Evaluation of Micronutrients and Components of Macronutrients Intake in Cardiac Patients: A Cross-sectional Study of Cardiovascular Nutritional Risk in Lahore, Pakistan

Muteeba Komal [1], Muhammad Jawad [2*], Zainab Malik [3], Shaheer Ahmed [4], Maham Shafique [5], Manahil Afzal [6], Faran Khan [7], Izza Shahzad [8], Muhammad Saad [9]

[1,2,3,5] Department of Public Health, Health Services Academy, Islamabad, Pakistan

[1,2,4,6] Department of Nutrition Sciences, School of Health Sciences, University of Management and Technology, Lahore, Pakistan

[7] Department of Clinical Services, SHS, UMT, Lahore, Pakistan

[8] Department of Applied Psychology, GCUF, Faisalabad, Pakistan

[9] Pakistan Institute of Rehabilitation Sciences, ISRA University, Islamabad

* Corresponding Author: **Muhammad Jawad**

Article Info

ISSN (online): 2582-8940
Volume: 07
Issue: 01
January-March 2026
Received: 01-11-2025
Accepted: 20-12-2025
Published: 10-01-2026
Page No: 73-79

Abstract

Objectives: To assess micronutrients intake and evaluate macronutrients components to identify nutritional deficiencies underlying cardiovascular risks.

Methods: A simple random sampling technique was utilized. The study population consisted of cardiac patients aged 18–50 years, admitted to the inpatient department of a tertiary-care public cardiology facility. A sample size of (N=222) was calculated using OpenEpi, with a 5% margin of error and an assumed cardiovascular disease prevalence of 17.5%. A cross-sectional design was employed to obtain a snapshot of prevailing nutritional risk. Data were collected using a self-designed demographic survey and the Mini Nutritional Assessment—Short Form tool. Participants' dietary intake was analyzed using a weekly Food Frequency Questionnaire, with Cronometer software used to estimate nutrient values. Data were analyzed using IBM SPSS version 25.0, applying descriptive statistics, bivariate analysis (chi-square), and multivariate analysis of variance (MANOVA), with significance set at $p < 0.05$.

Results: The mean age of participants was 33.47 ± 9.44 years. The sample included 44.1% (n=98) males and 55.9% (n=124) females. Body mass index (BMI) distribution was 28.4% (n=63) underweight, 34.2% (n=76) normal weight, 28.4% (n=63) overweight, and 9.0% (n=20) obese. MANOVA indicated a statistically significant overall difference in nutrient intake profiles (Wilks' $\Lambda = 0.76$, $F(10, 428)$, $p < 0.001$). Well-nourished individuals demonstrated the highest mean intake of B vitamins, whereas malnourished individuals showed the lowest. Fat-soluble vitamin intake was also significantly higher among well-nourished individuals (Wilks' $\Lambda = 0.51$, $F(20, 418)$, $p < 0.001$). Similarly, mineral consumption differed significantly between groups, with the lowest intake observed in malnourished individuals.

Conclusion: Increased nutritional risk, associated with reduced food consumption during cardiovascular disease, was evident. Future studies are recommended to establish causal relationships between specific vitamins, minerals, and cardiovascular outcomes.

DOI: https://doi.org/10.54660/IJMBHR.2026.7.1.73-79

Keywords: Micronutrients intake, CVDs, nutritional risk, cardiac patients, nutrients deficiencies

Introduction

According to the World Health Organization (WHO), cardiovascular diseases (CVDs) are the leading cause of death worldwide. In 2022 alone, an estimated 19.8 million deaths were attributed to CVDs, accounting for approximately 32% of global mortality[1]. Furthermore, global CVD prevalence increased from 0.061% in 2010 to 0.070% in 2019 [2]. In the European region, over 60 million potential years of life are lost annually to CVDs, with mortality higher among women than men [3]. A particularly notable surge has been observed in South Asia, where prevalence rose from 3304.2 to 4944.1 cases per 100,000 population between

1990 and 2019, an increase of about 49.6% [4]. In Pakistan, data from the 2019 Global Burden of Disease study indicate an age-standardized CVD incidence of 918.18 per 100,000 people, markedly higher than the global average of 684.33 per 100,000 [5].

Nutritionally poor diets have a significant adverse impact on cardiovascular health, whereas nutritionally rich diets and their functional food components are effective in preventing and reducing CVD risk [6]. Multiple studies suggest that more than 90% of myocardial infarctions could be prevented through improved nutrition and environmental factors [6-8]. Adequate and balanced intake of various vitamins, including A, B-complex, C, D, E, and K, plays a preventive role in human health. Vitamin A, for instance, supports immune function, growth, and mucosal integrity, thereby contributing to improved cardiovascular outcomes [9].

Vitamin D modulates cardiac muscle function [10], while vitamin E exerts anti-oxidative properties that may prevent cardiovascular cancers [11]. Vitamin C, in turn, protects vascular endothelial function [12]. Furthermore, B-complex vitamins play a significant protective role in the prevention of cardiovascular diseases [13]. In addition to vitamins, several minerals are key to CVD prevention. Potassium regulates blood pressure and reduces the risk of coronary heart disease and stroke.[14] Low magnesium levels are an established predictor of CVDs,[15] whereas calcium is involved in cardiac muscle contraction and the bone–heart axis [16]. Adequate selenium and zinc support normal cardiovascular function, [17] and balanced iron levels are vital for cardiovascular well-being[16].

Macronutrient components, including sugars, fiber, protein, saturated fats, trans fats, and unsaturated fats—also influence cardiovascular health. Saturated and trans fats adversely affect cardiovascular outcomes, while unsaturated fats (both monounsaturated and polyunsaturated) are beneficial[19]. Dietary fiber within carbohydrates demonstrates positive cardiovascular effects, whereas high sugar intake contributes to vascular damage[20]. Although recent evidence shows no direct effect of protein on heart health, optimal protein intake is necessary to reduce CVD-related mortality [21].

Several nutritional risk assessment tools are used in cardiac patients, with the Subjective Global Assessment (SGA) and Mini Nutritional Assessment (MNA) being the most prominent. The MNA categorizes patients into three groups: 1) normal nutritional status, 2) at risk of malnutrition, and 3) malnourished. Similarly, the SGA classifies patients into Stage A (well-nourished), Stage B (moderately malnourished), and Stage C (severely malnourished) [22-24].

This study aims to promote better cardiovascular health by evaluating nutrient intake patterns in cardiac patients, with a focus on assessing micronutrient intake and macronutrient composition to identify nutritional deficiencies that may contribute to cardiovascular risk. These deficiencies could also serve as nutritional risk factors associated with the national burden of CVDs. Limited data are currently available on nutrient intake among cardiac patients in Pakistan, particularly in Lahore.

Methods

Study population and characteristics

A simple random sampling technique was used after identifying the target population from the cardiac wards of the facility. The study population consisted of cardiac patients aged 18–50 years, admitted to the inpatient department of a tertiary-care public cardiology facility. A sample of 222 participants (N = 222) was calculated using OpenEpi with a 5% margin of error, a CVD prevalence of 17.5% in Punjab, Pakistan,[25] and a design effect of 1.0 for a random sample. Both male and female patients were included if they had a clinical diagnosis of cardiac disease and had received treatment for at least one day as inpatients. Patients with comorbid systemic or psychiatric conditions, such as bipolar disorder, schizophrenia, dementia, or other mental disorders—were excluded, as these conditions could impede their ability to provide accurate study-related information.

Data collection and study design

A cross-sectional design was employed to obtain a snapshot of the prevailing nutritional risk among patients with CVD. Data were collected using a self-designed demographic survey and the Mini Nutritional Assessment—Short Form (MNA-SF). Dietary intake was assessed using a weekly Food Frequency Questionnaire (FFQ) with estimated portion sizes based on household food measures. Nutrient values were estimated using Cronometer, an application designed to accurately quantify calories, macronutrients, and micronutrients. Data collection took place over approximately five months, from January 3, 2024, to May 30, 2024. Prior to data collection, approval was obtained from the Institutional Review Committee (letter no. 0299/IRC/BMR). Informed consent was obtained from each participant to ensure ethical adherence and transparency.

Statistical analysis

Data were analyzed using IBM SPSS version 25.0. Descriptive statistics, including mean (M), standard deviation (SD), frequency (f), and percentage (%) were applied after confirming normality assumptions. Bivariate analysis using the Chi-square test was performed on non-parametric variables. Additionally, multivariate analysis of variance (MANOVA) was conducted to examine group differences and maintain statistical rigor.

Results

Table 1: Descriptive statistics of demographic characteristics

Variable	Category	Mean ± SD	Frequency (f)	Percentage (%)
Age (years)	—	**33.47 ± 9.44**	—	—
Gender	Male	—	98	44.1
	Female	—	124	55.9
BMI Category	Underweight	—	63	28.4
	Normal	—	76	34.2
	Overweight	—	63	28.4
	Obese	—	20	9.0

The mean age of participants was 33.47 ± 9.44 years (Table 1). The sample included 98 males (44.1%) and 124 females (55.9%). Body mass index (BMI) distribution was as follows: 63 participants (28.4%) were underweight, 76 (34.2%) were of normal weight, 63 (28.4%) were overweight, and 20 (9.0%) were obese.

Table 2: Chi-square analysis between BMI and gende

BMI	Gender		Chi-square (χ^2)	*p*-value
	Female	**Male**		
Underweight	38	25	9.767	.021*
Normal	39	37		
Overweight	30	33		
Obese	17	3		
Total	124	98		

Note: $p < 0.05^*$, $p < 0.01^{**}$

Gender-stratified BMI data were presented in Table 2. Female participants included 38 underweight, 39 normal weight, 30 overweight, and 17 obese individuals. Male participants included 25 underweight, 37 normal weight, 33 overweight, and 3 obese individuals. A statistically significant association was found between gender and BMI (χ^2 = 9.767, p < .05), indicating that gender significantly influenced BMI distribution in this study.

Table 3: Chi-square analysis between gender and nutritional risk

Nutritional risk	Gender		Chi-square (χ^2)	*p*-value
	Female	**Male**		
Normal nutritional status	5	4	7.836	.020*
At risk of malnutrition	58	28		
Malnourished	61	66		
Total	124	98		

Note: $p < 0.05^*$, $p < 0.01^{**}$

Nutritional risk status by gender was displayed in Table 3. Among females, 5 were well-nourished, 58 were at risk of malnutrition, and 61 were malnourished. Among males, 4 were well-nourished, 28 were at risk, and 66 were malnourished. A significant relationship was observed between gender and nutritional risk (χ^2 = 7.836, p < .05). While the proportion of females at risk of malnutrition was notably higher, the malnourished category included comparable numbers of males and females.

Table 4: Descriptive statistics of macronutrient components intake by nutritional risk

Nutrients	Nutritional risk		
	Normal nutritional status (n =9)	**At risk of malnutrition (n = 86)**	**Malnourished (n = 127)**
Fiber (g)	28.22±1.68	21.41±5.74	16.33±12.14
Starch (g)	120±26.53	100.03±41.89	69.25±41.33
Sugars (g)	102.38±8.91	76.90±29.02	134.21±353.56
Saturated fats (g)	17.38±1.52	15.30±7.83	13.83±7.38
Trans fats (g)	0.90±0.00	1.18±0.87	0.96±0.72

A MANOVA was conducted to compare macronutrient intake across nutritional risk groups (Table 4). A statistically significant overall effect was observed (Wilk's Λ = 0.76, F(10, 428) = , p < .001), indicating significant differences in nutrient intake by nutritional status. The effect size was moderate (partial η^2 = 0.127), with observed power of 1.00, confirming adequate sample size. As nutritional status declined, mean daily intake of fiber decreased from 28.22 ± 1.68 g (well-nourished) to 16.33 ± 12.14 g (malnourished), and starch intake decreased from 120.26 ± 26.53 g to 69.25 ± 41.33 g. In contrast, mean sugar intake was higher in malnourished individuals (134.21 ± 353.56 g) compared to well-nourished individuals (102.38 ± 8.91 g), though variance was high in the malnourished group. Mean saturated fat intake was 17.38 ± 1.52 g, 15.30 ± 7.83 g, and 13.83 ± 7.38 g in the well-nourished, at-risk, and malnourished groups, respectively. Corresponding trans fat intake values were 0.90 ± 0.00 g, 1.18 ± 0.87 g, and 0.96 ± 0.72 g.

Table 5: Descriptive statistics of B-vitamins intake by nutritional risk

Nutrients	Nutritional risk		
	Well-nourished	**At risk**	**Malnourished**
B1 (mg)	1.60±0.00	1.28±0.50	0.98±0.57
B2 (mg)	1.75±0.05	1.27±0.44	0.98±0.60
B3 (mg)	24.12±3.53	16.93±7.41	9.31±6.11
B5 (mg)	6.25±0.15	4.09±1.57	2.86±1.65
B6 (mg)	1.84±0.05	1.29±0.52	0.85±0.53
B9 (µg)	501.86±42.84	380.21±163.28	206.40±146.99
B12 (µg)	3.05±0.42	2.13±1.37	1.97±1.92

A significant multivariate effect of nutritional risk status on B-vitamin intake was observed (Wilk's Λ = 0.52, F(14, 424) = , $p < .001$) (Table 5). The effect size was large (partial η^2 = 0.275), with observed power of 1.00, indicating robust results. Well-nourished individuals had the highest mean B-vitamin intake, followed by those at risk of malnutrition; the lowest intake was observed in malnourished individuals.

Table 6: Descriptive statistics of fats and water soluble vitamins intake by nutritional risk

	Nutritional risk		
Nutrients	**Well-nourished**	**At risk**	**Malnourished**
Vitamin A (µg)	460.67±61.92	352.79±205.27	224.03±196.19
Vitamin C (mg)	60.61±15.75	73.26±50.62	45.92±32.83
Vitamin D (IU)	157.83±48.69	105.17±70.95	68.89±68.43
Vitamin E (mg)	14.34±3.84	6.23±3.29	6.59±5.63
Vitamin K (µg)	76.30±6.64	65.77±88.56	40.12±34.08

Nutritional risk status significantly affected fat-soluble vitamin intake (Wilk's Λ = 0.68, F(10, 428) = , $p < .001$) (Table 6). The effect size was moderate (partial η^2 = 0.173; observed power = 1.00). Well-nourished individuals demonstrated higher intakes of vitamins A, D, E, and K compared to at-risk and malnourished groups. Vitamin C intake was slightly higher in the at-risk group, while malnourished individuals had the lowest intake.

Table 7: Descriptive statistics of minerals intake by nutritional risk

	Nutritional risk		
Nutrients	**Well-nourished**	**At risk**	**Malnourished**
Calcium (mg)	665.10±25.61	505.68±201.60	415.85±322.05
Copper (mg)	1.30±0.00	1.04±0.29	0.66±0.37
Iron (mg)	15.04±1.84	11.44±4.69	6.48±4.99
Magnesium (mg)	319.11±26.45	252.14±76.63	170.76±105.42
Manganese (mg)	7.48±0.10	6.24±2.03	4.20±2.95
Phosphorus (mg)	1326.04±18.92	944.67±393.41	691.60±422.81
Potassium (mg)	2961.58±34.73	2104.24±608.72	1519.41±792.89
Selenium (µg)	130.23±10.27	102.68±39.39	63.68±40.61
Sodium (mg)	1761.51±746.71	1720.82±793.86	967.06±630.92
Zinc (mg)	10.10±0.47	7.42±2.88	4.77±2.90

A MANOVA revealed a significant multivariate effect of nutritional risk on mineral consumption (Wilk's Λ = 0.51, F(20, 418) = , $p < .001$) (Table 7). The effect size was large (partial η^2 = 0.284; observed power = 1.00). Descriptive statistics showed a consistent gradient: well-nourished participants had the highest intake of all measured minerals (calcium, copper, iron, magnesium, manganese, phosphorus, potassium, selenium, sodium, zinc), at-risk individuals had moderately reduced intake, and malnourished individuals had the lowest intake across all minerals.

Discussion

As evident from the findings of this study, the prevalence of being underweight, having a normal BMI, and being overweight was higher among the studied population of cardiac patients. Interestingly, female participants took part in the study in greater numbers, while males were less represented. This finding deviated from the cultural and hospital setting, where women were typically less able to speak freely with male healthcare professionals without the presence of family members. These results also contrasted with a previous cross-sectional study, in which women were underrepresented compared to men [25]. Another prospective stability trial reported that both underweight BMI (<20 kg/m²) and very high BMI (>35 kg/m²) were strong markers of risk for poor prognosis [26].

Moreover, findings from the Chi-square analysis demonstrated that more females were in the underweight and obese categories, whereas both genders had similar numbers in the normal and overweight categories. A significant relationship ($\chi^2 = 9.767$, $p < 0.05$) was observed between BMI and cardiovascular diseases. A previous systematic review and meta-analysis supported these findings, reporting a J-shaped relationship between BMI and mortality in cardiac patients, suggesting an inverse association of mortality risk with BMI [27]. Another study reported increased incidences of cardiac mortality among obese individuals [28].

Additionally, the chi-square analysis of nutritional risk revealed that female participants were at higher risk of malnutrition; however, both genders had higher numbers in the malnourished state. A statistically significant relationship was established between gender and nutritional risk (χ^2 = 7.836, $p < .05$). A previous study reported persistent gaps in food security between men and women, which kept women at higher risk of malnourishment [29]. Contrarily, a retrospective analysis indicated that both underweight status and risk of malnutrition directly predicted the odds of in-hospital mortality in men, but not in women with cardiac diseases [30].

Furthermore, findings from the MANOVA test demonstrated significant differences among nutritional risk groups regarding macronutrient intake. The sample size was sufficient to determine the effect size for nutrient intake across the groups. Intake of dietary fiber was highest in subjects with normal nutritional status and gradually declined in those at risk of malnutrition and those who were malnourished. Similarly, starch intake also declined progressively across groups from normal nutritional status to malnourished state. Lower intake of fiber and higher intake of refined carbohydrates could result in cardio-metabolic complications in patients with cardiac diseases. A previous study reported a negative association between higher fiber intake, lower refined carbohydrate intake, and cardio-metabolic complications such as diabetes and hypertension [31].

The current study also illustrated that high sugar intake was more prevalent in malnourished individuals compared to those with normal nutritional status or at risk of malnutrition. Meanwhile, no significant difference was observed in trans fat intake among the groups; however, saturated fat intake steadily declined from the normal to the malnourished group. A probable explanation for these patterns may be reduced food intake following admission to cardiac inpatient wards. Another study demonstrated that lower fat intake coupled with higher carbohydrate consumption was associated with adverse lipid profiles, while higher saturated fat intake was linked to poorer outcomes [32].

Additionally, a steady decline was observed in the intake of all analyzed B vitamins, including B1, B2, B3, B4, B5, B6, B9, and B12. Every B vitamin intake was lowest in the malnourished group and highest in the normal group. Lower intake of these vitamins from food sources may exacerbate the severity of cardiac disease symptoms. Conversely, adequate vitamin B complex intake may play a protective role in preventing cardiovascular diseases. These findings are supported by a systematic review and meta-analysis in which higher intakes of B vitamins were associated with lower cardiovascular risk.[33] Another study reported that vitamin B complex reduced the risk of metabolic syndrome, a known complication in cardiovascular diseases [34].

Concomitantly, intake of fat-soluble vitamins (A, D, E, and K) declined progressively from normal nutritional status to malnourished status, whereas the water-soluble vitamin C was surprisingly higher in the at-risk group. Poor nutritional intake may explain the persistent decline in fat-soluble vitamin levels from normal to malnourished patients. These findings align with a cross-sectional study that reported persistently lower caloric and macronutrient intake among patients with congestive heart failure, leading to reduced micronutrient intake [35]. As reported in previous studies, fat-soluble vitamins, especially vitamin K (specifically K2), play a protective role in heart health [36, 37]. Regarding vitamin C intake, another study confirmed its beneficial effect on improving lipid profiles in patients with cardiovascular disease [38].

Finally, findings from mineral intake analysis revealed that individuals with normal nutritional status had the highest intake of calcium, copper, iron, magnesium, manganese, phosphorus, potassium, selenium, sodium, and zinc. Those at risk of malnutrition and in a malnourished state had lower intakes of these essential minerals. Cardiac patients with lower mineral intake may face a higher likelihood of severe complications and mortality risk. These findings are consistent with previous research in which lower mineral intake was associated with higher mortality rates, increased hospitalization costs, longer hospital stays, and greater complication rates [39]. Another study reported that mineral intake was negatively associated with the risk of all-cause cardiovascular mortality across different BMI categories [40].

Limitations

The overall sample size was adequate to support replication and generalization of the findings; however, future work with a larger sample is needed to establish a causal relationship between nutritional risk and cardiac outcomes. Additionally, this study was not designed to establish a causal association between nutritional risk factors and the incidence of cardiac diseases. These limitations could be addressed through longitudinal cohort studies, with a focus on determining the causal role of nutrient intake in the development of cardiac diseases.

Conclusion

The results of this study suggested that nutritional risk was increased with reduced food consumption among individuals with cardiovascular disease. Substantial micronutrient deficiencies were evident among those categorized as malnourished. Further studies are recommended to establish causal relationships between specific vitamins, minerals, and cardiovascular disease incidence, which may provide deeper insight into underlying pathophysiological mechanisms. Such research could inform the development of policies and preventive approaches aimed at reducing the global burden of cardiovascular disease.

Acknowledgement

The authors acknowledge Ms. Marriam Ahmed for her continuous support and assistance in obtaining the ethical approval letter and for her guidance during manuscript preparation. Her contributions were instrumental in the smooth completion of this manuscript.

Declarations

Authors' contributions

Muteeba Komal and Muhammd Jawad designed the study, did conceptualization, collected data and wrote original manuscript, Zainab Malik and Shaheer Ahmed performed statistical analysis, and interpretation of the data, Maham Shafique and Manahil Afzal prepared the final document, critically revised it and validate methodology, Faran Khan did supervision, validation and proofreading of the final document, Izza Shahzad and Muhammad Saad critically revised the manuscript and approved the final version.

Ethical Approval

This study was approved by the Institutional Review Committee (IRC) for Biomedical Research of University of South Asia Lahore under the letter no. 0299/IRC/BMR.

Conflict of Interest

All authors declare no conflict of interest for this study at any point.

Funding

No funding was received to perform this research. This work is the collaborative effort of all the authors. All authors are based in low-middle-income country.

References

1. World Health Organization. Cardiovascular diseases (CVDs) . Geneva: World Health Organization; 2025 Jul 31 . Available from: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds).
2. Rethemiotaki I. Global prevalence of cardiovascular diseases by gender and age during 2010-2019. Arch Med Sci Atheroscler Dis. 2023;8:e196-205. doi:10.5114/amsad/176654.
3. Timmis A, Townsend N, Gale CP, Torbica A, Lettino M, Petersen SE, *et al*. European Society of Cardiology: cardiovascular disease statistics 2019. Eur Heart J.

2020;41(1):12-85.
4. Raheem A, Ahmed S, Kakar AW, Majeed H, Tareen I, Tariq K, *et al*. Burden of cardiovascular diseases in South Asian region from 1990 to 2019: findings from the global burden of disease study. Pak Heart J. 2022;55(1):15-21.
5. Samad Z, Hanif B. Cardiovascular diseases in Pakistan: imagining a postpandemic, postconflict future. Circulation. 2023;147(17):1261-3. doi:10.1161/CIRCULATIONAHA.122.059122.
6. Tappia PS, Blewett H. Nutrition and cardiovascular health. Int J Mol Sci. 2020;21(7):2284. doi:10.3390/ijms21072284.
7. Gadgil MD, Anderson CA, Kandula NR, Kanaya AM. Dietary patterns are associated with metabolic risk factors in South Asians living in the United States. J Nutr. 2015;145(6):1211-7. doi:10.3945/jn.114.207753.
8. Mritunjay M, Ramavataram DVSS. Predisposing risk factors associated with acute myocardial infarction (AMI): a review. Indian J Forensic Med Toxicol. 2021;15(2):[pages not provided in query].
9. Andrès E, Lorenzo-Villalba N, Terrade JE, Méndez-Bailon M. Fat-soluble vitamins A, D, E, and K: review of the literature and points of interest for the clinician. J Clin Med. 2024;13(13):3641. doi:10.3390/jcm13133641.
10. de la Guía-Galipienso F, Martínez-Ferran M, Vallecillo N, Lavie CJ, Sanchis-Gomar F, Pareja-Galeano H. Vitamin D and cardiovascular health. Clin Nutr. 2021;40(5):2946-57. doi:10.1016/j.clnu.2020.12.025.
11. US Preventive Services Task Force, Mangione CM, Barry MJ, Nicholson WK, Cabana M, Chelmow D, *et al*. Vitamin, mineral, and multivitamin supplementation to prevent cardiovascular disease and cancer: US Preventive Services Task Force recommendation statement. JAMA. 2022;327(23):2326-33. doi:10.1001/jama.2022.8970.
12. Morelli MB, Gambardella J, Castellanos V, Trimarco V, Santulli G. Vitamin C and cardiovascular disease: an update. Antioxidants (Basel). 2020;9(12):1227. doi:10.3390/antiox9121227.
13. Aguilera-Méndez A, Boone-Villa D, Nieto-Aguilar R, Villafaña-Rauda S, Molina AS, Sobrevilla JV. Role of vitamins in the metabolic syndrome and cardiovascular disease. Pflugers Arch. 2022;474(1):117-40. doi:10.1007/s00424-021-02619-x.
14. McLean RM, Wang NX. Potassium. Adv Food Nutr Res. 2021;96:89-121. doi:10.1016/bs.afnr.2021.02.013.
15. Liu M, Dudley SC Jr. Magnesium, oxidative stress, inflammation, and cardiovascular disease. Antioxidants (Basel). 2020;9(10):907. doi:10.3390/antiox9100907.
16. Michos ED, Cainzos-Achirica M, Heravi AS, Appel LJ. Vitamin D, calcium supplements, and implications for cardiovascular health: JACC focus seminar. J Am Coll Cardiol. 2021;77(4):437-49. doi:10.1016/j.jacc.2020.09.617.
17. Othon-Martínez D, Fernandez-Betances OA, Málaga-Espinoza BX, Torres-Perez ME, Cobos E, Gutierrez-Martinez C. Iron and cardiovascular health: a review. J Investig Med. 2024;72(8):787-97. doi:10.1177/10815589241268462.
18. DiNicolantonio JJ, O'Keefe JH. Monounsaturated fat vs saturated fat: effects on cardio-metabolic health and obesity. Mo Med. 2022;119(1):69-73.
19. Evans CEL. Dietary fibre and cardiovascular health: a review of current evidence and policy. Proc Nutr Soc. 2020;79(1):61-7. doi:10.1017/S0029665119000673.
20. Fischer NM, Pallazola VA, Xun H, Cainzos-Achirica M, Michos ED. The evolution of the heart-healthy diet for vascular health: a walk through time. Vasc Med. 2020;25(2):184-93. doi:10.1177/1358863X19901287.
21. Jawad M, Maryam M, Tariq M, Khan F. Screening, assessment and evaluation of macronutrients & their components intake among cardiac patients at tertiary care hospital of Lahore. Int J Pharm Integr Health Sci. 2024;5(2). doi:10.56536/ijpihs.v5i2.136.
22. Jarosz I, Gorecki K, Kalisz G, Popiolek-Kalisz J. Nutritional status assessment tools in cardiovascular patients. Nutrients. 2025;17(16):2703. doi:10.3390/nu17162703.
23. Zhou YQ, He WM, Jing S, Xie YQ, Chen S, Li JN. Comparing GLIM and SGA nutritional criteria for malnutrition assessment and prognosis in chronic heart failure patients. Int J Gen Med. 2025;18:1669-79. doi:10.2147/IJGM.S514143.
24. Steinberg JR, Turner BE, Weeks BT, Magnani CJ, Wong BO, Rodriguez F, *et al*. Analysis of female enrollment and participant sex by burden of disease in US clinical trials between 2000 and 2020. JAMA Netw Open. 2021;4(6):e2113749. doi:10.1001/jamanetworkopen.2021.13749.
25. Held C, Hadziosmanovic N, Aylward PE, Hagström E, Hochman JS, Stewart RA, *et al*. Body mass index and association with cardiovascular outcomes in patients with stable coronary heart disease: a STABILITY substudy. J Am Heart Assoc. 2022;11(3):e023667. doi:10.1161/JAHA.121.023667.
26. Wang ZJ, Zhou YJ, Galper BZ, Gao F, Yeh RW, Mauri L. Association of body mass index with mortality and cardiovascular events for patients with coronary artery disease: a systematic review and meta-analysis. Heart. 2015;101(20):1631-8.
27. Wei S, Nguyen TT, Zhang Y, Ryu D, Gariani K. Sarcopenic obesity: epidemiology, pathophysiology, cardiovascular disease, mortality, and management. Front Endocrinol (Lausanne). 2023;14:1185221. doi:10.3389/fendo.2023.1185221.
28. Ma C, Ho SK, Singh S, Choi MY. Gender disparities in food security, dietary intake, and nutritional health in the United States. Am J Gastroenterol. 2021;116(3):584-92.
29. Kwaśny A, Uchmanowicz I, Juárez-Vela R, Młynarska A, Łokieć K, Czapla M. Sex-related differences in the impact of nutritional status on in-hospital mortality in heart failure: a retrospective cohort study. Eur J Cardiovasc Nurs. 2024;23(2):176-87.
30. Brandt EJ, Leung CW, Chang T, Ayanian JZ, Banerjee M, Kirch M, *et al*. Differences in US adult dietary patterns by cardiometabolic health and socioeconomic vulnerability. J Nutr. 2025 Jun 9. doi:10.1016/j.tjnut.2025.05.012. [Note: Exact DOI may vary; based on query details.]
31. Koemel NA, Senior AM, Laouali N, Celermajer DS, Grech A, Parker HM, *et al*. Associations between dietary macronutrient composition and cardiometabolic health: data from NHANES 1999–2014. Eur J Nutr. 2025;64(1):41. [Note: Volume/issue adjusted per standard.]
32. Miao Y, Guo Y, Chen Y, Lin Y, Lu Y, Guo Q. The effect

of B-vitamins on the prevention and treatment of cardiovascular diseases: a systematic review and meta-analysis. Nutr Rev. 2024;82(10):1386-401.
33. Wu Y, Li S, Wang W, Zhang D. Associations of dietary vitamin B1, vitamin B2, niacin, vitamin B6, vitamin B12 and folate equivalent intakes with metabolic syndrome. Int J Food Sci Nutr. 2020;71(6):738-49.
34. Godinez Flores T, Barron C, Payró G, Castillo Martinez LI. Inadequate calorie and macronutrient intake in a population with congestive heart failure in a non-cardiovascular tertiary hospital. Circulation. 2024;150(Suppl_1):A4119926.
35. Aliasgharpour M. Fat soluble vitamins role in health promotion. J Emerg Health Care. 2022;11(4):49-68.
36. Haugsgjerd TR, Egeland GM, Nygård OK, Vinknes KJ, Sulo G, Lysne V, *et al*. Association of dietary vitamin K and risk of coronary heart disease in middle-age adults: the Hordaland Health Study Cohort. BMJ Open. 2020;10(5):e035953. doi:10.1136/bmjopen-2019-035953.
37. Moser MA, Chun OK. Vitamin C and heart health: a review based on findings from epidemiologic studies. Int J Mol Sci. 2016;17(8):1328. doi:10.3390/ijms17081328.
38. Bansal N, Alharbi A, Shah M, Altorok I, Assaly R, Altorok N. Impact of malnutrition on the outcomes in patients admitted with heart failure. J Clin Med. 2024;13(14):4215.
39. Duan C, Lv M, Shou X, Chen Z, Luan Y, Hu Y. Associations between nine dietary minerals intake and all-cause mortality in individuals with atherosclerotic cardiovascular disease. Front Nutr. 2024;11:1447167. doi:10.3389/fnut.2024.1447167.