

Vitamin-D deficiency in adults of Mumbai city: Change in the last decade

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ABSTRACT

Background: Vitamin-D deficiency is a pandemic that is being linked to various noncommunicable diseases. The present study is an attempt to study the demographic profile and the prevalence of comorbidities in association with the vitamin-D status of the Mumbai-based study population. The authors also attempt to understand the change in prevalence over the last decade. **Methodology:** Fasting blood samples were collected from consenting asymptomatic adults visiting the hospital and were analyzed for the prevalence of vitamin-D deficiency and diabetes mellitus, and participants were clinically examined for the presence of hypertension (as defined by AHA guidelines) and obesity (as defined by body mass index of more than equal to 30). **Results:** It was found that 57% of participants were deficient, 25% had insufficient, and 18% had adequate vitamin-D levels. There were a greater number of younger ($P = 0.003$) and upper-middle-class participants in the deficient group ($P = 0.043816$). Prevalence of obesity, hypertension, and diabetes mellitus and the distribution of genders was comparable in the deficient and sufficient vitamin-D groups. However, diabetic vitamin-D-sufficient participants had better control of blood sugar compared to diabetic vitamin-D-deficient participants. **Conclusion:** Although the prevalence of vitamin-D deficiency has slightly reduced compared to the previous decade, it is still highly prevalent. Diabetic vitamin-D-sufficient participants had better glycemic control compared to diabetic vitamin-D-deficient participants. Thus, it is highly recommended for primary care physicians to screen everyone for vitamin-D deficiency.

Keywords: Glycemic control, Mumbai city, vitamin-D deficiency

Introduction

Vitamin-D deficiency has been linked to many non-skeletal disorders such as diabetes, hypertension, autoimmune disorders, and cancers.^[1] In fact, it is postulated that individuals with vitamin-D deficiency infected with COVID-19 are susceptible to a dysregulated immune response.^[2]

Vitamin-D deficiency and obesity are both ongoing pandemics.^[1,3] India is the world capital of diabetes mellitus.^[4] Various papers^[3] suggest a possible higher prevalence of obesity, diabetes mellitus, and increased cardiovascular risk in the vitamin-D-deficient population. Therefore, it is important to see if any correlation exists.

In the Indian subcontinent, the prevalence of vitamin-D deficiency is 70%–100%.^[5,6] This high prevalence is irrespective of age,^[6] gender,^[7] socioeconomic status,^[8] and urban or rural residence.^[9]

Taking into consideration the impact of vitamin-D deficiency on our health, this paper aims to impress upon the primary care and family physicians the need for screening and treating vitamin-D deficiency. Previous studies (in the past decades) point to the high prevalence

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of vitamin-D deficiency.^[8] To the best of our knowledge, there are very few studies^[10] on the prevalence of vitamin-D deficiency in the last decade. This paper attempts to understand the present scenario in regards to vitamin-D deficiency in the country, the change in prevalence when compared to previous studies in the last decade, and to understand the demographic pattern of vitamin-D deficiency, as well the prevalence of various comorbidities in the vitamin-D-deficient population. We hope this will encourage prompt diagnosis and treatment of this easily correctable deficiency.

Material and Methods

This is a cross-sectional observational study conducted at a tertiary care hospital in Mumbai. Adults who visited the Health Check-up Clinic between December 2016 and August 2017 were included in the study.

A. Eligibility criteria:

1. Exclusion criteria
 - Ongoing vitamin-D supplement intake
2. Inclusion criteria
 - (a) Age >18 years
 - (b) People who consented to participate in the study

Patients were divided into two groups based on 25-hydroxy-vitamin-D levels^[11]: group A (deficient: vitamin-D <20 ng/mL) and group B (not deficient: vitamin-D > 20 ng/mL). Group B was further segregated into subgroup B1 (insufficient vitamin-D ≥ 20 ng/mL and <30 ng/mL) and subgroup B2 (adequate/sufficient: vitamin-D ≥ 30 ng/mL).

Variables studied were 25-OH-vitamin-D levels, socioeconomic factors, gender, age, the prevalence of diabetes mellitus, hypertension, and obesity.

B. Data Collection, source, and measurement

A written consent form (approved by the institutional ethics committee) was given to all participants. Anthropometric data including weight and height were measured. The blood pressure reading of all patients was recorded during the hospital visit. All participants were asked questions regarding demographic data and past medical history, for example, comorbidities, supplement intake, and medication history as per the predesigned per-forma. Socioeconomic history was also noted as per Kuppaswamy urban socioeconomic scale^[12]

Further, 10 mL of peripheral blood was drawn in a plain tube. Blood samples were centrifuged at 2500–3000 rpm for 10 min. Serum level of vitamin D was measured using the electro-chemiluminescence method. The analyzer used for Vitamin-D samples was Roche Cobas 6000 analyzer. Vitamin-D deficiency is classified as 25 (OH) D <20 ng/mL, insufficiency as 20–29 ng/mL, and adequate levels as ≥ 30 ng/mL.^[11] Participants with body mass index (BMI) values of >30 kg/m² were considered obese and those with a BMI of >25 kg/m² were considered overweight.^[13] Diabetes mellitus was diagnosed as per the definition of American Diabetes

Association (ADA)^[14] as follows: when fasting blood sugar (FBS) is >126 mg/dL or postprandial blood sugar (PPBS) is >200 mg/dL or glycosylated hemoglobin (HBA1C) is >6.5% OR if the patient gave a history of being a known diabetic on medications or lifestyle management. Impaired fasting glucose was defined as a FBS of 100–126 mg/dL.

As per the American Heart Association (AHA) guidelines, hypertension was diagnosed when a participant's systolic blood pressure (SBP) in the OPD was ≥ 140 mm Hg and/or their diastolic blood pressure (DBP) was ≥ 90 mm Hg following repeated examination,^[15] or if the patient gave a history of being a known hypertensive on medications or lifestyle management.

Bias: Blinding was used. As the laboratory values were available after the health checkup and interview of every participant, it was not known to the interviewer which group the participants belonged to.

C. Sample size

Calculation of sample size was done using the given formula^[16] by using proportion values from a Hyderabad-based study on vitamin-D deficiency and dyslipidemia.^[7] Substituting the values in the formula, we get

$$n_1 = n_2 = \frac{(1.96 + 1.282)^2 (0.542 (1-0.542) + 0.0.307 (1-0.307))}{(23.5)^2}$$

$$= 87.736 \sim 88$$

This is as mentioned in Hinduja *et al.*'s^[17] unpublished paper titled "25-Hydroxy Vitamin-D Levels and Serum Lipids Amongst Asymptomatic Adults in A Metropolitan City."

Therefore, a minimum of 90 subjects were taken in each of the two groups, that is, group A (vitamin D <20 ng/mL) and group B (vitamin D ≥ 20 ng/mL).

A total of 243 participants were present in this study.

D. Statistical analysis

Data were recorded on a predesigned proforma, tabulated, and the results were analyzed statistically using Microsoft Excel, Office 16 as follows:

- a. Chi-square test was used to test the association of columns and rows in tabular data and in the case of qualitative, categorical data.
- b. Two-tailed unpaired *t* test was used to compare differences between statistical means of quantitative measurements.

A *P* value of < 0.05 was considered significant.

Observations and Results

This study consisted of a total of 243 participants, who were segregated as depicted in Table 1; 57% of all study participants

Table 1: Distribution of participants in groups A and B (subgroup B1 + subgroup B2)

Total number of participants	Participants in Group A (Vitamin-D-deficient group) (Vitamin D <20 ng/mL)	Participants in Group B (Vit D ≥20 ng/mL) (Group B1 (Vit-D Insufficient) + Group B2 (Vit-D Sufficient))		
		Total	Subgroup B1 (Vit D ≥20 ng/mL and <30 ng/mL)	Subgroup B2 (Vit D ≥30 ng/mL)
243	139 (57%)	104	60 (25%)	44 (18%)

were vitamin-D deficient (group a with vitamin D <20 ng/mL), 25% had insufficient vitamin-D levels (group B1 with vitamin D ≥20 ng/mL and <30 ng/mL), and 18% had adequate vitamin-D levels (vitamin D ≥30 ng/mL) [Table 1]. In Hinduja et al.'s^[17] unpublished paper, the above is mentioned, and in the present paper, it is further analyzed. The analysis on the prevalence of comorbidities and socioeconomic background of the study population is mentioned in this paper as follows.

The respective groups were compared for demographic data (age, gender, and socioeconomic class) as described in Figure 1. Group A (vitamin D <20 ng/mL) had more participants below the age of 50 when compared to group B ($P = 0.003^*$). On further analysis, there was no difference in age groups between subgroups B1 and B2 ($P = 0.42$). The distribution of gender [Figure 1] in groups A and B was comparable ($P = 0.927$). Similarly, gender distribution in subgroups B1 and B2 was also comparable ($P = 0.39$). All participants of this study belonged to the upper class (UC) or upper-middle-class (UMC) socioeconomic scale. There were more UMC participants in the vitamin-D-deficient group (Group A) ($P = 0.044^*$). On further analysis, subgroups B1 and B2 were comparable for socioeconomic class ($P = 0.88$).

The prevalence of comorbidities is as described in Figure 2. There was no statistical difference in the average blood pressures of groups A and B (SBP: $P = 0.065$, DBP: $P = 0.488$). On comparing the prevalence of various comorbidities, no significant difference in the prevalence of obesity, hypertension, and diabetes mellitus was found between groups A and B (obesity: $P = 0.3504$, hypertension: $P = 0.2705$, diabetes mellitus: $P = 0.570$). Prevalence of the various comorbidities was also comparable between subgroups B1 and B2 (hypertension: $P = 0.26$, diabetes mellitus: $P = 0.46$, obesity: $P = 0.38$) and group A and subgroup B2 (hypertension: $P = 0.98$, diabetes mellitus: $P = 0.81$, obesity: $P = 0.95$). The participants were also analyzed for being overweight and the number of overweight participants in each group (group A vs. group B ($P = 0.868$) and group A vs. subgroup B2 ($P = 0.789$)) was comparable. The number of participants with impaired fasting glucose was also comparable (group A vs. group B ($P = 0.189$) and group A vs. subgroup B2 ($P = 0.24$)).

Average vitamin-D levels of the study population were analyzed after subdividing into groups based on gender, age, and socioeconomic strata. Average vitamin-D levels were significantly lower in participants less than 50 years of age when compared with those over 50 years ($P = 0.0005$). There was no significant difference in average vitamin-D levels of both

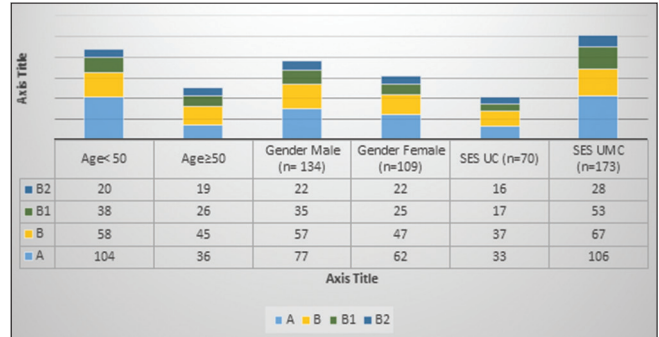


Figure 1: Demographic distribution of participants Abbreviations: SES: Socioeconomic scale (Kuppuswamy); UC: Upper-class; UMC: Upper middle-class. A: Group A (Vit D <20 ng/mL); B: Group B (Vit D ≥20 ng/mL); B1: Subgroup B1 (Vit D ≥20 ng/mL and <30 ng/mL); B2: Subgroup B2: (Vit D ≥30 ng/mL)

genders ($P = 0.4603$), nor was there any statistically significant difference in average vitamin-D levels of upper-middle-class and upper-class participants of this study ($P = 0.1065$). Similarly, the deficient group (group A) had a lower average age compared to group B. Groups A and B are comparable for average age ≥50 years; however, for age <50 years, group A had a significantly younger average age ($P = 0.0002$).

Subanalysis of those over 60 years was also done as depicted in Table 2. Subanalysis for the age group ≥60 years revealed that average FBS values were significantly lower in group B ($P = 0.0115$). The prevalence of diabetes was also more in group A (0.027). The duration of diabetes was comparable in both groups A and B. The prevalence of diabetes was comparable in both groups A and B for age groups of <60 years of age.

Diabetic participants of groups A and B were compared as in Table 3. There was a significant difference in average FBS, PPBS, and HbA1c levels of group A and group B, with group B participants exhibiting better glycemic control [Table 3].

Discussion

Of the 243 participants; 57.2% had vitamin-D deficiency and 24.69% had vitamin-D insufficiency. Only 18.11% of participants had levels of 25-OH-vitamin-D ≥30 ng/mL [Table 1]. In comparison to our study, Shivane et al.'s^[18] study conducted in Mumbai showed a vitamin-D deficiency prevalence of 70% among the participants, only 7.2% had sufficient levels of vitamin D and the rest of the population had insufficient vitamin-D levels. The average vitamin-D level in the current study was 19.25 ± 12.78 ng/mL compared to 17.4 ± 9.1 ng/mL in the 2008 study by Shivane et al.^[18] Bawaskar et al.'s^[19] study of vitamin-D

Table 2: Subgroup analysis of age group ≥60 years; comparison of fasting blood sugar levels, duration of diabetes mellitus, and number of diabetics in groups A and B

Parameter	Group A (Vit D <20 ng/mL) n=7	Group B (Vit D ≥20 ng/mL) n=17	P ^{*,€}
FBS in those ≥60 years of age	157±64.33	102.58±33.26	0.0115* [€]
Duration of diabetes Mellitus in Diabetics of each group for over 60 years of age (5,3)	7.75±8.26	9.67±8.96	0.7675 [€]
Number of diabetics over 60 years of age			
Diabetic over the age of 60 years	5	3	0.027* [€]
Not Diabetic over age of 60 years	2	14	

£= using Chi square test, € = using students (unpaired) t-test (two-tailed), n=number of ≥60 years of age participants in each group, BP: Blood Pressure, Vit D: Vitamin-D, *P<0.05=highly significant, n=number of participants in each group, unit for FBS mg/dL

Table 3: Comparison of glycosylated hemoglobin (hba1c), postprandial and fasting blood sugar levels amongst diabetic participants of groups A and B

Parameter	Group A (Vit D <20 ng/mL) n=20	Group B (Vit D ≥20 ng/mL) n=20	P*
Duration of diabetes (years)	5.44±5.8	4.78±5.18	0.7592
FBS	178±67.2	129.1±38.92	0.0237*
PPBS	281.6±111.5	184.06±93.1	0.0201*
HBA1C (%)	8.2±1.9	7.065±1.6	0.047*

Vit D: 25-OH Vitamin-D, n=number of participants in each group, unit for FBS and PPBS: mg/dL; *P<0.05 using students (unpaired) t-test (two-tailed)

deficiency prevalence in a rural population in a town of Western India (in 2017) showed that only 11% population had adequate vitamin-D levels. This was a more diverse study involving geriatric and pediatric rural population with average vitamin-D levels of 19.49 ± 15.45 ng/mL, like the present study. Shivane et al.'s^[18] study was conducted in 2008 in a government medical college on participants of 25–35 years of age. Multani et al.^[20] in their study (in 2003) conducted on Mumbai-based doctors observed a higher prevalence of vitamin-D deficiency, with 87% of participants having vitamin-D levels of <20 ng/mL. In fact, their average levels were much lower: 12.8 ± 7.94 ng/mL in males and 10.94 ± 4.54 ng/mL in females. The present study was conducted in 2016–2017 in a much more diverse population age-wise (compared to Shivane et al.'s study^[18] and Multani et al.'s^[20] study) who were probably more aware of hypovitaminosis D and had a better lifestyle as a remedial action as they possibly belonged to a more affluent society compared to the rural population in Bawaskar et al.'s^[19] However, it can be noted that over the years, there is a steady rise in the average vitamin-D levels. The present study and Bawaskar et al.^[19] had much higher levels of vitamin D compared to studies conducted in 2003^[20] and 2008.^[18] Random-effects meta-analysis done by Siddiqee et al.^[5] showed that the prevalence of vitamin-D deficiency was higher in 2001–2010 (73%; 95% CI: 64–80) in comparison with 2011–2019 (66%; 95% CI: 61–72) in a South-Asian population.

Various studies from other states reveal a similar prevalence of vitamin-D deficiency across India,^[5,21] which is higher compared to other countries like the USA (24%)^[22] and European countries (40%).^[23,24] This emphasizes the magnitude of the problem in India and reflects on the need for regular screening at the primary health care level.

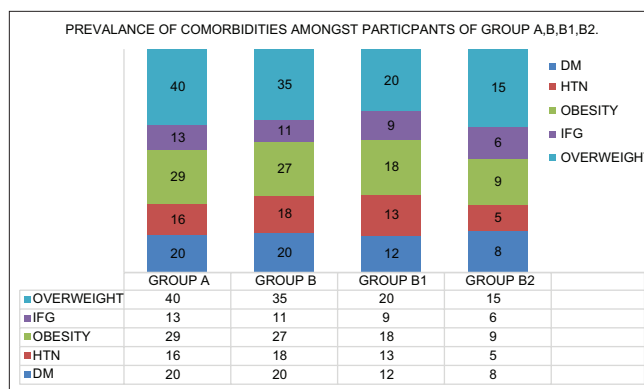


Figure 2: Prevalence of comorbidities in the study population. Abbreviations: Group A(Vit D < 20 ng/ml); Group B(Vit D ≥ 20 ng/ml); Sub-Group B1 (Vit D ≥ 20 ng/ml and < 30 ng/ml); B2:Sub-group B2: (Vit D ≥ 30 ng/ml). abbreviations: HTN- Hypertension, DM - Diabetes mellitus- type 2, IFG- Impaired fasting hyperglycemia.

Gender

In this study, deficiency and insufficiency of vitamin D were observed to be almost evenly distributed among both males (46.1%) and females (35.8%) with comparable levels in both genders [Figure 1]. Other studies^[7,19] have also reported similar findings. A gender-wise analysis suggested that in South Asia, the prevalence of vitamin-D deficiency was higher in females than males^[5] probably due to cultural practices.

Age

The present study found a higher prevalence (64.19%) in younger participants (age less than 50 years) compared to the older participants (50 plus age group having 44.4% prevalence) (P = 0.0031 [Figure 1]). The average vitamin-D levels were also significantly lower in younger participants. A retrospective analysis done by Goel^[10] revealed that the prevalence of vitamin-D level of <20 ng/mL was highest in the age group of ≥18 to ≤30 years (61.9%) versus 35.5% in the >65-years age group, with the trend resonating across all the four zones of India. These results highlight the fact that it is important to screen for vitamin-D deficiency irrespective of the age group.

Socioeconomic scale

As this study was conducted in a private hospital, all participants of this study belonged to the upper class (UC) or upper-middle

class (UMC) as per the Kuppuswamy urban socioeconomic scale (SES) [Figure 1].^[12] In the present study, 55% of upper-class participants were found to be deficient in vitamin D versus 61.2% in the upper-middle class (UMC). In contrast to this, an Indian study found no significant difference in the prevalence of hypovitaminosis D in lower and upper socioeconomic school girls.^[8] Garg *et al.*^[25] reported that vitamin-D deficiency was found to be more prevalent in children (less than 5 years of age) of upper socioeconomic strata in the Indian population, probably linked to less sunlight exposure. The deficient and insufficient vitamin-D status was found in a less percentage of children belonging to the lower-middle and lower class.^[25] Irrespective of which SES class has a higher prevalence of vitamin-D deficiency, it must be noted that the numbers are on the higher side in all studies irrespective of class. This reiterates the fact that every patient should be screened for vitamin-D deficiency irrespective of class.

Vitamin D and diabetes mellitus, hypertension, and obesity

Inadequate levels of vitamin D play a major role in the development of various cancers, cardiovascular diseases, diabetes mellitus, Parkinson's disease, tuberculosis, etc.^[5] Despite the high physiological importance, deficiency of this vitamin is commonly reported around the world. In the present study, the prevalence of hypertension in both groups A and B was comparable ($P = 0.2705$) [Figure 2]. The mean SBP ($P = 0.065$) and DBP ($P = 0.488$) were also comparable in both groups. However, Kota *et al.*^[26] found that the SBP and DBP were significantly higher among vitamin-D-deficient subjects. However, pooled results of RCTs showed that there was no significant reduction in SBP or DBP after vitamin-D supplementation.^[27]

Of the 243 participants, 56 (22.13%) were obese. The prevalence of obesity was comparable in the deficient group (26.36%), in the vitamin-D-insufficient group (30%), and in the vitamin-D-sufficient group (20.45%). Studies have found a significant inverse correlation between vitamin-D levels and BMI^[28] or waist circumference.^[29] A cross-sectional study conducted in Ethiopia by Wakayo *et al.*^[30] revealed that vitamin-D deficiency is significantly associated with overweight/obesity among schoolchildren from both rural and urban backgrounds. Similarly, a longitudinal study on the older Norwegians adult population by Mai^[31] revealed that vitamin-D deficiency is associated with a significantly increased risk of obesity. Similarly, Sahasrabudhe *et al.*^[32] found that obese individuals are more likely to suffer from hypovitaminosis D. Physically active individuals are more likely to go outdoors and thus have better vitamin-D levels.

The prevalence of diabetes mellitus was comparable in deficient, insufficient, and sufficient ($P = 0.4134$). Similarly, the number of participants with impaired fasting glucose was also comparable in both groups. However, for participants older than 60 years, diabetes was more prevalent in the deficient group than in the

sufficient group [Table 2]. Cigolini *et al.*^[33] reported that the age- and sex-adjusted prevalence of hypovitaminosis D was higher in diabetic patients than in control subjects (60.8 vs. 42.8%, $P < 0.001$). In the present study, further analysis of the diabetic subgroup revealed that diabetics with vitamin D >20 ng/dL had significantly better FBS, HbA1c, and PPBS than those with vitamin D <20 ng/mL [Table 3]. Similarly, Karau *et al.*^[28] found a significant inverse correlation between vitamin-D levels and glycemic control. Sahasrabudhe *et al.*^[32] found that insulin resistance is associated with vitamin-D deficiency. This may be a possible explanation of better glycemic control in patients with adequate vitamin-D levels. In contrast, an Indian study^[34] revealed no correlation between vitamin-D status and glycemic control.

Conclusion

Only 18.11% of participants had adequate vitamin-D levels. The prevalence of vitamin-D deficiency was equally distributed in both genders. Upper-middle-class participants had a higher prevalence of vitamin-D deficiency. There was no difference in the prevalence of comorbidities in vitamin-D-deficient, insufficient, and sufficient participants. Vitamin-D-sufficient diabetic participants had better control of blood sugar compared to diabetic vitamin-D-deficient participants. The present study showed a slightly lower prevalence of vitamin-D deficiency when compared with studies conducted a few years earlier.

Limitations of the study

All participants were adults and belonged to the metropolitan city of Mumbai in western India. They were asymptomatic and visited the hospital for routine health checks. The impact of dietary preferences, physical activity, lifestyle, and other metabolic variables had not been factored in the study. The diabetic population of the study was small. Thus, the observed findings of the study cannot be generalized.

Strengths of the study

We believe this is one of the few papers that has studied vitamin-D prevalence comparing it with previous data of Mumbai city and considered variables such as socioeconomic background and comorbidities such as hypertension, diabetes mellitus, and obesity.

Summary/Key findings

Although there has been a marginal improvement in the prevalence of deficiency in Mumbai, the numbers are far from satisfactory. Vitamin-D deficiency is more prevalent in the young but also impacts the elderly. Men and women are equally affected. Low vitamin-D status might act as a factor for the rise of various noncommunicable diseases. In this study, however, there was no increase in the prevalence of diabetes, hypertension, and obesity. However, the present study found a better glycemic status in diabetic patients with vitamin-D sufficiency. The findings of

this study should motivate primary care physicians to screen all individuals for vitamin-D deficiency, especially diabetics.

Take-home message

a. What is added by this report? This report reveals that although the prevalence is still high, it has reduced in the last decade. Diabetic patients with sufficient vitamin-D levels had better glycemic control. The younger population is also at risk of vitamin-D deficiency.

b. What are the implications for public health practice? Vitamin-D deficiency screening should be done irrespective of age and gender. It is important to screen all patients with diabetes for vitamin-D deficiency due to its possible role in insulin resistance, as brought to light by this study that glycemic control is better in patients with sufficient vitamin-D levels.

Originality

The paper is an original research work of the authors.

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Conflicts of interest

There are no conflicts of interest.

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