STEMedicine

ORIGINAL RESEARCH ARTICLE

Prevalence and Clinical Predictors of Vitamin B12 Deficiency Among Patients with Type 2 Diabetes Mellitus

Dr. Shivaraj Hadimani[1]*, Dr. Pragati Nalkamana[2], Dr. Manish Kumar[3]

[1]Assistant Professor, Department of General Medicine, S.R. Patil Medical College, Badagandi, Bagalkote, Karnataka
[2]House Surgeon, S.S. Institute of Medical Sciences, Davanagere, Karnataka
[3]Assistant Professor, Department of General Medicine, Balvir Singh Tomar Institute of Medical Science Research & Hospital, Jaipur - Delhi Highway, Jaipur, Rajasthan

Corresponding Author: Dr. Shivaraj Hadimani
Email: drshivarajhadimani@gmail.com

Abstract: Background: Vitamin B12 deficiency is an important complication in patients with type 2 diabetes mellitus (T2DM), particularly among those receiving metformin. This study assessed its prevalence and associated clinical predictors.**Methods:** A cross-sectional analysis included 360 adults with T2DM and available serum vitamin B12 measurements. Deficiency was defined as vitamin B12 <180 pg/mL. Multivariable logistic regression evaluated associations with metformin use, age, dietary pattern, proton pump inhibitor use, diabetes duration, and HbA1c.**Results:** Vitamin B12 deficiency was present in 138 patients (38.3%). Current metformin use was independently associated with deficiency (adjusted OR 3.47, 95% CI 1.91–6.32), as were older age and vegetarian or vegan diet. Among current metformin users, higher daily dose was associated with deficiency (OR 1.36 per 500 mg), whereas treatment duration was not significant. Deficient patients had more anemia and macrocytosis. Vitamin B12 deficiency was not independently associated with a positive neuropathy screen.**Conclusion:** Vitamin B12 deficiency was common in T2DM and was strongly associated with metformin use, higher dose, older age, and vegetarian or vegan diet.

Keywords: type 2 diabetes mellitus; vitamin B12 deficiency; metformin; neuropathy; vegetarian diet.

Received:20.01.2026 | Revised:03.02.2026 | Accepted:10.02.2026 | Published:30.03.2026

Citation: Dr. Shivaraj Hadimani *et al* (2026). Prevalence and Clinical Predictors of Vitamin B12 Deficiency Among Patients with Type 2 Diabetes Mellitus. STEMed, 7(1): 15-21.

Introduction

Clinically, B12 deficiency can cause hematological abnormalities, neuropsychiatric symptoms and peripheral neuropathy, and occasionally neurological dysfunction without the presence of macrocytic anemia [1]. Patients with T2DM may be at a special risk due to a number of common clinical and treatment-related factors that may negatively impact vitamin B12 status, such as older age, dietary restriction, acid-suppressive therapy, and long-term use of metformin.

Although metformin is a mainstay of the pharmacological therapy for T2DM, its association with low levels of vitamin B12 is well known. Long-term metformin use resulted in a sustained decrease in circulating vitamin B12 and an absolute increase in the risk of biochemical deficiency in a randomized placebo-controlled trial [2]. A higher prevalence of low or borderline low vitamin B12 was also observed in the Diabetes Prevention Program Outcomes Study, with a greater risk associated with the number of years on metformin [3]. Data from the National Health and Nutrition Examination Survey also revealed that biochemical B12 deficiency occurred more often in adults with diabetes who were taking metformin than in those who were not taking it [4].

 © 2026 Dr. Shivaraj Hadimani et al. Open Access under the Creative Commons Attribution 4.0 International License.

The strength of this relationship may be related to the intensity of treatment. Kim et al. showed a clear dose-response relationship with increasing odds of vitamin B12 deficiency with increasing daily dose of metformin [5]. Other factors may be at play at the same time. Food-bound cobalamin absorption may be affected by chronic acid suppression, and there is a higher risk of B12 deficiency with chronic use of proton pump inhibitors (PPIs) [6]. Dietary pattern is also important as vitamin B12 is mainly obtained from animal-source food, and vegetarian or vegan diets are linked to low B12 levels when supplementation or fortified food consumption is insufficient [7].

Laboratory abnormalities are not the only clinical implications of the identification of deficiency in T2DM. Vitamin B12 deficiency can have symptoms that are similar to diabetic peripheral neuropathy, making it difficult to attribute numbness, paresthesias, burning sensations, and sensory impairment. However, associations between lower vitamin B12 levels and peripheral neuropathic features have been reported in studies of metformin-treated patients and the strength and independence of these relationships have been inconsistent [8]. This uncertainty supports evaluation of biochemical deficiency together with hematological and neurological findings, rather than assuming that diabetic neuropathy is solely a result of chronic hyperglycemia.

The present study thus aimed to assess the prevalence of B12 deficiency in adults with T2DM and to investigate the relationship of B12 deficiency with current use of metformin, the dose and duration of metformin use, dietary pattern, PPI use, age, glycemic status, and other clinical parameters. Hematological abnormalities and the relationship between vitamin B12 deficiency and peripheral neuropathy screening were also evaluated.

Methods

Study design and population

A cross-sectional study was performed with 360 records of adults (18 years or older) with known T2DM and total serum vitamin B12 level. The study period was from November 2025 to January 2026. Outpatient and noncritical inpatient encounters were included in the study. Patients who had received recent therapeutic vitamin B12 replacement, had a history of pernicious anemia, major gastrointestinal surgery or malabsorption, or had suffered from a critical illness were excluded.

Outcome and exposure definitions

The main outcome was biochemical vitamin B12 deficiency (serum vitamin B12 <180 pg/mL). Concentrations were defined as deficient (<180 pg/mL), indeterminate (180–350 pg/mL, inclusive), and above (>350 pg/mL). The main comparison was made using ≥180 pg/mL as the reference category.

The main exposure was the use of metformin at the time of the analysis. For the primary analysis, former users and those who never used metformin were combined into noncurrent users. Among current users, daily dose and duration of treatment were evaluated separately. For descriptive analysis, dietary pattern was categorized as omnivorous, vegetarian, or vegan. For regression, vegetarian and vegan diets were grouped together. Estimated glomerular filtration rate (eGFR) was estimated using the 2021 CKD-EPI creatinine equation.

Hematological findings and screening for neuropathy

Anemia was considered to be hemoglobin <12 g/dL in women and <13 g/dL in men. Macrocytosis was considered as MCV >100 fL. The neuropathy screen included three symptoms (numbness, tingling, and burning feet) and three examination findings (reduced vibration perception, abnormal 10-g monofilament testing, and absent ankle reflex). A positive screen had to have 2 or more positive items, at least 1 of which had to be an examination finding. Only records with a completed neuropathy screen were included in the neuropathy analysis.

Statistical analysis

Categorical variables were presented as n (%) and continuous variables were presented as median (Q1–Q3). The proportions of deficiencies were reported using 95% Wilson confidence intervals. The Mann–Whitney U test was used to compare groups for continuous variables and Pearson's χ^2 test was used for categorical variables. Macrocytosis was tested using Fisher's exact test and the dietary-pattern p-value was calculated using a fixed-margin Monte Carlo test with 9,999 draws.

Univariable and multivariable logistic regression provided crude and adjusted odds ratios with 95% confidence intervals and Wald tests. Age, current use of metformin, vegetarian/vegan diet, current use of proton pump inhibitors, diabetes duration, and HbA1c were included in the primary model. Modified Poisson regression with robust standard errors was used to estimate adjusted prevalence ratios, and the logistic analysis was repeated without records with indeterminate B12, without former metformin users, or with the inclusion of eGFR. For those taking metformin, the dose and duration of treatment were modelled together with age and diet. The neuropathy model evaluated the relationship between B12 deficiency and a positive

screen, after controlling for age, diabetes duration and HbA1c. Available observations were used for analyses of each comparison and complete cases for each regression model. Two-sided p values were used for all analyses. Analyses were conducted in SPSS version 22.

Results

Vitamin B12 deficiency in type 2 diabetes

Of 360 records, 138 (38.3%) met the biochemical definition of vitamin B12 deficiency (95% CI 33.5%–43.5%). Serum B12 was indeterminate in 148 (41.1%) and above 350 pg/mL in 74 (20.6%). Deficiency was more frequent among current metformin users than among noncurrent users (Figure 1). Baseline characteristics by deficiency status are presented in Table 1.

Factors associated with vitamin B12 deficiency

In the primary multivariable model, current metformin use was associated with higher odds of deficiency (adjusted OR 3.47, 95% CI 1.91–6.32). Older age and a vegetarian or vegan diet were also associated with higher odds of deficiency (Table 3, Figure 2). Among current metformin users, higher daily dose was associated with deficiency after adjustment. The confidence interval for treatment duration included 1. The association with current use persisted across the sensitivity analyses (Table 4).

Hematological findings and peripheral neuropathy

Anemia and macrocytosis were more frequent in the deficient group (Table 2). Neuropathy screening was completed in 339 records. After adjustment for age, diabetes duration and HbA1c, the odds ratio for a positive screen in the deficient group was 1.32 (95% CI 0.80–2.18, p = 0.271). Table 4 shows the adjusted estimate.

Table 1. Baseline characteristics by serum vitamin B12 deficiency

Characteristic	Deficient (n = 138)	B12 ≥180 pg/mL (n = 222)	Statistic	p value
Age, years	59.0 (52.0–67.0)	57.0 (49.0–63.0)	U = 13,336.5	0.039
Female sex	70 (50.7%)	99 (44.6%)	$\chi^2 = 1.28$	0.257
Outpatient setting	112 (81.2%)	175 (78.8%)	$\chi^2 = 0.29$	0.593
Dietary pattern			$\chi^2 = 9.94$	0.005
Omnivore	73 (52.9%)	143 (64.4%)		
Vegetarian	61 (44.2%)	79 (35.6%)		
Vegan	4 (2.9%)	0 (0.0%)		
Body mass index, kg/m²	26.5 (23.3–28.7)	27.4 (24.6–29.8)	U = 17,488.5	0.024
Diabetes duration, years	7.8 (4.1–12.4)	7.5 (4.7–11.6)	U = 14,944.0	0.697
HbA1c, %	7.7 (6.9–8.7)	7.5 (6.8–8.4)	U = 14,092.5	0.202
Current metformin use	119 (86.2%)	156 (70.3%)	$\chi^2 = 12.02$	<0.001
Current PPI use	37 (26.8%)	42 (18.9%)	$\chi^2 = 3.09$	0.079
Hypertension	81 (58.7%)	126 (56.8%)	$\chi^2 = 0.13$	0.717
Dyslipidemia	74 (53.6%)	102 (45.9%)	$\chi^2 = 2.01$	0.157
Chronic kidney disease	22 (15.9%)	21 (9.5%)	$\chi^2 = 3.40$	0.065
eGFR, mL/min/1.73 m²	83.7 (69.9–97.4)	85.5 (70.6–100.6)	U = 16,080.0	0.428

Values are n (%) or median (Q1–Q3). U denotes the Mann–Whitney statistic calculated with the ≥180 pg/mL group first. Pearson χ^2 tests have 1 df for binary comparisons and 2 df for dietary pattern. The dietary p value uses a fixed-margin Monte Carlo test. PPI, proton pump inhibitor. eGFR, estimated glomerular filtration rate.

Table 2. Hematological findings and neuropathy screening by B12 deficiency

Characteristic	Deficient (n = 138)	B12 ≥180 pg/mL (n = 222)	Statistic	p value
Hemoglobin, g/dL	12.9 (12.1–13.9)	13.6 (12.6–14.6)	U = 19,844.5	<0.001
Anemia	50 (36.2%)	44 (19.8%)	$\chi^2 = 11.88$	<0.001
Mean corpuscular volume, fL	91.8 (86.2–95.9)	87.3 (82.7–91.4)	U = 10,008.5	<0.001
Macrocytosis	11 (8.0%)	2 (0.9%)	OR = 9.53	<0.001
Positive neuropathy screen	88/131 (67.2%)	120/208 (57.7%)	$\chi^2 = 3.05$	0.081

Values are n (%), n/N (%) or median (Q1–Q3). Pearson χ^2 tests have 1 df. U denotes the Mann–Whitney statistic calculated with the ≥180 pg/mL group first. The macrocytosis p value is from Fisher's exact test, with the

 © 2026 Dr. Shivaraj Hadimani et al. Open Access under the Creative Commons Attribution 4.0 International License.

sample odds ratio shown. Neuropathy percentages use the number with a completed screen.

Table 3. Logistic regression for vitamin B12 deficiency

Factor	Crude OR (95% CI)	Wald z	p value	Adjusted OR (95% CI)	Wald z	p value
Age, per 10 years	1.23 (1.01–1.49)	2.07	0.038	1.27 (1.03–1.57)	2.27	0.023
Current metformin use	2.65 (1.51–4.65)	3.39	<0.001	3.47 (1.91–6.32)	4.08	<0.001
Vegetarian or vegan diet	1.61 (1.05–2.48)	2.16	0.031	1.60 (1.01–2.51)	2.02	0.043
Current PPI use	1.57 (0.95–2.60)	1.75	0.080	1.56 (0.91–2.68)	1.60	0.109
Diabetes duration, per 5 years	1.12 (0.93–1.35)	1.25	0.213	1.08 (0.88–1.33)	0.74	0.461
HbA1c, per 1 percentage point	1.12 (0.95–1.33)	1.33	0.182	1.13 (0.93–1.36)	1.23	0.217

The adjusted model includes all six listed covariates (360 records, 138 events). Binary reference categories are noncurrent metformin use, omnivorous diet and no current PPI use. OR, odds ratio.

Table 4. Sensitivity and secondary analyses

Comparison	N	Type	Adjusted estimate (95% CI)	Wald z	p value
Current use, modified Poisson	360	PR	2.18 (1.46–3.26)	3.83	<0.001
Current use, indeterminate B12 excluded	212	OR	6.35 (2.88–14.01)	4.58	<0.001
Current use vs never use	319	OR	3.10 (1.45–6.62)	2.93	0.003
Current use, additional eGFR adjustment	360	OR	3.61 (1.96–6.64)	4.11	<0.001
Daily dose, per 500 mg	275	OR	1.36 (1.04–1.78)	2.23	0.026
Treatment duration, per 5 years	275	OR	1.27 (0.96–1.68)	1.67	0.095
B12 deficiency and positive neuropathy screen	339	OR	1.32 (0.80–2.18)	1.10	0.271

The sensitivity models retain the Table 3 covariates. The current-user model includes age, diet, daily dose and treatment duration. The neuropathy model adjusts for age, diabetes duration and HbA1c. PR, prevalence ratio estimated by modified Poisson regression with robust standard errors.

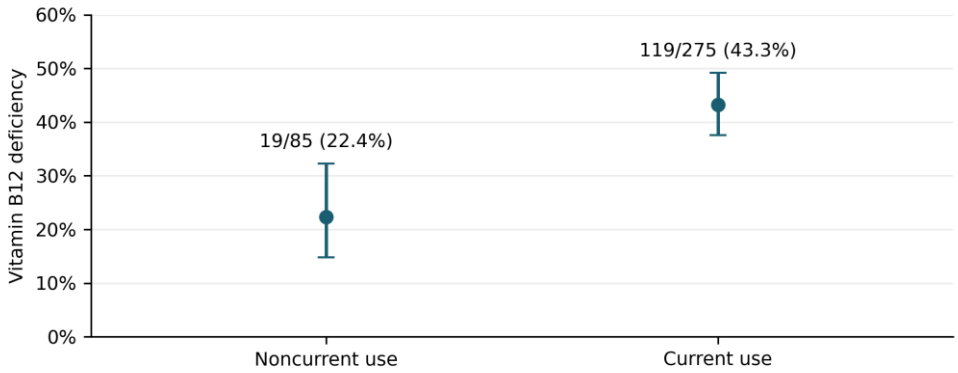

Figure 1. Vitamin B12 deficiency by current metformin use

Points show proportions and bars show 95% Wilson confidence intervals. Noncurrent use includes former and never use.

 © 2026 Dr. Shivaraj Hadimani et al. Open Access under the Creative Commons Attribution 4.0 International License.

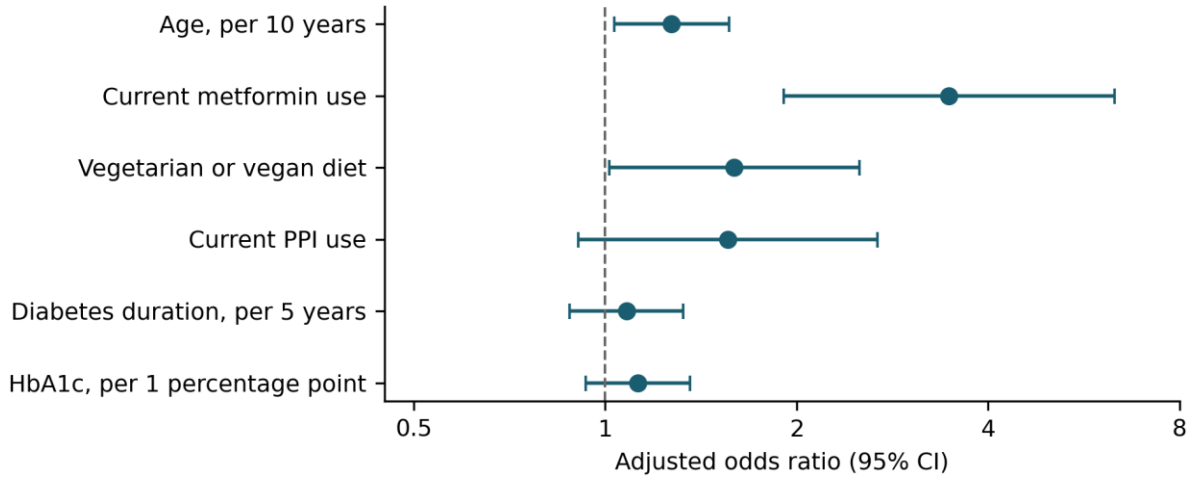

Figure 2. Adjusted associations with vitamin B12 deficiency

Points show adjusted odds ratios and bars show 95% confidence intervals from the primary logistic model. The vertical line marks an odds ratio of 1.

Discussion

Vitamin B12 deficiency was found in 38.3% of adults with type 2 diabetes mellitus (T2DM) in this study. The highest adjusted odds for deficiency were observed in current use of metformin (more than threefold higher). Deficiency was also independently linked to older age and vegetarian or vegan diets. In the current metformin users, dose of metformin per day was still significant, but the duration of treatment was not. Deficient patients had more anemia and macrocytosis, but there was no independent association with the positive neuropathy screen after adjustment for age, diabetes duration and HbA1c. Together, these results suggest that dietary pattern, age, and exposure to metformin are clinically relevant factors, and that biochemical deficiency is not always reflected in measurable neuropathy.

The prevalence observed is higher than in some previous T2DM cohorts, but this is heavily dependent on the diagnostic criteria. Pflipsen et al. [9] investigated 203 primary-care patients, and found that 22% had metabolically confirmed deficiency, with mean serum B12 levels being lower in those taking metformin (426 pg/mL) than in those not taking it (527 pg/mL), and the use of multivitamins was associated with significantly reduced odds of deficiency (OR 0.31). These results are consistent with the significant burden seen in our population and demonstrate the potential impact of confirmatory testing of methylmalonic acid or homocysteine on prevalence estimates.

Our metformin association is similar to that of Ting et al. [10] which reported a dose-response relationship. For B12 deficiency, each 1-g/day increase in metformin dose was linked to an OR of 2.88, and metformin use for ≥3 years was associated with an adjusted OR of 2.39 versus <3 years of use in the case-control analysis. Current use was strongly associated with deficiency in our study in several sensitivity analyses and each additional 500 mg/day was associated with 36% increased odds. Duration was less precise, however, suggesting that current dose may offer a more robust exposure signal in some populations.

Deficiency was also observed in 22.5% of 231 metformin-treated patients, and in 7.4% of matched controls [11]. The difference remained after excluding those taking acid-suppressive therapy (17.9% vs 5.6%) and proton pump inhibitor or H2-receptor antagonist use was associated with deficiency (OR 2.60). On the other hand, there was an increased but non-significant adjusted association with PPI use in our cohort. This difference could be due to the duration of exposure, sample size, or differences in the acid-suppressive prescribing patterns.

Wee and Sultana [12] support the importance of age and diet in our model. Of the 592 patients with T2DM, 27.7% were B12 deficient. Deficiency was independently associated with higher daily dose of metformin (OR 2.79) and with age ≥80 years (OR 2.86) and with vegetarianism (OR 21.61). They obtained an AUROC value of 0.803 with their multivariable model. The association with diet in our study was smaller, but the direction was the same, and it further emphasizes the need to take into account non-pharmacological factors in addition to metformin use.

More recently, multicentre data have confirmed a more important dose effect than treatment duration.

 © 2026 Dr. Shivaraj Hadimani et al. Open Access under the Creative Commons Attribution 4.0 International License.

Gao et al. [13] investigated 1027 patients who were prescribed metformin and found that 2.15% and 13.66% of them had definite and borderline B12 deficiency, respectively. The prevalence was not significantly different between treatment duration ≥3 years and <3 years, but the number of patients with borderline deficiency was significantly higher in those receiving ≥1500 mg/day (16.76% versus 9.91%). Peripheral neuropathy was also slightly more prevalent in B12 deficient patients (18.18% vs. 11.27%) but this was not statistically significant. This pattern is similar to our dose association with significant dose effect and non-significant duration and adjusted neuropathy risk.

The association of B12 status and neuropathy is less consistent between studies. Singh et al. [14] reported decreased mean B12 levels in metformin versus non-metformin users (410 vs 549 pg/mL), OR 4.45 for possible deficiency, and increased clinical neuropathy scores in metformin users. The B12 level was negatively associated with cumulative exposure to metformin (r=−0.68). Similarly, Alvarez et al. [15] reported low B12 levels in 7.3% of 162 metformin-treated patients, and low or borderline B12 levels were found in 64% of patients with neuropathy versus 17% without neuropathy, with a higher dose of metformin being associated with lower B12 levels. Neuropathy-screen positivity was more common in those with deficiency (67.2% vs. 57.7%), with an adjusted OR of 1.32, which was not significant in our cohort. These divergent estimates may be due to variations in the definition of neuropathy, nerve-conduction testing, thresholds for B12, diabetes duration, and glycemic exposure.

The hematological findings are clinically relevant. Deficient patients had lower hemoglobin, almost twice as many had anemia, and macrocytosis was much more common. However, the majority of deficient patients were not macrocytic, and so, mean corpuscular volume would be inadequate to pick up many patients.

There are a number of restrictions to be taken into account. The cross-sectional design does not allow for conclusions about temporal causality between metformin exposure and deficiency. No routine confirmation of methylmalonic acid or homocysteine was performed and dietary intake was not quantified but rather categorized. Neuropathy screening is a clinically structured screening that cannot completely differentiate diabetic neuropathy from B12-related neurological dysfunction. There may also be residual confounding due to supplements, diet and medication exposure. More large-scale longitudinal studies with functional B12 biomarkers would help to better understand the clinical implications of biochemical deficiency.

Conclusion

Vitamin B12 deficiency was common among adults with T2DM and was independently linked to current metformin use, older age, and a vegetarian or vegan diet. Among current users, higher doses of metformin were associated with deficiency, but treatment duration was not. Deficiency was associated with hematological abnormalities, while an independent association with neuropathy was not found. The results of this study justify the use of targeted B12 assessment in patients with known clinical and treatment-related risk factors.

References

1. Shipton MJ, Thachil J. Vitamin B12 deficiency—A 21st century perspective. *Clin Med (Lond).* 2015;15(2):145–150. **doi:10.7861/clinmedicine.15-2-145.**
2. de Jager J, Kooy A, Lehert P, et al. Long term treatment with metformin in patients with type 2 diabetes and risk of vitamin B-12 deficiency: randomised placebo controlled trial. *BMJ.* 2010;340. **doi:10.1136/bmj.c2181.**
3. Aroda VR, Edelstein SL, Goldberg RB, et al.; Diabetes Prevention Program Research Group. Long-term metformin use and vitamin B12 deficiency in the Diabetes Prevention Program Outcomes Study. *J Clin Endocrinol Metab.* 2016;101(4):1754–1761. **doi:10.1210/jc.2015-3754.**
4. Reinstatler L, Qi YP, Williamson RS, Garn JV, Oakley GP Jr. Association of biochemical B12 deficiency with metformin therapy and vitamin B12 supplements: the National Health and Nutrition Examination Survey, 1999–2006. *Diabetes Care.* 2012;35(2):327–333. **doi:10.2337/dc11-1582.**
5. Kim J, Ahn CW, Fang S, Lee HS, Park JS. Association between metformin dose and vitamin B12 deficiency in patients with type 2 diabetes. *Medicine (Baltimore).* 2019;98(46). **doi:10.1097/MD.0000000000017918.**
6. Lam JR, Schneider JL, Zhao W, Corley DA. Proton pump inhibitor and histamine 2 receptor antagonist use and vitamin B12 deficiency. *JAMA.* 2013;310(22):2435–2442. **doi:10.1001/jama.2013.280490.**
7. Janko RK, Haussmann I, Patel A. Vitamin B12 status in vegan and vegetarian Seventh-Day Adventists: a systematic review and meta-analysis of serum levels and dietary intake. *Am J Health Promot.* 2025;39(1):162–171. **doi:10.1177/08901171241273330.**
8. Roy RP, Ghosh K, Ghosh M, et al. Study of vitamin B12 deficiency and peripheral neuropathy in metformin-treated early type 2 diabetes mellitus. *Indian J Endocrinol Metab.* 2016;20(5):631–637. **doi:10.4103/2230-8210.190542.**

 © 2026 Dr. Shivaraj Hadimani et al. Open Access under the Creative Commons Attribution 4.0 International License.

9. Pflipsen MC, Oh RC, Saguil A, Seehusen DA, Seaquist D, Topolski R. The prevalence of vitamin B12 deficiency in patients with type 2 diabetes: a cross-sectional study. *J Am Board Fam Med.* 2009;22(5):528–534. **doi:10.3122/jabfm.2009.05.090044.**
10. Ting RZ, Szeto CC, Chan MH, Ma KK, Chow KM. Risk factors of vitamin B12 deficiency in patients receiving metformin. *Arch Intern Med.* 2006;166(18):1975–1979. **doi:10.1001/archinte.166.18.1975.**
11. Damião CP, Rodrigues AO, Pinheiro MFMC, et al. Prevalence of vitamin B12 deficiency in type 2 diabetic patients using metformin: a cross-sectional study. *Sao Paulo Med J.* 2016;134(6):473–479. **doi:10.1590/1516-3180.2015.01382111.**
12. Wee AKH, Sultana R. Determinants of vitamin B12 deficiency in patients with type-2 diabetes mellitus—a primary-care retrospective cohort study. *BMC Prim Care.*2023;24:102. **doi:10.1186/s12875-023-02057-x.**
13. Gao L, Ran X, Liu X, et al. The effects of daily dose and treatment duration of metformin on the prevalence of vitamin B12 deficiency and peripheral neuropathy in Chinese patients with type 2 diabetes mellitus: a multicenter cross-sectional study. *J Diabetes.* 2023;15(9):765–776. **doi:10.1111/1753-0407.13428.**
14. Singh AK, Kumar A, Karmakar D, Jha RK. Association of B12 deficiency and clinical neuropathy with metformin use in type 2 diabetes patients. *J Postgrad Med.* 2013;59(4):253–257. **doi:10.4103/0022-3859.123143.**
15. Alvarez M, Rincón Sierra O, Saavedra G, Moreno S. Vitamin B12 deficiency and diabetic neuropathy in patients taking metformin: a cross-sectional study. *Endocr Connect.* 2019;8(10):1324–1329. **doi:10.1530/EC-19-0382.**

 © 2026 Dr. Shivaraj Hadimani et al. Open Access under the Creative Commons Attribution 4.0 International License.