batterham, A.H. Abdul Latiff, W.Y. Gan, et al., Vitamin D deficiency during pregnancy and its associated factors among third trimester Malaysian pregnant women, PLoS One 14 (2019), e0216439, <https://doi.org/10.1371/journal.pone.0216439>.