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Characteristic Analysis of Serum Vitamin D Levels with Hba1c in Type 2-Diabetes Mellitus Patients

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Abstract

Diabetes is one of the fastest growing global health emergencies of the 21st century with an estimated 537 million (10.3%) people suffering from diabetes, and this figure is expected to reach 643 million (11.3%) by 2030, and 783 million (12.2%) by 2045. Vitamin D plays a role in insulin secretion by stimulating beta cell secretion or facilitating the conversion of pro-insulin to insulin. Therefore, vitamin D deficiency may be involved in the pathogenesis of type 2 DM. This study aims to analyze the characteristics, serum vitamin D levels and HbA1c levels in type 2 DM patients in primary care. The research was conducted in September 2022 with research subjects being type 2 DM patients who came to the Plaju Palembang Community Health Center. The results of the study showed that there was a significant relationship between age and HbA1c levels in type 2 DM patients (p=0.020) and there was no relationship between gender, occupation, education, BMI, abdominal circumference, family history, duration of suffering from DM, and vitamin D levels with HbA1c levels in type 2 DM patients (p>0.05)

Keywords: Diabetes Mellitus, Serum Vitamin D, HbA1c Levels

1. Introduction

Diabetes mellitus (DM) describes a metabolic disorder with various etiologies characterized by chronic hyperglycemia with impaired metabolism of carbohydrates, proteins and fats. Recent studies state that in type 2 DM, vitamin D deficiency is found which is caused by low vitamin D diets and reduced vitamin D production. The prevalence of vitamin D deficiency in type 2 DM patients reaches 63.5% -91.1%.[1]

Vitamin D is needed to improve insulin production and sensitivity, facilitate Beta cell biosynthesis and accelerate proinsulin to insulin. Vitamin D modulates monocyte and macrophage activity by binding to Vitamin D Responses or VDRs, which are responsible for insulin, insulin action, and/or both.[2]

Pittas et al. in his study on the role of vitamin D in type 2 DM showed that insulin sensitivity increased by 60% when 25-Hydroxyvitamin-D3 levels increased from 25 to 75 nmol/L. Vitamin D aids in insulin secretion by stimulating beta cell secretion or possibly facilitating the conversion of pro-insulin to insulin. Vitamin D increases the sensitivity and promotes the survival of beta cells by modulating the effects of cytokines. Therefore, vitamin D deficiency may be involved in the pathogenesis of type 2 DM.[3]

Recently vitamin D3 has been considered important in the pathogenesis of diabetes. One of the most important characteristics of type 2 DM is the occurrence of low-grade inflammation as a result of increased circulating cytokines TNF-alpha and IL-6, which contribute to the development of insulin resistance. Vitamin D3 being a strong immunosuppressant, tends to downregulate the transcription of various pro-inflammatory

cytokine genes, such as interleukin-2, interleukin-12 and Tumor necrosis factor-alpha in patients with type 2 DM. Administration of Vitamin D 60,000 IU every week for 8 weeks can improve vascularization, reducing oxidative stress in type 2 DM patients with vitamin D deficiency.[4]

Research on the relationship between vitamin D levels in controlled and uncontrolled type 2 DM patients is still limited, especially in Indonesia and because of differences in previous research, this research was carried out. This study aims to analyze the characteristics, status of HbA1c levels, status of vitamin D levels in type 2 DM patients in primary care at the Plaju Palembang Community Health Center.

2.   Method

Cross-sectional research design. The research sample was type 2 diabetes mellitus patients who came for examination and treatment at the Plaju Palembang Community Health Center during the research period. The data for this research were obtained from filling out questionnaires, interviews with patients, and taking blood samples for examination at the ISO 9001;15189:2009 certified Pramita Clinic laboratory.

The dependent variable in this study was the HbA1c level of type 2 Diabetes Mellitus patients and the independent variables in this study consisted of age, gender, body mass index, education, type of work, length of time suffering from DM, family history, and serum vitamin D levels. The collected data were processed using SPSS and analyzed using the *chi-square test* and an alternative test, namely *the Fisher's Exact Test.*

3.   Results

In this study, 42 research subjects were obtained with the following characteristics. Based on the data displayed in table 1 above, it was found that of the total 42 who suffered from type 2 diabetes mellitus, the majority were women, 24 (57.1%) respondents with a ratio of women to men of 4:3.

Table 1. Characteristics of Research Subjects

Characteristics	Number (n)	Percentage (%)
Gender		
Woman	24	57.1
Man	18	42.9
Age		
Mature	21	50.0
Elderly	21	50.0
Education		
Low education	14	33.3
Middle education	15	35.7
higher education	13	31.0
Work		
Formal Sector	10	23.8
Informal Sector	9	21.4
Doesn't work	23	54.8
Suffering from DM for a long time		
<5 years	18	42.9
5-10 years	21	50.0
>10 years	3	7.1
Abdominal Circumference		
Normal	4	9.5
Obesity	38	90.5
Body mass index		
18.5-22.9 (Normal)	11	26.2
23-24.9 (Overweight)	12	28.6
≥25 (Obesity)	19	45.2
Laboratory Examination Results		
HbA1c levels		
<6.5%	9	21.4
≥6.5%	33	78.6
Vitamin D serum		
Deficiency	4	9.5
Insufficiency	11	26.2
Sufficiency	27	64.3

The adult age group (18-59 years) has an equivalent number to the elderly age group (>60 years), namely 21 respondents (50.0%),

the highest level of education is secondary education, 15 respondents (35.7%). Based on occupation, most of them did not work as many as 23 respondents (54.8%).

Based on the length of time respondents suffered from Type 2 DM, the maximum was 5–10 years with 21 respondents (50.0%), Based on family history of DM, 23 respondents (54.8%) had a family history of DM. Based on body mass index (BMI), the majority were obese with 15 respondents (35.7%). Meanwhile, based on waist circumference, there were 38 (90.5%) obese.

The table also shows laboratory data, namely HbA1c levels in the blood, 33 respondents (78.6%) had HbA1c levels ≥6.5%. Meanwhile, based on serum vitamin D levels in the blood, 4 respondents (9.5%) had vitamin D deficiency, 11 respondents (26.2%) had vitamin D insufficiency, and 27 respondents (64.3%) had vitamin D deficiency.

Chi-Square test and *Fisher's Exact Test* in table 2 below show that there is a significant relationship between age and HbA1c levels in type 2 DM patients (p=0.020) and there is no significant relationship between gender, occupation, education, BMI, abdominal circumference, family history of DM, duration of suffering from DM, and vitamin D levels with HbA1c levels in type 2 DM patients (p>0.05)

4. Discussion

4.1. Relationship between Age and HbA1c

The results of this study showed that there was a significant relationship between age and HbA1c levels in type 2 DM patients (p = 0.020). In addition, it was found that the frequency of uncontrolled DM patients was greater at ages < 60 years. These results are not in line with research by Arosemena *et al* (2015)[5], Ko *et al* (2013)[6], and Fiagbe *et al*

(2017)[7] who found that age over 50 years is a risk factor for uncontrolled blood sugar.

However, these results are in line with research by Siddiqui *et al* (2015)[8] and Yeemard *et al* (2022)[9] which found that patients younger than 50 years were more susceptible to experiencing uncontrolled diabetes mellitus. This is due to the difficulty of carrying out routine control and carrying out self-care considering the larger responsibilities towards work and family. They may also be more affected by rapid lifestyle changes reflected in obesity patterns, dietary indicators, and activity.[7]

4.2. Relationship between Gender and HbA1c Levels

The results of this study show that there is no significant relationship between type sex with HbA1c levels (p=0.139) in patients DM type 2. This is in line with research by Arosemena *et al* (2015)[5], Siddiqui *et al* (2015)[8], Fiagbe *et al* (2017)[7] that patient with sugar blood controlled No different in a way significant from patient with uncontrolled blood sugar when related to type sex. On the contrary, study This compare backwards with results Which obtained by Yeemard *et al* (2022).[9]

In this study it was found that women had more HbA1c less controlled than men. This is in line with study by Dalvi *et al* (2010)[10] and Siddiqui *et al* (2014)[8] that women are identified as a higher risk factor for experiencing uncontrolled blood glucose compared to men due to physical factor. Premenstrual syndrome and post-menopause make distribution fat body easily accumulated due to hormonal process, putting women at risk of experiencing T2DM.[6]

Table 3. Analysis of Characteristics with HbA1c Levels

Variable	HbA1c levels		*p-value* *	OR (95% CI)
	<6.5%	≥6.5%		
Age				
18-59 years (Adult)	1	20	0.020	0.081
≥60 years (Senior)	8	13		(0.009-0.728)
Gender				
Woman	3	21	0.139	0.286
Man	6	12		(0.060-1.355)
Work				
Formal Sector	3	7		2,036 (0.361-11,479)
Informal Sector	2	5	0.718	1.357(0.202-9.126)
Doesn't work	4	19		Comparison
Education				
Low education	4	10		Comparison
Middle education	3	12	0.696	1,600 (0.288-8.901)
higher education	2	11		2,200 (0.329-14.726)
BMI				
18.5-22.9 (Normal)	2	9		Comparison
23-24.9 (Overweight)	3	9	0.922	0.667 (0.890-4.994)
≥25 (Obesity)	4	15		0.833 (0.126-5.504)
Abdominal Circumference				
Normal	1	3	1,000	1,250
Obesity	8	30		(0.114-13.694)
Long time DM				
<5 years	4	14		0.914 (0.204-4.088)
5-10 years	5	16	0.639	Comparison
>10 years	0	3		-
DM history				
There is	3	20	0.257	0.325 (0.069-1.534)
There isn't any	6	13		
Serum Vitamin D Levels				
Deficiency	2	2	0.072	2,857 (0.336-24,299)
Insufficiency	0	11		-
Sufficiency	7	20		Comparison

4.3. Relationship between work and HbA1c levels

The results of this study show that there is no significant relationship between work and HbA1c levels (*p*= 0.718) in type 2 DM patients. Although the results of the analysis do not show a significant relationship between work and blood sugar levels in type 2 DM patients, the research results are descriptive. This is in line with research by

Syatriani (2019)[11] and Kalumbang et al (2018)[12] which shows that the incidence of DM and uncontrolled blood sugar levels is more common in patients who do not work than in patients who work.

The results of this study show that more DM patients with uncontrolled blood sugar levels are not working. This is because people who do not work are more susceptible to stress than those who work. Not having a job will make Type 2 DM sufferers think about the costs for their lives and their families, including the costs of their care and treatment. Having a lot of mental stress will make type 2 DM sufferers easily experience stress. According to Morewitz (2016), if type 2 DM patients do not work, they are at risk of experiencing psychological problems (such as anxiety and stress) and financial problems. Having no source of income can make someone feel worried about not being able to meet their needs and the needs of their family, which will ultimately cause them to become stressed.[11]

4.4. Relationship between Education and HbA1c Levels

The results of this study show that there is no significant relationship between education and HbA1c levels ($p= 0.696$) in type 2 DM patients. However, the results of this study are in line with research by Pahlawati *et al* (2016)[13] which shows that blood sugar levels are not control is more common in higher education. However, these results are not in line with research by Kassahun *et al* (2019)[14] which shows that the incidence of DM occurs more frequently in patients with low education than with high education. Both studies found that blood sugar levels were significantly ($p<0.05$) related to education level.

The level of education has an influence on blood sugar levels because people with a high level of education usually have a lot of knowledge about health. With this knowledge, people will have awareness of maintaining their health. So the person will maintain a diet to maintain their blood sugar levels.[15]

4.5. Relationship between BMI and HbA1c levels

The results of this study show that there is no significant relationship between BMI and HbA1c levels ($p=0.696$) in type 2 DM patients. These results are in line with research by Arosemena et al (2015)[5], Ko et al (2013)[6], and Siddiqui et al (2014)[8] who did not find a significant relationship between BMI and uncontrolled diabetes mellitus. In contrast, the research results of Ma et al (2019)[16] and Ji et al (2015)[17] found that the average HbA1c was significantly ($p<0.001$) worse in individuals with obesity and *overweight* when compared to individuals with normal body weight.

Patient with obesity own possibility fail in control sugar blood Because reluctance or inability patient in change style life healthy and improve insulin resistance and blood glucose concentration thereby making treatment pharmacological more difficult.[18] On study This, results Which obtained No in accordance with theory It may also be caused by other individual factors such as diet and medication compliance.

4.6. Relationship between Abdominal Circumference and HbA1c Levels

The results of this study show that there is no significant relationship between abdominal circumference and HbA1c levels ($p=1,000$) in type 2 DM patients. Although the results of the analysis do not show a significant relationship, descriptively these results are in line with research by Feller et al (2016)[19] and Wei et al (2019)[20] which showed that the incidence of DM was more common in patients with central obesity. Both studies found that blood sugar levels were significantly ($p<0.05$) worse in individuals with

central obesity when compared to individuals with normal abdominal circumference.

Abdominal circumference can be used to see fat distribution to determine abdominal obesity. Increasing abdominal circumference can have an impact on increasing blood sugar because glucogenesis occurs which can inhibit insulin action. Abdominal fat has metabolic products in the form of fatty acids which are released into the hepatic portal vein. Excessive free fatty acids circulating to the liver will cause oxidation and produce Acetyl CoA. This acetyl CoA will activate the pyruvate carboxylase enzyme in the liver, which converts pyruvic acid into glucose in the liver, this process is called gluconeogenesis. In addition, increasing levels of free fatty acids circulating in the liver can reduce the sensitivity of muscle cells to insulin, thereby causing insulin resistance. Therefore, muscle cells require more insulin to uptake blood glucose into the muscles.[21.22]

4.7. Long Relationship Suffering from DM with HbA1c Levels

The results of this study show that there is no significant relationship between the duration of suffering from DM and HbA1c levels (p=0.656) in type 2 DM patients. These results are in line with research by Arosemena et al (2015). In this study, it was found that many patients with uncontrolled T2DM were in the group of patients who had been diagnosed with T2DM for less than 5 years. This suggests that there is a great opportunity for lifestyle interventions and counseling early in the disease process that can change the course of an individual's disease.[5] Apart from that, these results are also in line with research by Siddiqui et al (2014) [8] which did not find a significant relationship between the duration of suffering from DM and uncontrolled diabetes mellitus.

However, these results are not in line with studies by Yeemard et al (2022)[9], Haghighatpanah et al (2018)[23], and Radwan et

al (2018)[24], which showed that longer duration of diabetes is a risk factor for poor glycemic control. bad and ongoing. The most likely cause of this is because the amount of carbohydrates attached to HbA1c increases with increasing duration of DM, and also DM is known as a progressive disease, so insulin resistance increases over time due to progressive impairment of insulin secretion from beta cells.[24]

4.8. Relationship between Family History of DM and HbA1c Levels

The results of this study showed that there was no significant relationship between family history of DM and HbA1c levels (p=0.639). These results are in line with research by Haghighatpanah et al (2018)[23], Fiagbe et al (2017)[7], and Almutairi et al (2013)[25], where no significant relationship was found between family history and blood sugar levels. However, in this study, it was observed that patients with a family history of diabetes were more likely to have poor glycemic control.

Patients with a family history of diabetes have a higher prevalence of diabetes compared to patients without diabetes relatives. However, no differences in the level of glycemic control and prevalence of other chronic complications were observed between patients with or without a family history of DM.[26]

4.9. Relationship between Serum Vitamin D Levels and HbA1c Levels

The results of this study show that there is no significant relationship between serum vitamin D levels and HbA1c levels (p=0.257) in type 2 DM patients. These results are in line with research by Ghavam et al (2018)[27], and Jorde and Figenschau (2009)[28], where there was no significant relationship between HbA1c levels and serum vitamin D levels in T2DM patients.

On the other hand, these results are not in line with research by Sudhir et al (2020)[3], where it was found that there was a significant relationship between HbA1c levels and serum vitamin D levels in T2DM patients. There is an inverse relationship between Vitamin D and HbA1C in patients with type 2 Diabetes Mellitus, which means that in cases of low Vitamin D, high HbA1c levels are obtained. Vitamin D deficiency often occurs in Type 2 Diabetes mellitus so that vitamin D supplementation can improve glycemic control in Type 2 Diabetes mellitus patients.[3]

Research by Alkhatatbeh et al (2020)[29] also reported that serum 25-hydroxyvitamin D levels in patients with good glycemic control were significantly higher than in patients with uncontrolled DM. The role of vitamin D in T2DM found that insulin sensitivity increased by 60% when 25-Hydroxy vitamin-D3 levels increased from 25 to 75 nmol/L.[30]

5.   Conclusion

The characteristics of DM patients that have a significant relationship are age with HbA1c levels p=0.020. OR 0.081CI (0.009-0.728) and there is no relationship between gender, occupation, education, BMI, abdominal circumference, family history, duration of suffering from DM, and serum vitamin D levels with HbA1c levels in type 2 DM patients (p>0.05)

Health services need to carry out education on patients at risk of type 2 DM, check fasting blood sugar levels routinely for type 2 DM patients so that the number of incidents and complications can be prevented.

References

1.   Ac A, Ob O, Si O, Ia O, Hab C, Oa F, et al. Serum Vitamin D Levels in Persons with Type 2 Diabetes Mellitus in Lagos, Nigeria. Int J Diabetes Clin Res. 2020;2020:133.

2.   Yaribeygi H, Maleki M, Sathyapalan T, Iranpanah H, Orafai HM, Jamialahmadi T, et al. The molecular mechanisms by which vitamin D improves glucose homeostasis: A mechanistic review. Life Sci. 2020 Mar;244.

3.   Jha SC, Kumar H, Faisal SY. Correlation between Vitamin D and HbA1c in Type 2 Diabetic Patients. Acad J Med. 2020 May;3(1):4–10.

4.   Anandabaskar N, Selvarajan S, Dkhar SA, Kamalanathan SK, Tamilarasu K, Bobby Z. Effect of Vitamin D Supplementation on Vascular Functions and Oxidative Stress in Type 2 Diabetic Patients with Vitamin D Deficiency. Indian J Endocrinol Metab. 2017 Jul;21(4):555.

5.   Coronel A. Prevalence and Risk Factors of Poorly Controlled Diabetes Mellitus in a Clinical Setting in Guayaquil, Ecuador: A Cross-Sectional Study. Int J Diabetes Clin Res [Internet]. 2015 Aug 31.

6.   Ko J, Delafield R, Davis J, Mau MK. Characteristics of Patients with Type 2 Diabetes Mellitus in Two Rural, Medically Underserved Communities. 2013;72(6).

7.   Fiagbe J, Bosoka S, Opong J, Takramah W, Wk A, Owusu R, et al. Prevalence of controlled and uncontrolled diabetes mellitus and associated factors of controlled diabetes among diabetic adults in the hohoe municipality of Ghana. 2017;7(5):343–54.

8.   Siddiqui FJ, Avan BI, Mahmud S, Nanan DJ, Jabbar A, Assam PN. Uncontrolled diabetes mellitus: Prevalence and risk factors among people with type 2 diabetes mellitus in an Urban District of Karachi, Pakistan. Diabetes Res Clin Pract [Internet]. 2015 Jan 1 [cited 2022 Oct 6];107(1):148–56.

9.   Yeemard F, Srichan P, Apidechkul T, Luerueang N, Tamornpark R, Utsaha S. Prevalence and predictors of suboptimal

glycemic control among patients with type 2 diabetes mellitus in northern Thailand: A hospital-based cross-sectional control study. PLoS One [Internet]. 2022 Jan 1 [cited 2022 Oct 6];17(1).

10. Dalvi S, Khanolkar M, Biswas M. Weight reduction and improved glycemic control following estrogen replacement: individualizing diabetes care in women. Pract Diabetes Int [Internet]. 2010 Jun 1 [cited 2022 Oct 6];27(5):185–6.

11. Sri Syatriani. The Relationship of Work and Family Support With Stress in Type 2 Dm Patients in the Coastal Region of Makassar City. 2019 [cited 2022 Oct 6].

12. Kalumbang A. The Relationship of Job Type and Amount of Income With the Quality of Life of Type 2 Diabetes Mellitus Patients At Danurejan in Yogyakarta Health Center, 2017. 2018 Oct 23.

13. Pahlawati A, Nugroho PS. The Relationship between Education Level and Age with the Incidence of Diabetes Mellitus in the Working Area of the Palaran Community Health Center, Samarinda City in 2019. Borneo Student Res [Internet]. 2019 Dec 23 [cited 2022 Oct 6];1(1):1–5.

14. Kassahun T, Gesesew H, Mwanri L, Eshetie T. Diabetes related knowledge, self-care behaviors and adherence to medications among diabetic patients in Southwest Ethiopia: A cross-sectional survey. BMC Endocr Disord [Internet]. 2016 May 31 [cited 2022 Oct 6];16(1):1–11.

15. Berridge MJ. Vitamin D deficiency and diabetes. Biochem J [Internet]. 2017 Apr 15 [cited 2022 Sep 21];474(8):1321–32.

16. Ma J, Wang X, Zheng M, Yu H, Ma J, Li X, et al. A Multicenter Large-Scale Retrospective Analysis of the Correlation between Body Mass Index and All-Cause Mortality in Patients with Type 2 Diabetes Mellitus: A Seven-Year Real-World Study.

17. Ji L, Zou D, Liu L, Qian L, Kadziola Z, Babineaux S, et al. Increasing body mass index identifies Chinese patients with type 2 diabetes mellitus at risk of poor outcomes. J Diabetes Complications [Internet]. 2015 May 1 [cited 2022 Oct 6];29(4):488–96. Available from: https://pubmed.ncbi.nlm.nih.gov/25784086/

18. Safitri M. Comparison of the Effectiveness of Single Antidiabetics and Combinations in Controlling Blood Sugar in Outpatients With Type 2 Diabetes Mellitus At the Panembahan Senopati Hospital, Bantul – Bimawa-Uad. Ahmad Dahlan Univ Student and Alumni Affairs Bureau. 2020.

19. Feller S, Boeing H, Pischon T. Body Mass Index, Waist Circumference, and the Risk of Type 2 Diabetes Mellitus Implications for Routine Clinical Practice.

20. Wei J, Liu X, Xue H, Wang Y, Shi Z. Comparisons of Visceral Adiposity Index, Body Shape Index, Body Mass Index and Waist Circumference and Their Associations with Diabetes Mellitus in Adults. Nutrients [Internet]. 2019 Jul 1 [cited 2022 Oct 6];11(7).

21. Kinanti G. The Relationship between Physical Activity and Abdominal Circumference with the Possibility of Type 2 Diabetes Mellitus in Obese Women in Greater Malang | Silmi | Sport Science Journal. J Sport Sci [Internet]. 2021 [cited 2022 Oct 6];11(2).

22. Agung A, Krisnanta Adnyana N, Surudarma W, Made Wihandani D, Wayan I, Sutadarma G, et al. The Relationship of Abdominal Circumference to Blood Sugar Levels

Using the Oral Glucose Tolerance Test in Late Adolescents. Udayana Med E-Journal [Internet]. 2021 Oct 13 [cited 2022 Oct 6];10(10):52–7.

23. Haghighatpanah M, Nejad ASM, Haghighatpanah M, Thunga G, Mallayasamy S. Factors that Correlate with Poor Glycemic Control in Type 2 Diabetes Mellitus Patients with Complications. Osong Public Heal Res Perspect. 2018;9(4):167.

24. Radwan M, Elsous A, Al-Sharif H, Abu Mustafa A. Glycemic control among primary care patients with type 2 diabetes mellitus in the Gaza Strip, Palestine. Ther Adv Endocrinol Metab. 2018 Jan;9(1):3.

25. Almutairi MA, Said SM, Zainuddin H. Predictors of Poor Glycemic Control Among Type Two Diabetic Patients. Am JM edicine M edical Sci. 2013;3(2):17–21.

26. Papazafiropoulou A, Sotiropoulos A, Skliros E, Kardara M, Kokolaki A, Apostolou O, et al. Familial history of diabetes and clinical characteristics in Greek subjects with type 2 diabetes. BMC Endocr Disord. 2009 Apr;9:12.

27. Ghavam S, Ahmadi MRH, Panah AD, Kazeminezhad B. Evaluation of HbA1C and serum levels of vitamin D in diabetic patients. J Fam Med Prim Care. 2018;7(6):1314.

28. Jorde R, Figenschau Y. Supplementation with cholecalciferol does not improve glycemic control in diabetic subjects with normal serum 25-hydroxyvitamin D levels. Eur J Nutr. 2009 Sep;48(6):349–54.

29. Alkhatatbeh MJ, Abdul-Razzak KK. Association between serum 25-hydroxyvitamin D, hemoglobin A1c and fasting blood glucose levels in adults with diabetes mellitus. Biomed Reports. 2018 Dec;9(6):523–30.

30. Pittas AG, Dawson-Hughes B, Sheehan P, Ware JH, Knowler WC, Aroda VR, et al. Vitamin D Supplementation and Prevention of Type 2 Diabetes. N Engl J Med. 2019 Aug;381(6):520–30.