

ORIGINAL
Research

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The Association of Diet and Lifestyle Factors With Quality of Life and Self-Rated Health in Older Adults: The Loma Linda Longevity Study

Abstract: ***Introduction:** Subjective health predicts mortality in older adults. We examined associations of vegetarian diet, adherence duration, and a Healthy Lifestyle Index with quality of life (QoL) and self-rated health (SRH) in adults ≥ 75 years. **Methods:** We analyzed cross-sectional data from 421 Loma Linda Longevity Study participants using ordinal logistic regression. Three hierarchical models were estimated: M1 (diet + sociodemographic covariates), M2 (M1 + diet duration + Healthy Lifestyle Index), and M3 (final fully adjusted model: M2 + BMI + multimorbidity). Moderation by adherence duration (<10 vs ≥ 10 years) was tested via interaction and stratified analyses. **Results:** The Healthy Lifestyle Index showed strong dose-response (highest vs lowest quartile: QoL aOR = 7.24, 95% CI: 3.31-15.85; SRH aOR = 4.69, 95% CI: 2.26-9.72; both P for trend <0.001). Among long-term adherents (≥ 10 years), vegetarian diet was significantly associated*

with better SRH (aOR = 2.11, 95% CI: 1.11-4.00, P = 0.022). In the fully adjusted model, the

Keywords: lifestyle; vegetarian diet; quality-of-life; self-rated health; older adults

 “The strong association between the HLI and both QoL and SRH may reflect a meaningful convergence of behavioral, physiological, and psychosocial resilience.” 

*vegetarian association attenuated to borderline significance, with multimorbidity (for both outcomes) and BMI (for SRH only) emerging as stronger independent predictors. **Conclusions:** An integrated healthy lifestyle shows a robust dose-response with subjective health. Long-term vegetarian adherence is independently associated with better self-rated health in adults ≥ 75 years.*

Introduction

The global population is aging at an unprecedented rate. By 2030, one in six people worldwide will be aged 60 years or over, and by 2050, this demographic is projected to double to 2.1 billion.¹ Within this group, the oldest-old—those aged 75 years and older—represent the fastest-growing segment, bringing unique public health challenges and a critical need to identify modifiable

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factors that promote not only longevity, but also a high quality of life and positive health perception.^{2,3}

An individual's self-rated health (SRH) and perceived quality of life (QoL) have emerged as powerful and independent predictors of mortality and adverse outcomes in older populations. Recent longitudinal evidence underscores the profound prognostic value of these measures; for instance, a negative perception of health-related QoL has been shown to nearly double the risk of mortality over a seven-year period, even among physically independent older adults.⁴ Similarly, poor SRH is strongly associated with elevated all-cause mortality and has been found to capture short-term mortality risk almost as effectively as comprehensive objective measures, such as the frailty index.^{5,6} Crucially, the predictive power of SRH assessments remains highly robust even after rigorously adjusting for objective clinical risks, the number of existing comorbidities, and diagnosed physical diseases.^{7,8} This highlights the unique clinical value of subjective assessments in capturing a holistic view of an individual's well-being and prognostic trajectory, extending far beyond traditional objective medical measures.

Diet is one of the most influential and modifiable factors affecting overall health. Recent studies from diverse cohorts, such as the Adventist Health Study-2,⁹ UK Biobank,¹⁰ EPIC-Oxford,¹¹ and the Atherosclerosis Risk in Communities,¹² and two systematic reviews and meta-analyses,^{13,14} confirm that adherence to healthful plant-based dietary patterns is associated with reduced all-cause mortality, lower risks of cardiovascular disease, hypertension, metabolic syndrome, and type 2 diabetes, as well as lower body mass index (BMI). These

health benefits are particularly evident for vegetarian and vegan diets rich in whole plant foods like fruits, vegetables, whole grains, legumes, and nuts, which improve lipid profiles, glycemic control, and inflammation markers.¹⁵

Research on plant-based dietary patterns in older adults has predominantly focused on hard clinical endpoints like mortality and disease risk, with limited evidence examining subjective health outcomes such as QoL.^{16,17} While some cross-sectional and prospective studies show associations between healthful plant-based diets and improved QoL^{18,19} or SRH,²⁰ these are sparse compared to the extensive literature on mortality reduction, highlighting a notable evidence gap.

At least three significant gaps remain in the literature. First, there is a scarcity of research that uses SRH and QoL as primary, distinct outcomes in the oldest-old, particularly within North American cohorts that include a high proportion of long-term vegetarians.^{16,17} Second, while plant-based diet quality (healthful vs unhealthful) has been examined in relation to QoL,¹⁹ the temporal dimension of dietary adherence—that is, the length of time an individual has adhered to a specific dietary pattern—is a novel and largely unexplored variable in older adult populations. It is plausible that the benefits of a plant-based diet are cumulative¹¹; however, this has not been formally tested as a predictor or moderator of health outcomes in older adults. Third, while healthy lifestyle indices have been linked to better health,^{21,22} to the best of our knowledge, no study has integrated a composite healthy lifestyle score, vegetarian diets, and diet duration into a single, comprehensive model to predict subjective health in adults aged ≥75 years.

This study aimed to address these critical gaps by leveraging data from

the Loma Linda Longevity Study, a unique cohort of adults aged ≥75 years with diverse dietary habits. The primary objectives of this study were to (1) determine the association between vegetarian dietary patterns and subjective health (SRH and QoL), (2) investigate whether the duration of dietary adherence is an independent predictor of subjective health, (3) assess the independent association of a comprehensive Healthy Lifestyle Index with subjective health, and (4) test the hypothesis that diet duration moderates the relationship between diet type and subjective health outcomes.

Methods

Study Design and Participants

This research employed a cross-sectional study design, leveraging data derived from the Loma Linda Longevity Study.²³ Participants were recruited between July 2021 and March 2023 from various locations across San Bernardino and Riverside counties in Southern California. Recruitment sites included the Loma Linda University Drayson Center Office of Preventive Care, local churches, senior centers, community clinics, retirement homes, and assisted living facilities. Data were collected from participants either through a physical medium in the form of a paper survey or verbally via phone interviews.

To ensure that the target demographic was accurately captured, strict eligibility parameters were applied. The inclusion criteria were as follows: being aged 75 years or older, English-speaking, and currently residing in either San Bernardino or Riverside County, California. The exclusion criteria disqualified individuals who were otherwise unable to respond to the questionnaire.

Variables, Instrumentation, and Measurement

Data were gathered using the standardized Loma Linda Longevity Study Questionnaire, which captures sociodemographics, dietary habits, smoking status, alcohol consumption, sleep quality, physical activity, and other variables unrelated to this study.²³

Independent Variables: Healthy Lifestyle Index and Diet. The primary independent variable was the healthy lifestyle index, a composite score meticulously designed to quantify overall adherence to health-promoting behaviors. The index was constructed by assessing nine distinct lifestyle components: daily servings of fruits and vegetables, frequency of consumption of high-fat and high-sugar foods, sleep duration (hours), alcohol consumption patterns, current smoking status, and frequency of mild and vigorous physical activity (see Table 1). Each of these components was assigned a specific score based on established public health guidelines, and the individual values were summed to generate the total index score. For analytical purposes, the final scores were divided into quartiles (Q1 through Q4) to examine dose-response patterns across increasing levels of adherence while maintaining sufficient sample size within each group, with Q4 representing the highest level. This HLI has been previously applied within the Loma Linda Longevity Study to characterize lifestyle-related health outcomes in adults aged ≥ 75 years^{23,24} and follows the composite lifestyle-score methodology validated in large prospective cohorts as a predictor of chronic disease incidence and all-cause mortality.^{21,22}

Regarding diet, specific dietary patterns were evaluated. Participants self-identified their

primary dietary habit by selecting from standard classifications, including vegan (never eat any animal products), lacto-ovo vegetarian (never eat meat and fish but eat eggs and dairy), pesco-vegetarian (never eat meat but eat fish, eggs, and dairy), semi-vegetarian (eat meat one to three times per month), and non-vegetarian (eat all meat and animal products). Furthermore, to evaluate the chronicity and potential cumulative physiological impact of their nutritional habits, diet duration was assessed by asking participants to report the length of time they had adhered to their current dietary pattern, dichotomized a priori as <10 years vs ≥ 10 years to distinguish shorter- from long-term adherence.

Dependent Variables: Quality of Life and Self-Rated Health. The study evaluated two distinct domains of subjective well-being as primary outcomes. Overall QoL was assessed via a single, standardized question asking participants to rate their current overall quality of life on a 4-point scale: “Very bad,” “Bad,” “Good,” and “Very good.” The use of a single-item measure was deliberately chosen to minimize respondent burden and simplify data collection for this older population. Self-rated health was measured by asking participants to evaluate their general condition on a standard 4-point scale: “Poor,” “Fair,” “Good,” and “Excellent.”

Covariates. To ensure that the observed effects of lifestyle and diet were independently assessed, several sociodemographic and anthropometric covariates were incorporated into the adjusted models. These included age (categorized into 5-year brackets [i.e., 75-79, 80-84, 85-89, and 90+]), sex (male/female), marital status, race/ethnicity, education level (categorized as bachelor's degree or

higher vs lower), and annual income. Body mass index (BMI) was calculated using self-reported height and weight. Given its critical role in metabolic health, BMI was included as a primary covariate and classified into three distinct categories: low/normal weight (≤ 24.9 kg/m²), overweight (25.0-29.9 kg/m²), and obese (≥ 30.0 kg/m²).

Furthermore, clinical disease burden was assessed using a comprehensive comorbidities questionnaire, which queried the presence of conditions such as heart disease, diabetes, hypertension, kidney disease, lung disease, liver disease, arthritis, cancer, asthma, sleep apnea, and self-reported physical disability. A continuous multimorbidity score was generated by summing the total number of reported conditions for each participant. For the multivariate analyses, this disease burden was categorized into three distinct levels of multimorbidity: low (0-1 condition), moderate (2 conditions), and high (≥ 3 conditions).

Ethical Considerations

This study was conducted in accordance with ethical principles. The research protocol and data collection methods were approved by the Loma Linda University Institutional Review Board (IRB# 5210280). Prior to commencing survey administration, all participants were presented with an informed consent document explaining the study's purpose, risks, and benefits. Participation was voluntary, and respondents were explicitly assured of the anonymity and confidentiality of their data. No personally identifiable information was retained in the final dataset used for analysis.

Statistical Analysis

Data management and statistical analyses were performed to evaluate the association between

Table 1.

Components and Scoring System of the Healthy Lifestyle Index (HLI).

Variable	Scoring
Fruit consumption	5 or more servings/day = 4
	3-4 servings/day = 3
	1-2 servings/day = 2
	Less than 1 serving/day = 1
	None = 0
Vegetable consumption	5 or more servings/day = 4
	3-4 servings/day = 3
	1-2 servings/day = 2
	Less than 1 serving/day = 1
	None = 0
Sugar consumption	Never = 3
	Once a month = 2
	Weekly = 1
	Daily = 0
Fat consumption	Never = 3
	Once a month = 2
	Weekly = 1
	Daily = 0
Smoking status	No consumption = 1
	Any consumption = 0
Alcohol consumption	No consumption = 1
	Any consumption = 0
Mild physical activity	5 or more times/week = 4
	3-4 times/week = 3
	1-2 times/week = 2
	Less than once/week = 1
	No exercise = 0

(continued)

Table 1. (continued)

Vigorous physical activity	5 or more times/week = 4
	3-4 times/week = 3
	1-2 times/week = 2
	Less than once/week = 1
	No exercise = 0
Sleep duration	7-9 hours/night = 1
	More than 9 or less than 7 hours/night = 0
Healthy lifestyle index	
Quartile 1 (lowest)	Poor (3-8 points)
Quartile 2	Regular (9-11 points)
Quartile 3	Good (12-14 points)
Quartile 4 (highest)	Excellent (15-25 points)

diet type, lifestyle factors, and the subjective health outcomes of self-rated health and quality of life. To ensure statistical robustness and fulfill model assumptions (e.g., avoiding expected cell counts <5 in cross-tabulations), several variables were recoded prior to the primary analysis. The independent variable, diet type, was dichotomized based on frequency of meat consumption into “vegetarians” (comprising vegans, lacto-ovo vegetarians, pesco-vegetarians, and semi-vegetarians, all of whom consume meat less than once per week) and “non-vegetarians” (participants reporting regular meat consumption). Participants reporting “other” diets were excluded from these analyses to prevent misclassification bias. A composite HLI was calculated as a continuous score and subsequently categorized into quartiles to assess potential dose-response relationships (Table 1). The dependent variables (SRH and QoL) were collapsed from four to three ordinal levels to improve interpretability, ensure

stable model estimation, and avoid sparse cell counts. Self-rated health was categorized as poor/fair, good, and excellent; quality of life was categorized as very bad/bad, good, and very good.

The baseline characteristics of the study population are summarized and stratified by diet type. Categorical variables are presented as absolute frequencies and valid percentages (n, %), while the continuous Healthy Lifestyle Index is presented as mean $\pm$ standard deviation (SD). Bivariate comparisons between the vegetarian and non-vegetarian groups (Table 2) were conducted using Pearson’s chi-square (χ^2) test for categorical variables and the independent-samples Student’s t-test for continuous variables. Bivariate associations between sociodemographic/lifestyle variables and the three-level subjective health outcomes were tested with Pearson’s chi-square for Self-Rated Health (Table 3), where all expected cell counts were ≥ 5 , and with the Fisher–Freeman–Halton

exact test (the $k \times m$ generalization of Fisher’s exact test) for Quality of Life (Table 4), where the “Very Bad/Bad” category contained only 13 participants and produced expected cell counts <5 in several variable groups, violating the Pearson chi-square assumption.

To determine the independent associations of diet type, dietary adherence duration, and the Healthy Lifestyle Index with subjective health outcomes, ordinal logistic regression (proportional-odds cumulative-logit models) was conducted to evaluate the odds of reporting higher categories of QoL and SRH. Models generated adjusted odds ratios (aOR) with 95% confidence intervals (CI). Models were estimated hierarchically: Model M1 adjusted for sociodemographic covariates (age, sex, race/ethnicity, marital status, annual income, and education); Model M2 also adjusted for sociodemographic covariates alongside dietary adherence duration and the Healthy Lifestyle Index; Model M3 additionally adjusted for BMI and

Table 2.

Sociodemographic and Lifestyle Characteristics by Diet Type (n = 421).

	Diet Type		χ^2 P-value
	Non-vegetarian n = 146 (%)	Vegetarian n = 275 (%)	
Gender			0.315
Male	76 (52.1%)	129 (46.9%)	
Female	70 (47.9%)	146 (53.1%)	
Age			<0.001
75-79	90 (61.6%)	129 (46.9%)	
80-84	39 (26.7%)	58 (21.1%)	
85-89	14 (9.6%)	53 (19.3%)	
90+	3 (2.1%)	35 (12.7%)	
Marital status			0.146
Married	72 (49.3%)	156 (56.7%)	
Not married	74 (50.7%)	119 (43.3%)	
Race			<0.001
White	103 (70.5%)	142 (51.6%)	
Non-White	43 (29.5%)	133 (48.4%)	
Annual income			0.178
\$29 999 or less	44 (30.1%)	83 (30.2%)	
\$30 000 to 59 999	50 (34.2%)	119 (43.3%)	
\$60 000 to 89 999	28 (19.2%)	43 (15.6%)	
\$90 000 or more	24 (16.4%)	30 (10.9%)	
Education level			<0.001
High school graduate or less	71 (48.6%)	48 (17.5%)	
Bachelor's degree or more	75 (51.4%)	227 (82.5%)	
Body Mass Index (kg/m ²)			<0.001
Low/Normal weight (<24.9)	38 (26.0%)	145 (52.7%)	
Overweight (25-29.9)	39 (26.7%)	93 (33.8%)	
Obesity (≥30)	69 (47.3%)	37 (13.5%)	
Diet duration			<0.001
Less than 10 years	13 (8.9%)	86 (31.3%)	
≥10 years	133 (91.1%)	189 (68.7%)	
Multimorbidity			0.004
Low (0-1 conditions)	68 (46.6%)	167 (60.7%)	
Moderate (2 conditions)	31 (21.2%)	57 (20.7%)	
Severe (3+ conditions)	47 (32.2%)	51 (18.5%)	
Healthy lifestyle index	9.3 ± 2.8	13.0 ± 3.4	<0.001

Bold *P*-values indicate statistical significance ($P < 0.05$). Values are presented as n (%) for categorical variables and mean ± standard deviation (SD) for continuous variables. *P*-values were calculated using Pearson's chi-square test for categorical variables and independent-samples Student's *t*-test for continuous variables.

Table 3.

Bivariate Associations Between Sociodemographic and Lifestyle Variables and Self-Rated Health (n = 421).

Variable	Self-rated health			
	Poor/fair n = 70 (%)	Good n = 253 (%)	Excellent n = 98 (%)	χ^2 P-value
Diet Type				<0.001
Non-vegetarian	31 (21.2%)	105 (71.9%)	10 (6.8%)	
Vegetarian	39 (14.2%)	148 (53.8%)	88 (32.0%)	
Healthy lifestyle index score				<0.001
Quartile 1 (lowest)	26 (28.0%)	62 (66.7%)	5 (5.4%)	
Quartile 2	22 (21.6%)	70 (68.6%)	10 (9.8%)	
Quartile 3	15 (12.7%)	73 (61.9%)	30 (25.4%)	
Quartile 4 (highest)	7 (6.5%)	48 (44.4%)	53 (49.1%)	
Body Mass Index (kg/m ²)				<0.001
Low/normal weight (≤ 24.9)	20 (10.9%)	97 (53.0%)	66 (36.1%)	
Overweight (25-29.9)	20 (15.2%)	84 (63.6%)	28 (21.2%)	
Obesity (≥ 30)	30 (28.3%)	72 (67.9%)	4 (3.8%)	
Multimorbidity				<0.001
Low (0-1 conditions)	27 (11.5%)	130 (55.3%)	78 (33.2%)	
Moderate (2 conditions)	13 (14.8%)	62 (70.5%)	13 (14.8%)	
Severe (3+ conditions)	30 (30.6%)	61 (62.2%)	7 (7.1%)	
Gender				0.964
Male	35 (17.1%)	122 (59.5%)	48 (23.4%)	
Female	35 (16.2%)	131 (60.6%)	50 (23.1%)	
Age				0.051
75-79	40 (18.3%)	142 (64.8%)	37 (16.9%)	
80-84	15 (15.5%)	55 (56.7%)	27 (27.8%)	
85-89	10 (14.9%)	33 (49.3%)	24 (35.8%)	
90+	5 (13.2%)	23 (60.5%)	10 (26.3%)	
Marital status				<0.001
Married	34 (14.9%)	122 (53.5%)	72 (31.6%)	
Not married	36 (18.7%)	131 (67.9%)	26 (13.5%)	

(continued)

Table 3. (continued)

Race				0.419
White	44 (18.0%)	149 (60.8%)	52 (21.2%)	
Non-White	26 (14.8%)	104 (59.1%)	46 (26.1%)	
Annual income				0.028
\$29 999 or less	24 (18.9%)	84 (66.1%)	19 (15.0%)	
\$30 000 to 59 999	33 (19.5%)	95 (56.2%)	41 (24.3%)	
\$60 000 to 89 999	9 (12.7%)	38 (53.5%)	24 (33.8%)	
\$90 000 or more	4 (7.4%)	36 (66.7%)	14 (25.9%)	
Education level				<0.001
High school graduate or less	33 (27.7%)	78 (65.5%)	8 (6.7%)	
Bachelor's degree or more	37 (12.3%)	175 (57.9%)	90 (29.8%)	

Cell values are count (row %); row percentages are computed within each independent-variable category. Bold *P*-values indicate statistical significance ($P < 0.05$). Pearson's chi-square test on the 2×3 (or $k \times 3$) contingency table; all expected cell counts ≥ 5 . Sample size reflects complete-case analysis after excluding 64 participants with missing diet type ($n = 41$) or income ($n = 23$) data.

multimorbidity. Model M3 was considered the final fully adjusted model.

To formally test for dose-response relationships, trend analyses (*P* for trend) were conducted for the Healthy Lifestyle Index, multimorbidity, and BMI by modeling these ordinal categorical variables as continuous covariates in the regression models. The proportional-odds assumption was tested using the Test of Parallel Lines; where borderline violations were detected, multinomial logistic regression was performed as a sensitivity check, with results examined for directional consistency. Multicollinearity was assessed via variance inflation factors.

To test the hypothesis that the health benefits of a vegetarian diet depend on the chronicity of exposure, a moderation analysis was conducted as a separate model fit. A diet type $\times$ diet duration product term was added to Model M3 in this auxiliary fit to formally test

whether the vegetarian effect differed between short-term (<10 years) and long-term (≥ 10 years) adherents. Main-effect estimates reported in [Tables 5](#) and [6](#) are derived from Model M3 without the interaction term; the interaction-term estimate (shown in the "Moderation Analysis" row) is derived from this separate M3 fit with the product term included. As a complementary descriptive analysis, Model M3 was also fit separately within each duration stratum to obtain stratum-specific adjusted odds ratios for the vegetarian effect.

Multivariable regression models were conducted using complete-case analysis (listwise deletion) for all included covariates. We used all available data from the Loma Linda Longevity Study. The extent of missing data was minimal: 41 participants (8.5%) lacked valid dietary data, and an additional 23 participants (4.7%) had missing income information, resulting in a final analytical sample of 421 participants.

All statistical analyses were conducted using IBM SPSS Statistics software (version 31.0; IBM SPSS, Inc., Armonk, NY). A two-sided *P*-value of < 0.05 was considered statistically significant for all tests. The study is reported in accordance with the STROBE guidelines for cross-sectional studies.

Sample Size

A sensitivity power analysis was initially conducted using G*Power (version 3.1) via a binary logistic regression approximation. Assuming a two-tailed $\alpha = 0.05$, a power of 80% ($1 - \beta = 0.80$), and a conservative R^2 of 0.15 for covariates, the analytical sample of 421 participants yielded a baseline minimum detectable odds ratio of 2.62. However, because ordinal logistic regression preserves ordered variance across three outcome levels (unlike binary approximations), it intrinsically possesses substantially higher statistical power. This enhanced sensitivity was empirically confirmed in our final models, which successfully detected significant main effects at

Table 4.

Bivariate Associations Between Sociodemographic and Lifestyle Variables and Quality of Life (n = 421).

Variable	Quality of life			
	Very Bad/Bad n = 13 (%)	Good n = 231 (%)	Very good n = 177 (%)	χ^2 P-value
Diet Type				<0.001
Non-vegetarian	8 (5.5%)	103 (70.5%)	35 (24.0%)	
Vegetarian	5 (1.8%)	128 (46.5%)	142 (51.6%)	
Healthy lifestyle index score				<0.001
Quartile 1 (lowest)	6 (6.5%)	74 (79.6%)	13 (14.0%)	
Quartile 2	4 (3.9%)	61 (59.8%)	37 (36.3%)	
Quartile 3	2 (1.7%)	64 (54.2%)	52 (44.1%)	
Quartile 4 (highest)	1 (0.9%)	32 (29.6%)	75 (69.4%)	
Body Mass Index (kg/m ²)				<0.001
Low/normal weight (≤ 24.9)	5 (2.7%)	88 (48.1%)	90 (49.2%)	
Overweight (25-29.9)	4 (3.0%)	63 (47.7%)	65 (49.2%)	
Obesity (≥ 30)	4 (3.8%)	80 (75.5%)	22 (20.8%)	
Multimorbidity				<0.001
Low (0-1 conditions)	9 (3.8%)	106 (45.1%)	120 (51.1%)	
Moderate (2 conditions)	2 (2.3%)	59 (67.0%)	27 (30.7%)	
Severe (3+ conditions)	2 (2.0%)	66 (67.3%)	30 (30.6%)	
Gender				0.024
Male	11 (5.4%)	112 (54.6%)	82 (40.0%)	
Female	2 (0.9%)	119 (55.1%)	95 (44.0%)	
Age				0.060
75-79	10 (4.6%)	129 (58.9%)	80 (36.5%)	
80-84	3 (3.1%)	54 (55.7%)	40 (41.2%)	
85-89	0 (0.0%)	30 (44.8%)	37 (55.2%)	
90+	0 (0.0%)	18 (47.4%)	20 (52.6%)	
Marital status				<0.001
Married	9 (3.9%)	106 (46.5%)	113 (49.6%)	
Not married	4 (2.1%)	125 (64.8%)	64 (33.2%)	

(continued)

Table 4. (continued)

Race				0.313
White	9 (3.7%)	140 (57.1%)	96 (39.2%)	
Non-White	4 (2.3%)	91 (51.7%)	81 (46.0%)	
Annual income				0.072
\$29 999 or less	2 (1.6%)	82 (64.6%)	43 (33.9%)	
\$30 000 to 59 999	6 (3.6%)	87 (51.5%)	76 (45.0%)	
\$60 000 to 89 999	2 (2.8%)	40 (56.3%)	29 (40.8%)	
\$90 000 or more	3 (5.6%)	22 (40.7%)	29 (53.7%)	
Education level				<0.001
High school graduate or less	4 (3.4%)	94 (79.0%)	21 (17.6%)	
Bachelor's degree or more	9 (3.0%)	137 (45.4%)	156 (51.7%)	

Cell values are count (row %); row percentages are computed within each independent-variable category. Bold *P*-values indicate statistical significance ($P < 0.05$). The Fisher–Freeman–Halton exact test was applied to all cross-tabulations because the “Very Bad/Bad” QoL category contained only 13 participants, producing expected cell counts <5 in several variable groups and violating the Pearson chi-square assumption. Sample size reflects complete-case analysis after excluding 64 participants with missing diet type ($n = 41$) or income ($n = 23$) data.

lower thresholds (e.g., vegetarian effect aOR = 1.99, 95% CI: 1.17–3.38, under Model M2, $P = 0.011$ for SRH). Therefore, the sample size was adequately powered to detect the principal demographic-adjusted dietary effects and the long-term stratified moderation findings.

To assess potential selection bias arising from complete-case analysis, baseline demographic and health characteristics (age, sex, race/ethnicity, marital status, education level, body mass index, and multimorbidity burden) were compared between the analytical sample ($n = 421$) and the 64 participants excluded due to missing data on diet type or income, using Pearson chi-square tests.

Results

Baseline Characteristics

This study examined the association between dietary patterns, lifestyle factors, and overall subjective health outcomes (QoL

and SRH) among older adults. We present the results in three stages: baseline characteristics by diet type (Table 2), bivariate associations with the two main subjective health outcomes SRH and QoL (Tables 3 and 4), and fully adjusted multivariable regression including moderation analysis (Tables 5 and 6).

Of the initial 485 study participants, 444 provided valid dietary data. From this cohort, 23 additional cases were excluded from the multivariable models due to missing data on income, resulting in a final complete-case analytical sample of 421. Descriptive statistics for the demographic and health characteristics of the baseline cohort ($n = 421$) are summarized in Table 2. The cohort was predominantly female (51.3%), between the age 75–79 years old (52.0%), highly educated (71.7% holding a bachelor's degree or higher), and predominantly vegetarians ($n = 275$, 65.3%).

Comparison of baseline characteristics between the analytical sample ($n = 421$) and the 64 excluded participants (Supplemental Table S1) revealed no statistically significant differences in age ($P = 0.183$), sex ($P = 0.461$), marital status ($P = 0.187$), race/ethnicity ($P = 0.954$), education level ($P = 0.131$), or BMI ($P = 0.546$). However, multimorbidity burden differed significantly between groups ($P < 0.001$), with excluded participants disproportionately represented in the moderate multimorbidity category (43.8% vs 20.9% in the analytical sample) and proportionally similar in the low (43.8% vs 55.8%) and high multimorbidity (12.5% vs 23.3%) categories. Because multimorbidity was included as an a priori adjustment variable in the fully adjusted model (M3), the impact of this distributional difference on the reported associations is mitigated.

The baseline sociodemographic and clinical characteristics of the

Table 5.

Hierarchical Ordinal Logistic Regression Analysis (Model M1, M2, M3) for Self-Rated Health (n = 421).

Variable	Model M1 aOR (95% CI), <i>P</i>	Model M2 aOR (95% CI), <i>P</i>	Model M3 aOR (95% CI), <i>P</i>
Diet Type			
Non-vegetarian	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Vegetarian	2.18 (1.37-3.45), <0.001	1.99 (1.17-3.38), 0.011	1.68 (0.97-2.90), 0.066
Demographics ^a			
Education (Bachelor's +)	2.22 (1.35-3.65), 0.002	1.70 (1.01-2.86), 0.045	1.70 (1.00-2.89), 0.048
Income \$60 000-89 999 (vs ≤\$29 999)	1.90 (1.01-3.58), 0.048	2.18 (1.12-4.23), 0.021	2.01 (1.02-3.97), 0.043
Age 85-89 (vs 75-79)	1.83 (1.03-3.23), 0.039	1.56 (0.85-2.86), 0.148	1.56 (0.83-2.94), 0.158
Not married	0.54 (0.34-0.84), 0.007	0.89 (0.55-1.45), 0.640	0.88 (0.54-1.45), 0.610
Diet duration			
Less than 10 years	—	1.00 (Reference)	1.00 (Reference)
≥10 years	—	3.39 (2.01-5.74), <0.001	3.63 (2.12-6.21), <0.001
Healthy lifestyle index	—	<i>P</i> for trend <0.001	<i>P</i> for trend <0.001
Quartile 1 (lowest)	—	1.00 (Reference)	1.00 (Reference)
Quartile 2	—	1.21 (0.67-2.20), 0.535	1.18 (0.64-2.18), 0.589
Quartile 3	—	2.31 (1.24-4.30), 0.009	2.04 (1.07-3.89), 0.030
Quartile 4 (highest)	—	6.13 (3.02-12.42), <0.001	4.69 (2.26-9.72), <0.001
Multimorbidity	—	—	<i>P</i> for trend < 0.001
Low (0-1 conditions)	—	—	1.00 (Reference)
Moderate (2 conditions)	—	—	0.45 (0.27-0.77), 0.003
Severe (3+ conditions)	—	—	0.30 (0.17-0.52), <0.001
Body Mass Index (kg/m ²)	—	—	<i>P</i> for trend = 0.011
Normal/Low weight (≤24.9)	—	—	1.00 (Reference)
Overweight (25-29.9)	—	—	0.62 (0.38-1.02), 0.058
Obesity (≥30)	—	—	0.47 (0.26-0.85), 0.013
Moderation analysis (in M3)			
Diet type × diet duration	—	—	2.25 (0.60-8.53), 0.232
Stratified: Vegetarian (<10 years) ^b	—	—	0.78 (0.19-3.21), 0.735
Stratified: Vegetarian (≥10 years) ^b	—	—	2.11 (1.11-4.00), 0.022

Bold *P*-values indicate statistical significance (*P* < 0.05). Abbreviations: aOR, adjusted odds ratio; CI, confidence interval. Values >1.00 indicate higher odds of reporting better Self-Rated Health. Model M1 adjusts for the diet exposure and sociodemographic covariates only (age, sex, race/ethnicity, marital status, annual income, education). Model M2 additionally includes diet duration and the Healthy Lifestyle Index. Model M3 is the final fully adjusted model, additionally including BMI and multimorbidity. “—” indicates the variable is not included in that model. Main-effect estimates are from Model M3 fit without the diet × diet duration interaction term. The “Moderation Analysis” row reports the interaction-term estimate from a separate M3 fit with the product term included; stratified vegetarian estimates are from M3 fit separately within each duration stratum.

^aDemographics significant in at least one model are shown; non-significant demographic contrasts (other age brackets, gender, race/ethnicity, other income brackets) are omitted for brevity.

^bStratified estimates derived from Model M3 fit separately within each duration stratum.

Table 6.

Hierarchical Ordinal Logistic Regression Analysis (Model M1, M2, M3) for Quality of Life (n = 421).

Variable	Model M1 aOR (95% CI), <i>P</i>	Model M2 aOR (95% CI), <i>P</i>	Model M3 aOR (95% CI), <i>P</i>
Diet Type			
Non-vegetarian	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Vegetarian	2.20 (1.36-3.56), 0.001	1.87 (1.08-3.24), 0.025	1.74 (0.98-3.06), 0.057
Demographics ^a			
Education (Bachelor's +)	2.79 (1.65-4.74), <0.001	2.13 (1.23-3.69), 0.007	2.05 (1.18-3.57), 0.011
Gender (Female)	2.10 (1.32-3.36), 0.002	1.92 (1.17-3.14), 0.010	1.91 (1.15-3.17), 0.013
Age 85-89 (vs 75-79)	1.92 (1.06-3.47), 0.032	1.84 (0.98-3.47), 0.058	1.79 (0.94-3.41), 0.077
Not married	0.54 (0.33-0.86), 0.009	0.77 (0.47-1.28), 0.317	0.74 (0.44-1.24), 0.250
Diet duration			
Less than 10 years	—	1.00 (Reference)	1.00 (Reference)
≥10 years	—	2.65 (1.55-4.55), <0.001	2.72 (1.58-4.70), <0.001
Healthy lifestyle index	—	<i>P</i> for trend <0.001	<i>P</i> for trend <0.001
Quartile 1 (lowest)	—	1.00 (Reference)	1.00 (Reference)
Quartile 2	—	2.35 (1.21-4.60), 0.012	2.41 (1.23-4.75), 0.011
Quartile 3	—	2.86 (1.45-5.62), 0.002	2.96 (1.48-5.95), 0.002
Quartile 4 (highest)	—	7.17 (3.37-15.27), <0.001	7.24 (3.31-15.85), <0.001
Multimorbidity	—	—	<i>P</i> for trend = 0.139
Low (0-1 conditions)	—	—	1.00 (Reference)
Moderate (2 conditions)	—	—	0.47 (0.27-0.81), 0.007
Severe (3+ conditions)	—	—	0.79 (0.45-1.38), 0.400
Body Mass Index (kg/m ²)	—	—	<i>P</i> for trend = 0.926
Normal/Low weight (≤24.9)	—	—	1.00 (Reference)
Overweight (25-29.9)	—	—	1.37 (0.82-2.30), 0.235
Obesity (≥30)	—	—	0.85 (0.45-1.60), 0.612
Moderation analysis (in M3)			
Diet type × diet duration	—	—	1.03 (0.23-4.53), 0.969
Stratified: Vegetarian (<10 years) ^b	—	—	1.67 (0.24-11.42), 0.601
Stratified: Vegetarian (≥10 years) ^b	—	—	1.70 (0.91-3.17), 0.095

Bold *P*-values indicate statistical significance (*P* < 0.05). Abbreviations: aOR, adjusted odds ratio; CI, confidence interval. Values >1.00 indicate higher odds of reporting better Quality of Life. Model M1 adjusts for the diet exposure and sociodemographic covariates only (age, sex, race/ethnicity, marital status, annual income, education). Model M2 additionally includes diet duration and the Healthy Lifestyle Index. Model M3 is the final fully adjusted model, additionally including BMI and multimorbidity. “—” indicates the variable is not included in that model. Main-effect estimates are from Model M3 fit without the diet × diet duration interaction term. The “Moderation Analysis” row reports the interaction-term estimate from a separate M3 fit with the product term included; stratified vegetarian estimates are from M3 fit separately within each duration stratum.

^aDemographics significant in at least one model are shown; non-significant demographic contrasts (other age brackets, race/ethnicity, income) are omitted for brevity.

^bStratified estimates derived from Model M3 fit separately within each duration stratum.

cohort differed significantly by diet type. Compared to non-vegetarians, the vegetarian group was significantly older ($P < 0.001$), with a higher proportion of individuals in the 85-89 and 90+ age brackets (32.0% combined vs 11.6% in non-vegetarians). Vegetarians were more likely to be non-white (48.4% vs 29.5%; $P < 0.001$) compared to non-vegetarians, and demonstrated substantially higher educational attainment, with 82.5% holding a bachelor's degree or higher compared to 51.4% of non-vegetarians ($P < 0.001$). Although most participants in both groups had followed their dietary pattern for ≥ 10 years, vegetarians had more short-term adherents than non-vegetarians (31.3% vs 8.9%; $P < 0.001$). There were no significant group differences in sex, marital status, or income.

Clinically, vegetarians presented with a significantly healthier physical profile than non-vegetarians. They were substantially more likely to be in the low/normal weight category (52.7% vs 26.0%) and exhibited drastically lower rates of obesity (13.5% vs 47.3%; $P < 0.001$). Accordingly, vegetarians reported a significantly lower burden of multimorbidity, with 60.7% in the low-multimorbidity category compared to 46.6% of non-vegetarians ($P = 0.004$).

Furthermore, analysis of the composite Healthy Lifestyle Index revealed that vegetarians engaged in significantly more health-promoting behaviors overall (mean HLI = 13.0 ± 3.4 vs 9.3 ± 2.8 ; t (df = 419) = 11.20, $P < 0.001$), corresponding to a large effect size (Cohen's $d = 1.15$).

Crude (i.e., unadjusted) cross-tabulations demonstrated strong associations between diet type and both subjective health outcomes (Tables 3 and 4). Bivariate analyses used Pearson's chi-square for SRH (Table 3) and the Fisher-Freeman-Halton exact test for QoL (Table 4). Vegetarians were substantially more

likely to report excellent SRH than non-vegetarians (32.0% vs 6.8%; $P < 0.001$) and very good QoL (51.6% vs 24.0%; $P < 0.001$). Better subjective health across both domains was also strongly associated with higher adherence to the Healthy Lifestyle Index, lower BMI, lower multimorbidity burden, higher education, and being married (all P values < 0.001 across both outcomes). Annual income was significantly associated with SRH ($P = 0.028$); gender was significantly associated with QoL ($P = 0.024$) but not SRH. Age was not significantly associated with either health outcome at the bivariate level, though both P -values approached the conventional threshold (SRH $P = 0.051$; QoL $P = 0.060$).

Under sociodemographic adjustment (Model M1), vegetarian dietary pattern was significantly associated with better SRH (aOR = 2.18, 95% CI: 1.37-3.45, $P < 0.001$). The association attenuated progressively with the addition of dietary adherence duration and the Healthy Lifestyle Index (Model M2: aOR = 1.99, 95% CI: 1.17-3.38, $P = 0.011$), and further with adjustment for BMI and multimorbidity in the final fully adjusted model (Model M3; Table 5: aOR = 1.68, 95% CI: 0.97-2.90, $P = 0.066$). Long-term dietary adherence (≥ 10 years) independently increased the odds of better SRH more than three-fold (aOR = 3.63, 95% CI: 2.12-6.21, $P < 0.001$) in the fully adjusted model.

In addition to diet, the HLI was associated with better SRH in a stepwise dose-response manner (P for trend < 0.001). The cumulative impact of these health-promoting behaviors was substantial: participants in the highest quartile had nearly five times the odds of reporting better SRH compared with the lowest quartile (aOR = 4.69, 95% CI: 2.26-9.72, $P < 0.001$), while the second quartile did not differ significantly from the reference category (aOR = 1.18, 95% CI: 0.64-

2.18, $P = 0.589$). Regarding clinical covariates, BMI showed a significant negative linear trend (P for trend = 0.011), with obesity independently predicting lower odds of better SRH (aOR = 0.47, 95% CI: 0.26-0.85, $P = 0.013$). Multimorbidity also showed a strong monotonic inverse trend with SRH (P for trend < 0.001), with severe multimorbidity reducing the odds of better SRH by 70% (aOR = 0.30, 95% CI: 0.17-0.52, $P < 0.001$).

Although the formal diet $\times$ duration interaction term did not reach statistical significance (aOR = 2.25, 95% CI: 0.60-8.53, $P = 0.232$), stratified analyses revealed a coherent and biologically interpretable pattern. Among long-term adherents (≥ 10 years; $n = 322$), vegetarian dietary pattern was independently and significantly associated with better SRH even after full adjustment (aOR = 2.11, 95% CI: 1.11-4.00, $P = 0.022$). Among short-term adherents (< 10 years; $n = 99$), no significant vegetarian association was observed (aOR = 0.78, 95% CI: 0.19-3.21, $P = 0.735$); this stratum was limited by a small non-vegetarian comparison group ($n = 13$), which constrained statistical power. Diagnostic checks confirmed validity of the cumulative-logit summary: the Test of Parallel Lines was supported for QoL ($P = 0.069$) and showed a borderline violation for SRH ($P = 0.029$) attributable to sparse cells; multinomial logistic regression yielded directionally consistent estimates. All variance inflation factors were below 2 (range 1.09-1.60), indicating no problematic multicollinearity.

Under sociodemographic adjustment (Model M1), vegetarian dietary pattern was significantly associated with better QoL (aOR = 2.20, 95% CI: 1.36-3.56, $P = 0.001$). The association attenuated progressively with the addition of dietary adherence duration and the Healthy Lifestyle Index (Model M2:

aOR = 1.87, 95% CI: 1.08–3.24, $P = 0.025$), and further with adjustment for BMI and multimorbidity in the final fully adjusted model (Model M3; Table 6: aOR = 1.74, 95% CI: 0.98–3.06, $P = 0.057$). Long-term dietary adherence (≥ 10 years) was strongly and independently associated with more than a two-fold increase in the odds of better QoL (aOR = 2.72, 95% CI: 1.58–4.70, $P < 0.001$) in the fully adjusted model.

Adherence to a healthy lifestyle showed a strong dose-response relationship with QoL (P for trend < 0.001). Relative to the lowest quartile, the adjusted odds of better QoL escalated progressively across the second (aOR = 2.41, 95% CI: 1.23–4.75, $P = 0.011$) and third quartiles (aOR = 2.96, 95% CI: 1.48–5.95, $P = 0.002$), peaking in the highest quartile, where participants exhibited over seven times the odds of better QoL (aOR = 7.24, 95% CI: 3.31–15.85, $P < 0.001$). Among the covariates, females (aOR = 1.91, 95% CI: 1.15–3.17, $P = 0.013$) and those with a bachelor's degree or higher (aOR = 2.05, 95% CI: 1.18–3.57, $P = 0.011$) had significantly higher odds of reporting better QoL.

Multimorbidity was significantly associated with QoL in the fully adjusted model (Wald $P = 0.027$), although the linear trend across multimorbidity categories was not significant (P for trend = 0.139), reflecting a non-monotonic pattern. Compared to the low-multimorbidity reference, participants with moderate multimorbidity showed significantly lower odds of better QoL (aOR = 0.47, 95% CI: 0.27–0.81, $P = 0.007$), while the high-multimorbidity category did not differ significantly from the reference category (aOR = 0.79, 95% CI: 0.45–1.38, $P = 0.400$). Body mass index did not show a significant independent association with QoL (P for trend = 0.926). Other sociodemographic covariates included in the fully adjusted

model—namely, age, marital status, race, and income—did not reach statistical significance as independent predictors but were retained a priori to control for demographic confounding.

To test the hypothesis that diet duration modifies the health benefits of a plant-based diet, an interaction term (diet type $\times$ diet duration) was added to the fully adjusted model. For QoL, the interaction term was non-significant (aOR = 1.03, 95% CI: 0.23–4.53, $P = 0.969$) and the vegetarian effect was essentially identical in both duration strata (long-term aOR = 1.70, 95% CI: 0.91–3.17, $P = 0.095$; short-term aOR = 1.67, 95% CI: 0.24–11.42, $P = 0.601$).

Discussion

This study extends the growing literature on lifestyle determinants of healthy aging by showing that among adults aged ≥ 75 years, both a higher Healthy Lifestyle Index (HLI) and long-term adherence to a vegetarian dietary pattern are independently associated with better subjective health, as measured by QoL and SRH. Three findings merit particular emphasis. First, the HLI exhibited a strikingly strong and monotonic dose-response with both outcomes, with the highest quartile conferring approximately five- to seven-fold greater odds of reporting superior subjective health. Second, in the final fully adjusted model (Model M3), the vegetarian dietary pattern was associated with both outcomes at borderline significance (QoL aOR = 1.74, $P = 0.057$; SRH aOR = 1.68, $P = 0.066$). For SRH, both BMI and multimorbidity emerged as stronger independent predictors than the dichotomous vegetarian classification. For QoL, multimorbidity (but not BMI) emerged as a stronger predictor. Third, long-term adherence (≥ 10 years) to a vegetarian dietary

pattern was independently associated with significantly higher odds of better SRH (aOR = 2.11, 95% CI: 1.11–4.00) and a directional improvement in QoL, while no such effect was detectable in short-term adherents, supporting a potential role of cumulative exposure. Taken together, these results support the premise that healthy aging is influenced not only by whether healthy behaviors are adopted, but also by how comprehensively and for how long they are sustained.

These findings are especially relevant because they arise in the “oldest-old,” a segment of the population that remains underrepresented in nutritional and lifestyle research, despite its rapid expansion worldwide.²⁵ Much of the existing literature on diet and healthy aging has focused on younger older adults, typically those between 60 and 75 years of age, in whom functional reserve, disease burden, and adaptation to behavioral change may differ meaningfully from those in later life.²⁶ In this context, the present study provides important evidence that lifestyle-related health advantages remain detectable beyond age 75, suggesting that health behaviors continue to matter well into advanced age. This observation aligns closely with the central principles of lifestyle medicine, which conceptualize health as the cumulative product of multiple interrelated behaviors rather than the isolated effect of single exposures.²⁷ The magnitude of the HLI associations in this study strongly reinforces this framework. Indeed, the robust dose-response pattern observed for both QoL and SRH suggests that the combined effect of healthy eating, physical activity, sleep, and avoidance of tobacco and alcohol may be more biologically and clinically meaningful than any individual behavior considered alone.

The strength of the HLI findings is consistent with prior evidence that lifestyle behaviors cluster and interact synergistically. Recent large-scale cohort data, including findings from the UK Biobank, have shown that adherence to a greater number of healthy lifestyle factors is associated with lower mortality, lower multimorbidity, and better perceived health.^{28,29} In two related analyses from the Loma Linda Longevity Study, a higher Healthy Lifestyle Index was associated with fewer prescribed medications, indicating a lower polypharmacy burden,²⁴ and with lower odds of COVID-19 infection among adults aged ≥ 75 years.²³ The current results extend these observations by showing that subjective outcomes remain highly responsive to the overall lifestyle profile. This is not a trivial point. In older adults, subjective health measures are not merely reflections of mood or preference; they are established predictors of healthcare utilization,³⁰ disability,³¹ and mortality.^{4,6} Therefore, the strong association between the HLI and both QoL and SRH may reflect a meaningful convergence of behavioral, physiological, and psychosocial resilience. From a clinical perspective, this implies that interventions targeting multiple lifestyle domains may yield disproportionately greater benefits than narrowly focused behavioral counseling.

The association between vegetarian dietary pattern and better subjective health is consistent with prior research demonstrating that plant-based dietary patterns are linked to favorable cardiometabolic profiles, lower inflammatory burden, and improved overall well-being. Recent analyses, such as the Lifelines Cohort Study,¹⁸ corroborate our results, demonstrating that healthy plant-based diets are independently associated with higher health-

related quality of life and physical well-being in older adults, independent of inflammatory markers. Longitudinal data from the UK Biobank¹⁰ and meta-analyses of prospective cohorts¹³ have firmly established the inverse association between healthy plant-based diets and all-cause mortality, cardiovascular disease, and multimorbidity. This study contributes to the literature by showing that the subjective health benefits of vegetarian dietary patterns appear to depend on sustained adherence—a temporal dimension rarely examined in this literature. Among long-term adherents (≥ 10 years), vegetarian dietary pattern was significantly associated with better self-rated health (aOR = 2.11; 95% CI: 1.11–4.00, $P = 0.022$), supporting a cumulative biological mechanism in the oldest-old, a population underrepresented in nutritional and lifestyle research.

In the fully adjusted model (Model M3), the vegetarian–subjective health association attenuated to borderline significance, with multimorbidity (for both outcomes) and BMI (for SRH only) emerging as stronger independent predictors than the dichotomous diet classification. Vegetarians in our sample exhibited more favorable BMI distributions and lower multimorbidity prevalence—characteristics that are themselves well-established predictors of subjective health in older adults and biologically consistent with the long-term effects of plant-based dietary patterns documented in the broader nutritional epidemiology literature, including improvements in adiposity,⁹ glucose regulation,³² cardiometabolic risk,¹⁰ and reduced incidence of type 2 diabetes,¹¹ cardiovascular disease,¹³ and certain malignancies.¹⁵ Because the

cross-sectional design cannot establish causal temporal ordering, we do not interpret the attenuation as formal evidence of mediation.

The second pattern is the duration dependence of the vegetarian diet–SRH association. Although the formal diet $\times$ duration interaction did not reach statistical significance—a result constrained by the small short-term non-vegetarian subgroup ($n = 13$)—stratified analyses showed that vegetarian dietary pattern was significantly associated with better SRH only among long-term adherents (≥ 10 years; aOR = 2.11, 95% CI: 1.11–4.00), with no detectable effect among short-term adherents. The QoL association, by contrast, was approximately equal in magnitude across duration strata, suggesting a duration-invariant pattern. This divergence has plausible biological grounding. SRH integrates a broad internal summary of health status—chronic disease burden, medication use, physical capability, mental health, cognitive functioning, and overall functional reserve³³—and reflects the cumulative outcome of metabolic and inflammatory processes that take years to remodel. Quality of life, in turn, integrates a broader set of psychological, social, and existential dimensions that may be more responsive to immediate experiential and contextual factors beyond dietary pattern alone.³⁴

The possibility of distinct temporal mechanisms is supported by emerging research on biological aging. Prolonged exposure to nutrient-dense plant-based dietary patterns has been associated with lower inflammatory signaling,³⁵ healthier microbial signatures,^{36,37} and more favorable markers of biological aging,³⁸ including telomere maintenance³⁹ and epigenetic regulation.⁴⁰ Although such pathways were not directly measured in the present study, they

provide a plausible conceptual framework for why long-term vegetarian adherence may be more strongly reflected in SRH than in QoL. At advanced age, when inflammaging, immune dysregulation, and multimorbidity are common, the cumulative benefits of a diet low in processed foods and animal products and rich in fiber, polyphenols, and other bioactive compounds may be especially relevant. The subjective experience of health in late life may therefore reflect both short-term symptom perceptions and long-term biological investment.

Consistent with this temporal interpretation, our data show that chronic clinical conditions affected SRH more strongly than QoL: severe multimorbidity reduced the odds of better SRH by 70% (aOR = 0.30, 95% CI: 0.17-0.52, $P < 0.001$) but did not show a statistically significant effect on QoL (aOR = 0.79, 95% CI: 0.45-1.38, $P = 0.400$), and obesity independently halved the odds of better SRH (aOR = 0.47, 95% CI: 0.26-0.85, $P = 0.013$) while showing no significant association with QoL (aOR = 0.85, 95% CI: 0.45-1.60, $P = 0.612$). This asymmetry suggests that integrated, long-term somatic health states—multimorbidity and adiposity—preferentially shape SRH, whereas QoL is more responsive to experiential and psychosocial factors. Of note, although annual income showed a significant bivariate association with SRH ($P = 0.028$; Table 3), this association did not persist in the fully adjusted model. This attenuation suggests that income's bivariate association was largely explained by correlated covariates in the model—particularly education, BMI, multimorbidity, and overall lifestyle adherence—rather than reflecting an independent effect on subjective health in this cohort.

The findings of this study should be interpreted considering both its

strengths and limitations. Its major strengths are the focus on adults aged ≥ 75 years, the use of a comprehensive lifestyle index rather than isolated behavioral measures, and the explicit examination of diet duration as a moderator. The analyses also adjusted for a broad set of sociodemographic and clinical covariates, thereby reducing the likelihood that the observed associations are explained entirely by age, sex, income, education, body mass index, or multimorbidity. In addition, the use of both QoL and SRH allowed the study to distinguish between related but non-identical subjective health constructs.

However, several limitations temper causal inferences. First, the cross-sectional design precludes definitive conclusions regarding directionality, although the duration-stratified findings argue against pure reverse causation given that detectable benefits required sustained exposure. Healthier individuals may be more likely to adopt vegetarian diets and other healthy behaviors. Residual confounding also remains possible, particularly from unmeasured variables, such as health literacy, genetic predispositions, social support quality, or lifetime patterns of healthcare utilization. In addition, the exposure variables were self-reported, including diet type and duration, physical activity, sleep, and other lifestyle and anthropometric measurements. Recall error and social desirability bias are likely, especially in an elderly cohort. The small short-term non-vegetarian subgroup ($n = 13$) limited statistical power for the formal interaction test, although the long-term stratum ($n = 322$) was well powered for stratum-specific inference. Although the analytical sample did not differ from the 64 excluded participants on most measured demographics, multimorbidity burden distribution differed significantly ($P < 0.001$),

with excluded participants over-represented in the moderate multimorbidity category. Adjustment for multimorbidity in Model M3 likely mitigates the impact of this difference on the reported diet–outcome associations, but residual selection bias cannot be entirely excluded.

Although the outcome measures were self-reported, this limitation should not be overstated. SRH, in particular, has repeatedly been shown to predict morbidity and mortality independently of objective clinical markers, suggesting that it captures a valid and prognostically relevant dimension of health.⁵⁻⁸ Nevertheless, the absence of parallel objective outcomes—such as gait speed, grip strength, frailty, hospitalization rates, inflammatory biomarkers, or incident cardiovascular events—means that the biological correlates of the reported subjective advantage remain inferential rather than directly demonstrated. In addition, QoL was measured using a single-item question and not using multiple-item questionnaires. However, single-item QoL measurements have been shown to be effective, easy to implement and clinically relevant in both young and older cohorts.^{41,42}

Generalizability is another important concern. The Loma Linda cohort is distinctive, with a relatively high prevalence of vegetarianism, a culture supportive of health-promoting behavior, and characteristics that may differ from broader older adult populations in the United States and elsewhere.⁴³ Thus, the magnitude of association observed in this study may not fully translate to settings where healthy eating is less socially reinforced or where access to nutritious plant-based foods is more constrained.

Notwithstanding these limitations, the clinical implications of this study are substantial. For clinicians caring for older adults, these results

challenge the notion that lifestyle modifications are of limited value at advanced age. Instead, the findings support a clear message: vegetarian dietary patterns and integrated healthy lifestyles are independently associated with better subjective health in adults aged ≥ 75 years, and the benefits of plant-based dietary pattern on self-rated health appear to require sustained adherence over several years.

This finding is clinically useful because it supports realistic counseling. Patients adopting vegetarian or plant-forward dietary patterns may be advised that meaningful self-perceived health benefits are likely to accumulate gradually, while the quality-of-life dimension may respond to broader lifestyle improvements regardless of the specific dietary pattern.⁴⁴ The strong HLI findings also argue against a reductionist approach to lifestyle counseling. Ideally, dietary advice should be integrated with physical activity promotion, sleep optimization, smoking and alcohol counseling, and social engagement strategies, particularly in geriatric care where multimorbidity and polypharmacy often complicate health management.

These results also have implications for public health and future research. Community-based interventions that combine plant-based nutrition education, social support, and broader healthy aging strategies may be particularly effective for older adults. Future studies should prospectively test the duration-dependent pattern of subjective health benefits, ideally through longitudinal cohorts that capture the exact timing of dietary transitions and repeated measures of QoL, SRH, biomarkers, functional status, and clinical outcomes. Such work would help determine whether a critical

duration of adherence threshold exists, and whether similar patterns are observed in more diverse populations.

In conclusion, the Healthy Lifestyle Index showed a strong monotonic dose-response with both quality of life and self-rated health in adults aged ≥ 75 years, supporting a multidimensional lifestyle medicine framework for healthy aging in the oldest-old. Long-term adherence (≥ 10 years) to a vegetarian dietary pattern was additionally associated with significantly better self-rated health. In the overall sample, the vegetarian diet association attenuated to borderline significance in the fully adjusted model, with multimorbidity (for both outcomes) and BMI (for self-rated health only) emerging as stronger independent predictors than the dichotomous diet classification.

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Ethical Considerations

Ethical approval for this study was obtained from the Loma Linda University Institutional Review Board (IRB#5210280).

Consent to Participate

Verbal informed consent was obtained from all participants before the study.

Author Contributions

Luiz Sella: Obtained access to the study database, designed the analytical approach, conducted data analysis, and drafted the manuscript.

Alaa Alabadi-Bierman: Provided edits and modifications to study design, data management, and manuscript revision.

Michael Paalani: Provided edits and modifications to study design and manuscript revision.

W. Lawrence Beeson: Provided edits and modifications to study design, statistical analysis and manuscript revision.

Hildemar Dos Santos: Supervised the research, provided critical review of the study design, statistical analysis, and manuscript.

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Data Availability Statement

The datasets analyzed during the current study are not publicly available due to ethical and confidentiality restrictions but are available from the corresponding author on reasonable request.

Supplemental Material

Supplemental material for this article is available online. 

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