Section: Community Medicine

Systematic Review and Meta-Analysis

NUTRITIONAL STATUS AND HEALTH OUTCOME IN VEGETARIAN, VEGAN AND NON-VEGETARIAN DIETS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: Dietary patterns directly impact nutrient intake and long-term health outcomes. With increasing worldwide interest in plant-based diets, understanding their nutritional adequacy and health outcome is essential.
Objective: To systematically review and quantitatively analyse nutrient intake and health outcomes across vegetarian, vegan and non-vegetarian dietary patterns.
Materials and Methods: A comprehensive search was conducted in PubMed, Google Scholar and other databases for studies comparing macronutrient/micronutrient intake and health outcomes like hypertension, diabetes, cardiovascular disease and stroke among three diets. Eleven eligible observational studies and randomised controlled trials (RCTs) were analysed using a random-effects model. Risk of bias was assessed using Newcastle-Ottawa Scale (NOS), Joanna Briggs Institute (JBI) Checklist and Cochrane Risk of Bias Tool 2.0 (RoB 2.0).
Results: Non-vegetarians had highest intake of energy, protein, fats, vitamin B12, calcium and vitamin D. Vegans consumed the most fibre, vitamin C and iron; vegetarians had higher vitamin A. Critically low vitamin B12 intake was noted among vegans (mean: 0.33 µg/day) and vegetarians had suboptimal calcium intake (mean: 501 mg/day). Plant-based diets have been related to improved glycemic management and reduced blood pressure. Despite reduced cardiovascular risk (HR: 0.78), stroke risk was increased among vegetarians (HR: 1.12). High heterogeneity ($I^2 > 90\%$) was observed.
Conclusions: Vegetarian and vegan diets offer adequate fibre and antioxidant intake but lack vitamin B12, calcium and vitamin D. Non-vegetarian diets offer broader nutrient coverage but lack fibre. Customized dietary planning and supplementation are recommended for all groups.
Keywords: Dietary Patterns, Nutritional Status & Health Outcome, Systematic Review & Meta-Analysis.

INTRODUCTION

Healthy eating supports lifelong well-being by promoting optimal functioning and positively influencing both physiological and psychological outcomes.[1] Eating patterns vegetarian, vegan and non-vegetarian have a direct bearing on nutrient consumption and thus on the outcome in terms of health. Vegetarian diet is the one where there is no consumption of meat, fish, eggs etc.[2] Vegan diet is the one where there is no consumption of meat, fish, eggs, dairy products, i.e. only plant-based food items are consumed.[2] Non-vegetarian diet is the one where there is consumption of meat, fish and eggs.[2] Increased popularity of the shift towards plant-based diets has fueled the demand to have greater understanding of its adequacy of nutrients and long-term health effects versus omnivorous diets.[3]

The building blocks of health are nutrients, which include macronutrients: carbohydrates, proteins and fats; and micronutrients, such as vitamins and minerals.[4] Vegetarian and vegan diets, when carefully planned, have a number of health benefits - high in fibre, antioxidants and some vitamins. They are short in some necessary nutrients like vitamin B12, iron, zinc, calcium and omega-3 fatty acids, which can result in deficiency unless supplemented or watched carefully.[5] In contrast, non-vegetarian diets offer haem iron, vitamin B12 and increased protein but are also likely to be linked with an excess of saturated fats and cholesterol, thus elevating the risk of non-communicable diseases (NCDs) such as hypertension and diabetes mellitus.[6]

Many studies have looked at different diets, but the results are still mixed due to varied methods and eating habits across regions. Few have clearly compared all three diet types in terms of nutrient intake, health outcomes and key vitamin and mineral levels in the blood.

This meta-analysis and systematic review seek to fill these loopholes by synthesizing available evidence on the nutritional status and health outcomes of vegetarian, vegan and non-vegetarian diets. In particular, it will:

- Recognize prevalent nutritional deficiencies or excesses in these patterns of diet;
- Compare macronutrient (energy, proteins, fats, fibre) and micronutrient (vitamins and minerals) dietary intake
- Assess the relationship between such diet types and key health outcomes such as hypertension and diabetes mellitus.

This meta-analysis and systematic review will try to fill the gaps that have been present in existing literature by performing a comprehensive comparison of health outcomes and nutrient status when vegetarian, vegan and non-vegetarian diets are compared. By integrating international evidence, this research seeks to support equitable nutrition, diet-related disease burden reduction and the improvement of global public health policy.

MATERIALS AND METHODS

2.1 Search Strategy

The protocol for the systematic review was registered with PROSPERO (Registration Number CRD42025643747). We systematically identified studies reporting nutrient status and health outcomes among vegetarians, vegans and non-vegetarians, including those comparing all three diets, using search terms related to dietary patterns, nutritional intake and health outcomes, i.e. ("Vegetarian diet" OR "veg diet") AND ("vegan diet" OR "plant based diets") AND ("Non-veg diet" OR "non-vegetarian diet") AND ("nutritional intake" OR "nutritional status" OR "nutrients" OR "Vitamins" OR "mineral" OR "micronutrient") AND ("health outcomes" OR "non-communicable diseases" OR "NCD" OR "anaemia" OR "diabetes" OR "hypertension"). The initial literature search was conducted in PubMed, Google scholar, Biomed Central, Clinical key, CORE and DOAJ. For the reporting of this systematic review, the preferred reporting item for systematic reviews and meta-analysis (PRISMA) was used.[7]

2.2 Inclusion and Exclusion criteria

- **Study population:** People consuming vegetarian, vegan and non-vegetarian diets, any age, any gender. Papers were examined from all over the world.
- **Type of studies:** Observational studies and interventional studies, that compared nutrient intake and health outcomes of minimum two different dietary patterns were included. Articles not published in English language were excluded.
- **Diets:** Studies comparing nutrient status and health outcomes among vegetarian, vegan and non-vegetarian diets.
- **Outcome parameters:** The included studies provided data on one or more of the following parameters: dietary intake of energy, protein, fats, fibre, vitamin B12, vitamin A, vitamin C, vitamin D, calcium, iron and health outcomes such as diabetes, hypertension, cardiovascular disease and stroke among vegetarian, vegan and non-vegetarian diets.

2.3 Data Extraction

The identified articles were imported to Ryaan software and duplicates were removed. All records were screened stepwise (title, abstract, full text) per standard methodology. Four independent reviewers screened and extracted data using predefined criteria, with discrepancies resolved through discussion with a fifth reviewer. For each study included, we extracted information about the year in which study was published, study location (country), study design, population characteristics (age-group, gender included), reported dietary pattern etc. For each dietary pattern, we extracted mean and standard deviation of dietary intake and nutritional status of following nutrients: energy, protein, fats, fibre, vitamin B12, vitamin A, vitamin C, vitamin D, calcium, iron. For the studies in which standard deviation was not mentioned, we calculated the standard deviation from confidence interval by using appropriate formula. We also extracted data on diabetes, hypertension, cardiovascular disease and stroke to study the health outcomes.

2.4 Data Handling

The definition of vegetarian, vegan and non-vegetarian diets varied across studies. To ensure consistent interpretation of data, we applied the following uniform definitions to categorize all reported dietary patterns:

- Vegetarian: consuming no meat, fish and eggs at all but can consume dairy.[2]
- Vegan: consuming no meat, fish, dairy and eggs at all.[2]

- Non-vegetarian: consuming meat, fish, eggs, in addition to plant based and dairy foods.[2]

2.5 Data Analysis

For ease of comparison and analysis, for each nutrient intake and status data were reported as Mean and SD and units were matched for each nutrient separately by using appropriate formula. If a study reported data for different age or genders, they were treated as individual data points in these calculations. For health outcome percentage of HbA1c decrease for diabetes, mean decrease in SBP (systolic blood pressure) and DBP (diastolic blood pressure) for hypertension and hazard ratio for CVD (cardiovascular disease) and stroke were taken into consideration.

All the values were compared for three different group i.e. vegetarians, vegans and non-vegetarians. A random-effects model was used to generate the pooled estimates in the forest plot.

2.6 Risk of Bias Assessment

For cohort studies, we utilized the Newcastle-Ottawa Scale (NOS),[8] to assess risk of bias. The NOS evaluates three domains: selection of participants, comparability of study groups and outcomes assessment. Studies were awarded stars in each domain up-to a maximum of 9 stars. Studies with 7-9 stars were low risk, with 5-6 stars were moderate risk and with less than 5 stars were high risk.

For cross-sectional studies we used the Joanna Briggs Institute (JBI) Critical Appraisal Checklist,[9] to assess the risk of bias. The tool evaluates inclusion criteria clarity, study subjects and settings, exposure/outcome assessment validity, identification and adjustment for confounders and appropriateness of statistical analysis. Based on the above criteria studies were awarded 1 point for each criterion fulfilled up to maximum of 8 points. Studies with 7-8 points were low risk, with 5-6 points were moderate risk and with 4 or less than 4 points were high risk of bias.

For randomised controlled trials (RCTs) Cochrane Risk of Bias Tool version 2.0 (RoB 2.0),[10] was used, which evaluates 5 domains including randomization, deviations from intended interventions, missing data, measurements of outcomes and selective reporting. Each domain was assessed and rated as low risk, some concern and high risk.

RESULTS

3.1 Search Results

The literature search and selection process is shown in figure 1. We identified a total of 20923 studies after removing duplicates, 20848 of which were excluded based on review of the title and abstract. The remaining 75 studies were reviewed in full, of which 64 were excluded. A total of 11 studies which met the eligibility criteria were included in the final analysis.

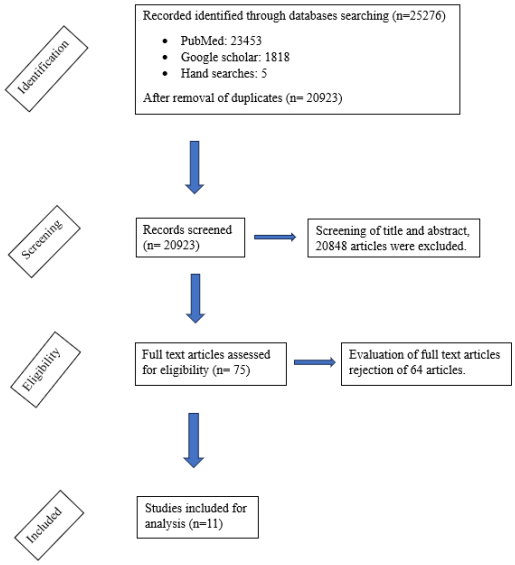

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) flow diagram of the literature screening process

3.2 Study Characteristics

Characteristics of the 11 included studies are shown in table 1. Out of the 11 studies included 6 of them were cross-sectional studies, 3 were cohort studies and 2 were RCT. The groups included in six of the studies were vegetarian, vegan and non-vegetarian, 3 with vegetarian and non-vegetarian, one with vegan and vegetarian and one with vegan and non-vegetarian.

Table 1: Characteristics of the studies included

Sr. No	First Author	Year	Area	Study Design	Sample Size	Groups Included
1.	Gwyneth K Davey et al[11]	2002	France	Cohort	58050	Vegetarian Vegan Non-Vegetarian
2.	Tammy Y N Tong et al[12]	2019	UK	Cohort	48188	Vegetarian Non-Vegetarian
3.	A M J Gilsing et al[13]	2010	UK	Cohort	689	Vegetarian Vegan Non-Vegetarian
4.	Stine Weder et al[14]	2022	Germany	Cross-sectional	430	Vegetarian Vegan Non-Vegetarian
5.	Chin-En Yen et al[15]	2008	Taiwan	Cross-sectional	49	Vegetarian Non-Vegetarian

6.	Christel L Larsson et al[16]	2002	Sweden	Cross-sectional	60	Vegan Non-Vegetarian
7.	Grace Austin et al[17]	2024	Australia	Cross-sectional	230	Vegetarian Vegan Non-Vegetarian
8.	Oliwia Grygorczuk et al[18]	2024	Poland	Cross-sectional	264	Vegetarian Vegan Non-Vegetarian
9.	Synne Groufh-Jacobsen et al[19]	2024	Norway	Cross-sectional	240	Vegetarian Vegan Non-Vegetarian
10.	David Ja Jenkins et al[20]	2022	Canada	RCT	164	Vegetarian Vegan
11.	Lelia Crosby et al[21]	2022	Washington	RCT	244	Vegan Non-Vegetarian

3.3 Nutrient intake and status among vegetarian, vegan and non-vegetarian dietary patterns.

The results for different nutrient status among vegetarian, vegan and non-vegetarian diet has been shown in table 2. The description for individual nutrient is as follow:

3.3.1 Energy

The energy intake is highest among non-vegetarians followed by vegetarians followed by vegan. The mean intake of energy among vegetarian, vegan and non-vegetarian is 6.87 MJ (6.49-7.25), 6.62 MJ (6.37-6.87) and 7.3 MJ (7.04-7.56) respectively. The weighted mean difference is 6.87 MJ (6.54-7.21) with a heterogeneity of 78.3%. Test for Subgroup Differences shows a p-Value of 0.001.

3.3.2 Protein

The protein intake is highest among non-vegetarians followed by vegetarians followed by vegan. The mean intake of protein among vegetarian, vegan and non-vegetarian is 13.41(% total energy) (13.02-13.80), 12.70(% total energy) (12.56-12.84) and 16.71(% total energy) (16.32-17.10) respectively. The weighted mean difference is 14.58(% total energy) (12.86-16.30) with a heterogeneity of 100%. Test for Subgroup Differences shows a p-Value of 0.001.

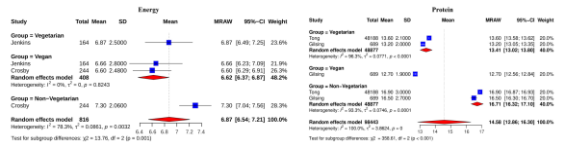

Figure 2: Forest plot for Energy and Protein Intake

3.3.3 Fats

The fat intake is highest among non-vegetarians followed by vegetarians followed by vegan. The mean intake of fats among vegetarian, vegan and non-vegetarian is 31.91(% total energy) (27.04-36.78), 30.83(% total energy) (26.35-35.31) and 33.43(% total energy) (29.18-37.68) respectively. The weighted mean difference is 32.16(% total energy) (29.70-34.62) with a heterogeneity of 98.4%. Test for Subgroup Differences shows a p-Value of 0.70.

3.3.4 Fibre

The fibre intake was highest among vegan followed by vegetarians followed by non-vegetarians. The mean intake of fibre among vegetarian, vegan and non-vegetarian is 25.36 g/day (6.80-43.92), 41.29 g/day (29.46-53.12) and 20.09 g/day (10.61-29.57) respectively. The weighted mean difference is 28.21 g/day (19.58-36.84) with a heterogeneity of 99.8%. Test for Subgroup Differences shows a p-Value of 0.02.

3.3.5 Vitamin B12

The Vitamin B12 intake is highest among non-vegetarians followed by vegetarians followed by vegan. The mean intake of Vitamin B12 among vegetarian, vegan and non-vegetarian is 2.25 microgram (1.61-2.88), 0.33 microgram (0.16-0.49) and 7.98 microgram (6.50-9.46) respectively. The weighted mean difference is 3.52 microgram (0.63-6.41) with a heterogeneity of 100%. Test for Subgroup Differences shows a p-Value of 0.001.

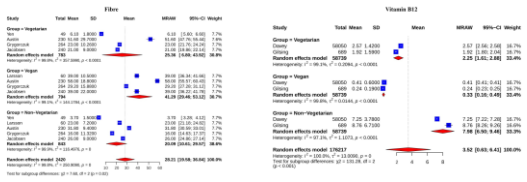

Figure 3: Forest plot for Fibre and Vitamin B12 Intake

3.3.6 Vitamin A

The Vitamin A intake is highest among vegetarians followed by non-vegetarians followed by vegans. The mean intake of Vitamin A among vegetarian, vegan and non-vegetarian is 2393.37 microgram (-980.82-5767.55), 851.07 microgram (555.70-1146.45) and 1160.05 microgram (93.06-2227.04) respectively. The weighted mean difference is 1385.87 microgram (472.82-2298.92) with a heterogeneity of 98.5%. Test for Subgroup Differences shows a p-Value of 0.58.

3.3.7 Vitamin C

The Vitamin C intake is highest among vegan followed by vegetarians followed by non-vegetarians. The mean intake of Vitamin C among vegetarian, vegan and non-vegetarian is 125.84 mg (61.75-189.93), 151.98 mg (77.51-226.45) and 83.66 mg (24.25-143.06) respectively. The weighted mean

difference is 120.04 mg (78.02-162.06) with a heterogeneity of 97.2%. Test for Subgroup Differences shows a p-Value of 0.34.

3.3.8 Vitamin D

On reviewing the study of Gwyneth K Davey et al,[11] the intake of Vitamin D is highest among non-vegetarians followed by vegetarians followed by vegan. Other cross-sectional studies also suggest the same relation between three groups.

3.3.9 Calcium

Calcium intake is highest among non-vegetarians followed by vegan followed by vegetarians. The mean intake of calcium among vegetarian, vegan and non-vegetarian is 501 mg (459.98-542.02), 552.46 mg (191.83-913.09) and 793.00 mg (745.47-840.53) respectively. The weighted mean difference is 599.29 mg (403.67-794.91) with a heterogeneity of 99.2%. Test for Subgroup Differences shows a p-Value of 0.001.

3.3.10 Iron

Iron intake is highest among vegan followed by vegetarians followed by non-vegetarians. The mean intake of iron among vegetarian, vegan and non-vegetarian is 14.11 mg (10.29-17.93), 15.67 mg (14.75-16.59) and 10.76 mg (6.87-14.64) respectively. The weighted mean difference is 13.04 mg (10.62-15.45) with a heterogeneity of 97.9%. Test for Subgroup Differences shows a p-Value of 0.04.

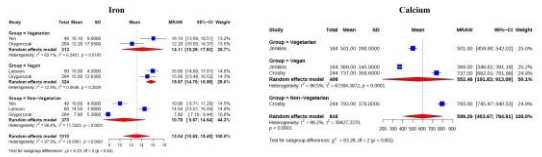

Figure 4: Forest plot for Iron and Calcium Intake

Table 2: Nutrient intake and status among vegetarian, vegan and non-vegetarian dietary patterns

Variables	Study Design used for Meta analysis	Weighted Mean Difference	95% CI	I^2	p-Value (Test for Sub-group differences)	Forest plot
Energy	RCT	6.87 MJ	6.54-7.21	78.3%	0.001	Figure 2
Protein	Cohort	14.58 (% total energy)	12.86-16.30	100%	0.001	Figure 2
Fats	Cross-sectional	32.16 (% total energy)	29.70-34.62	98.4%	0.70	-
Fibre	Cross-sectional	28.21g/day	19.58-36.84	99.8%	0.02	Figure 3
Vitamin B12	Cohort	3.52 microgram	0.63-6.41	100%	0.001	Figure 3
Vitamin A	Cross-sectional	1385.87 microgram	472.82-2298.92	98.5%	0.58	-
Vitamin C	Cross-sectional	120.04 mg	78.02-162.06	97.2%	0.34	-
Iron	Cross-sectional	13.04 mg	10.62-15.45	97.9%	0.04	Figure 4
Calcium	RCT	599.29mg	403.67-794.91	99.2%	0.001	Figure 4

3.4 Health Outcomes Among Vegetarians, Vegans and Non-Vegetarians

Different Health outcomes such as Hypertension, Diabetes, Cardiovascular Diseases, Stroke were looked for and compared.

3.4.1 Hypertension

According to the study of David Ja Jenkins et al,[20] the mean decrease in SBP and DBP (mm/hg) among vegetarians is 5.91 $\pm$ 10.43 and 4.13 $\pm$ 7.22 respectively. Similarly, the mean decrease in SBP and DBP (mm/hg) among vegans is 4.12 $\pm$ 10.4 and 3.54 $\pm$ 7.17 respectively.

3.4.2 Diabetes

According to the study of David Ja Jenkins et al,[20] the mean decrease in HbA1C (%) among Vegetarians and Vegans is 0.88 $\pm$ 0.35 and 0.99 $\pm$ 0.35 respectively. Similarly, according to the study of Grace Austin et al,[17] the mean decrease in HbA1C (%) among vegetarians, Vegans and Non-vegetarians is 0.4 $\pm$ 1.4, 1.8 $\pm$ 4.02 and 0.68 $\pm$ 2.38 respectively.

3.4.3 Cardiovascular diseases and Stroke

According to the study of Tammy Y N Tong et al,[12] the hazards ratio for cardiovascular diseases and stroke for vegetarian diet is 0.78 and 1.12 respectively compared with non-vegetarian diet.

3.5 Risk of Bias Assessment

Risk of bias in included cohort studies Gwyneth K Davey et al,[11] Tammy Y N Tong et al,[12] demonstrated low risk of bias, achieving 8 out of 9 stars on NOS and A M J Gilsing et al,[13] was assessed as moderate risk of bias receiving 6 out of 9 stars.

Among the cross-sectional studies four (Stine Weder et al,[14] Grace Austin et al,[17] Oliwia Grygorczuk et al,[18] Synne Groufh-Jacobsen et al,[19]) demonstrated low risk of bias based on clear definitions, appropriate exposure and outcome assessments, and adjustments for confounding factors. Chin-En Yen et al,[15] and Christel L Larsson et al,[16] were rated as moderate risk of bias due to limited reporting on confounding factors and adjustments.

Both included RCTs David Ja Jenkins et al,[20] and Lelia Crosby et al,[21] demonstrated some concerns for risk of bias primarily due to unclear reporting of randomization methods. Outcome measurement and adherence to interventions were assessed as low risk. Overall, these studies were considered to have some concerns but were deemed suitable for inclusion in the meta-analysis.

DISCUSSION

This systematic review and meta-analysis analysed data from 11 studies comparing nutrient intake and health outcomes among individuals following vegetarian, vegan, and non-vegetarian diets.

4.1 Nutrient Intake Across Dietary Patterns

Our analysis showed significant differences in nutrient intake across dietary groups. Non-vegetarians had the highest intake of energy, protein, fats, vitamin B12, calcium and vitamin D mainly due to larger animal product consumption. Vegans had the highest intake of fibre, vitamin C and iron. Vitamin B12 intake was critically low in vegans (mean: 0.33 µg/day), and calcium intake was below normal in vegetarians (mean: 501 mg/day). Despite high heterogeneity ($I^2 > 90\%$), there is significant subgroup differences in several nutrients indicating the importance of different dietary patterns.

4.2 Health Outcomes

Despite the limited number of studies on health outcomes, plant-based diets were associated with improved blood pressure and glycaemic control. Jenkins et al,[20] found that vegans had a higher HbA1c decrease (0.99%) than non-vegetarians (0.68%). Tammy Y N Tong et al,[12] found that vegetarians had a greater stroke risk (HR: 1.12) despite a decreased cardiovascular disease risk (HR: 0.78), which might be attributed to dietary deficiencies such as vitamin B12 or omega-3 fatty acids. These health outcomes are influenced by many factors, including genetics, lifestyle, and environment. Therefore, the findings reflect the role of diet within this multifactorial context, not direct causation.

4.3 Comparison with Previous Literature

Our findings corroborate earlier systematic review of Timothy J Key et al,[22] indicating that vegetarians and vegans generally consume more fibre and less saturated fat, but may be at risk of deficiencies in vitamin B12, calcium and vitamin D. The observed high intake of iron in vegans and vegetarians is notable. Similarly, the study of Jarle Saeby Dybvik et al,[23] also states that vegetarian diets are associated with reduced risk of CVD, but not stroke supporting our results. According to study of Eliska Selinger et al,[24] vegetarian and vegan diet shows controlled blood pressure and glycaemic control as compared to non-vegetarian diets which supports are results.

4.4 Strengths and Limitations

A major strength of this review is in detailed comparison of three different dietary patterns using meta-analysis. Risk of bias assessment is done in detail. Both observational studies and RCTs are included making it more reliable for population level and interventional inputs.

Dietary patterns vary across socio-cultural and socio-economic contexts, limiting generalizability. Use of a single database may have restricted study coverage. The health outcomes are multifactorial; hence, findings should be interpreted cautiously as associations. High heterogeneity and limited data precluded detailed subgroup and sensitivity analyses.

4.5 Implications and Future Directions

Our results highlight the benefits of plant-based diets with greater amounts of fiber, vitamin C and iron. But these diets carry large deficiencies as well, specifically vitamin B12, calcium and vitamin D. Future research should focus on long-term outcomes including bone health and stroke risk, using a variety of groups and common evaluation methods to guarantee comparability.

CONCLUSION

This systematic review and meta-analysis highlight significant differences in nutrient intake and health outcomes between vegetarian, vegan and non-vegetarian diets. While plant-based diets, particularly vegan are associated with higher intake of fibre, vitamin C and iron; they are deficient in vitamin B12 and vitamin D. Non-vegetarian diets provide higher levels of energy, protein and certain micronutrients but are deficient in fibre intake. Health outcome data suggest potential benefits of plant-based diets in controlling blood pressure and glycaemic control; though some risks such as stroke requires further investigation. Customised dietary planning and supplementation are essential to increase the health benefits of each dietary pattern. Table.3 shows a summary of nutrients excess and deficiency associated with each dietary pattern.

Table 3: Summary of nutrients excess and deficiency associated with each dietary pattern

Dietary pattern	Predominant Nutrients	Deficient Nutrient
Vegetarian	Energy, Fibre, Vitamin A.	Vitamin B12, Calcium.
Vegan	Fibre, Vitamin C, Iron.	Protein, Vitamin B12, Vitamin A, Vitamin D.
Non-Vegetarian	Energy, Protein, Fats, Vitamin B12, Vitamin D, Calcium.	Fibre, Vitamin C, Iron.

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