

NUTRITION AWARENESS, BEHAVIOR AND BARRIERS TO SUSTAINABLE, HEALTHY DIET AMONG COMMUNITY DWELLING OLDER ADULTS IN SAUDI ARABIA: A CROSS-SECTIONAL STUDY

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Abstract. As the global older population increases, promoting healthy, sustainable diets for older adults is vital to prevent age-related diseases and enhance well-being. The study assessed nutritional awareness, sustainable, healthy eating behavior and barriers among older adults in the Abha District, Saudi Arabia, using the Arabic Nutritional Awareness (NAS) and Sustainable Healthy Eating Behaviors Scales (SHEBS). Participants in the study consisted of 400 community-dwelling older adults, 53% females and 47% males, 60-89 years of age, with a mean age of 71.7 ± 7.1 years. The study also collected data on demographics, lifestyles and barriers to sustainable, healthy eating. High NAS and SHEBS scores were recorded in 53% and 54% of the participants respectively. Higher NAS score was significantly associated with younger age, urban residence, having a sufficient income, and taking physical exercise (p -value <0.001 , 0.034, <0.001 , and <0.001 , respectively); whereas a lower score was significantly associated with married status, chronic illness and eating an ordinary diet (p -value <0.001 , 0.002 and <0.001 , respectively). For SHEBS, a higher score was significantly associated with having a sufficient income and taking physical exercise (p -value = 0.029 and <0.001 respectively); whereas a lower score was significantly associated with married status and inadequate sleep (p -value <0.001).

for both). Although many older adults reported having high nutrition awareness, barriers (mainly psychological and social) still hindered attaining sustainable, healthy eating. These findings emphasized the importance of targeted public health initiatives to enhance access to affordable and sustainable, healthy food, thereby promoting a healthy older population in Saudi Arabia.

Keywords: aging, barrier, behavior, nutrition, older adult, sustainable and healthy diet

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INTRODUCTION

The world is undergoing unprecedented population aging, and by 2030, one in every six people worldwide will be over sixty years of age, as longer life expectancy contributes to the growing numbers of older adults, impacting the healthcare services and societal systems (WHO, 2020). Awareness of healthy aging would assist the older population in coping with the challenges of longer lives (Lloyd *et al*, 2019; Rudnicka *et al*, 2020). Maintaining a balanced diet is fundamental for healthy aging, which is perceived as a concept of maintaining mental, physical and social capacity, while reducing the

burden of chronic diseases and disabilities (Rodríguez-Mañas *et al*, 2021; Rodríguez-Mañas *et al*, 2023; Hu, 2024). Successful aging involves the acquisition of healthy eating habits tailored for older people to improve their overall health and quality of life (Dent *et al*, 2023; Hu, 2024; Rodríguez-Mañas *et al*, 2023). On the other hand, aging is associated with loss of taste, smell and nutrient absorption, which contribute to malnutrition, frailty, sarcopenia, and increased mortality. This highlights the urgent need for healthy dietary strategies, such as nutrition awareness (van Dillen *et al*, 2008; Abu-Hussein, 2017; Dent *et al*, 2023).

Nutrition awareness refers to an understanding of one's dietary needs, making informed food choices and recognizing the health implications of these choices. It also includes self-perception, categorized as minor, moderate or high, of eating a balanced diet (van Dillen *et al*, 2008; Abu-Hussein, 2017). The Dietary Guidelines for Americans (DGA) considers that high-quality diets, containing a higher proportion of fruits, vegetables, legumes, nuts, and whole grains, with lower amounts of saturated fat, trans-fat, cholesterol, and sodium, are protective against various diseases (HHS and USDA, 2015). de Morais (2021) and Ghalib and Mahmood (2024) found that most older patients attending geriatric health centers report a lack of knowledge about the importance of their dietary requirements. Vaudin *et al* (2022) also indicated that most older adults report a lack of awareness of nutritional requirements and educational dietary programs that are crucial for raising their awareness in making healthier food choices.

Recent studies have found that older adults have become more knowledgeable about the health benefits of several types of foods and more positive towards adhering to healthy aging dietary guidelines (Macit-Çelebi *et al*, 2023; Daniele *et al*, 2024). Thus, nutrition knowledge is a critical component of the dietary practices in an aging population (Abu-Hussein, 2017; Ghalib and Mahmood, 2024).

Beyond the emphasis on nutrition awareness, the integration of sustainable dietary practices into health promotion helps to broaden its scope (Rodríguez-Mañas *et al*, 2023; Macit-Çelebi *et al*, 2023). Specifically, the World Health Organization (WHO) and Food and Agriculture Organization (FAO) have defined "sustainable healthy diets" as "those dietary patterns that promote all aspects of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable and safe for all population groups; while also flexible in terms of culturally acceptable food preferences" (WHO and FAO, 2019).

Such a diet consists of a high content of vegetables, greens, fruits, legumes, and whole grains; a lower content of lean protein from meat or fish; a moderate consumption of eggs and dairy products; and fewer refined cereals or potatoes; all of which are considered health-promoting, environmentally friendly, and affordable. Additionally, this limits food waste by following a plant-based diet and purchasing local, seasonal produce (Willett *et al*, 2019).

Sustainable healthy eating has received considerable attention for enhancing, in general, the health status in the older population, which is a growing issue worldwide (Kim *et al*, 2013; Rodríguez-Mañas *et al*, 2023). Thus, specific sustainable nutritional strategies for older adults are needed to align with Sustainable Goals Agenda 2030. But such endeavors may encounter various barriers, including financial constraints and a lack of sustainable options and practices

Specific sustainable nutrition strategies for this population need to be aligned with the World Health

Organization's Sustainable Goals Agenda 2030 (WHO and FAO, 2019). However, such endeavors may encounter various barriers, such as financial constraints and a lack of sustainable options and practices (Kim *et al*, 2013; Caso and Vecchio, 2022). This is why it is essential to integrate such sustainable food education into public health policies, focusing on the development of personal and environmental responsibilities (Burgaz *et al*, 2023).

While the older adults are unique in terms of being able to maintain a sustainable diet due to home cooking skills and resource-oriented mindset that the younger generation lacks, but there exist barriers, such social, cultural and health issues, to their adherence to a healthy eating behavior not met by their younger counterparts (Kim *et al*, 2013; Miller and Steinle, 2020). Age-related physiological changes, *eg*, xerostomia, swallowing and chewing difficulties, and dental problems, have been identified as barriers to consuming fruits, vegetables, whole grains, and

lean proteins (de Boer *et al*, 2013; Neuhauser *et al*, 2020; Ueland *et al*, 2022). Financial barriers, such as low income and food insecurity, also limit older people's access to healthier foods (de Boer *et al*, 2013; Neuhauser *et al*, 2020). In addition, psychosocial determinants, viz., loneliness, depression and social isolation, add to these barriers and, as a result, often affect dietary behavior (de Boer *et al*, 2013; Neuhauser *et al*, 2020; Ueland *et al*, 2022). A study by Wang *et al* (2023) revealed that the elderly do not fully engage in healthy eating practices due to food insecurity and lack of transportation. Therefore, a multi-pronged strategy, which overcomes these obstacles, is necessary to increase the availability of low-cost, nutritious foods (Wang *et al*, 2023).

Despite the awareness that sustainable, healthy eating requires making healthy food choices and tailored nutritional strategies, a substantial research gap exists in understanding how dietary awareness can translate into adherence to sustainable diets among older adults. Exploring

awareness, behavior and barriers provides insights for public health strategies to help older adults adopt healthier eating habits, improve their quality of life and reduce healthcare needs (van Dillen *et al*, 2008; Rodríguez-Mañas *et al*, 2023).

To the best of our knowledge, no region-wide survey has been conducted in Saudi Arabia to assess awareness and sustainable dietary behavior related to healthy diets among older adults. Accordingly, this research examined in the region of Asir the older population's levels of dietary awareness, involvement in sustainable eating practices, and barriers encountered in attaining a healthy and sustainable diet. The study should generate baseline data to enable a deeper examination into how older adults can attain a sustainable, healthy diet.

MATERIALS AND METHODS

Study design and location

The research employed a descriptive cross-sectional approach, adhering to the guidelines outlined in the Strengthening

the Reporting of Observational Studies in Epidemiology (STROBE) checklist (von Elm *et al*, 2007). The study was conducted in the Abha District, Asir Region, Saudi Arabia, between December 2024 and February 2025.

Study participants

Inclusion criteria of the participants were (i) at least 60 years of age, and (ii) having intact cognitive function. Exclusion criteria were (i) displaying depressive symptoms,

manifested by a Beck Depression Inventory (BDI-II) score exceeding 20 (Beck *et al*, 1996), or (ii) showing considerable cognitive impairment, reflected by a Mini-Cog score ranging from zero to two (Albanna *et al*, 2017).

The required sample size was estimated using the following formula for estimating a single population proportion in cross-sectional studies (Daniel and Cross, 2018).

$$n = (Z_{1-\alpha/2} \times p(1-p))/d^2$$

where n = required sample size;

$Z_{1-\alpha/2}$ = 1.96 corresponds to a 5% type I error ($p < 0.05$);

p = anticipated proportion in the population;

d = margin of error

The value of p was based on previous studies (Cohen, 2016; Shoukr *et al*, 2023; Alhazmi *et al*, 2024; Hawash *et al*, 2024). The calculated sample size was 363 individuals. An additional 10% was added for non-

responses. A convenience sampling technique was employed, whereby participants were recruited based on their availability, accessibility, and willingness to participate during the data collection period.

This approach was selected due to practical considerations, including time constraints and the feasibility of accessing older adults within the study setting. Initially, 427 older adults were invited to participate in the survey. However, 8 participants were excluded based on the aforementioned criteria, 12 declined to participate, and 9 withdrew from the study, resulting in a final sample of 400 older adults (Fig 1).

Data acquisition tools

Data for this study were gathered using three tools, namely, the Demographic, Clinical Status, and Lifestyle Data Sheet for Older Adults (Miller and Steinle, 2020; Neuhouser *et al*, 2020), the Nutrition Awareness Scale (NAS) (van Dillen *et al*, 2008), and the Sustainable and Healthy Eating Behaviors Scale (SHEBS) (Zakowska-Biemans *et al*, 2019).

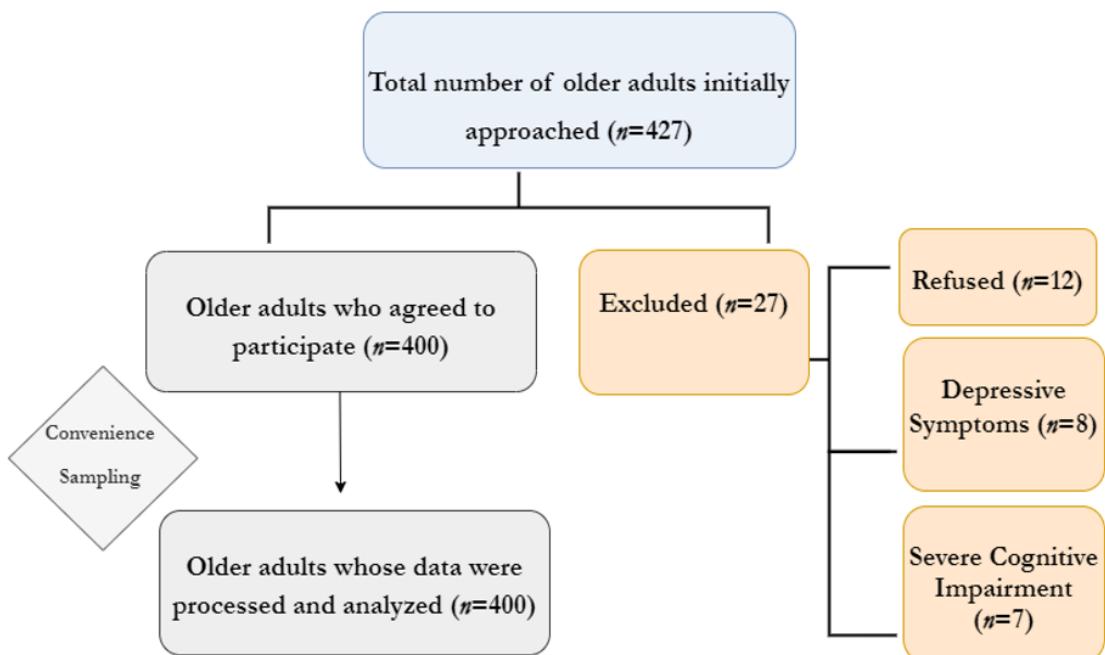


Fig 1 - Participants' recruitment flowchart

Demographic characteristics, clinical status, lifestyle, and barriers to sustainable diet data sheet: This data sheet (Table 1) was developed to collect information on sociodemographic characteristics, clinical status, lifestyle patterns, and perceived barriers to maintaining a sustainable and healthy diet among community-dwelling older adults. The demographic data collected were participants' age, sex, marital status, educational level, and financial status. Lifestyle data covered being a smoker, sleep duration, physical exercise, and diet type. Weight and height were measured three times using calibrated instruments (Omron BF508 body composition scale; Omron Healthcare Co Ltd, Kyoto, Japan) and wall-mounted vertical tape measure (Seca 206; Seca GmbH & Co KG, Hamburg, Germany). Body mass index (BMI) was calculated using the formula: weight/height² (kg/m²) (WHO, 2000). Additionally, the survey contained an eight-item checklist of the types of barriers that may hinder older adults from maintaining a sustainable and healthy diet (Table 2).

Nutrition Awareness Scale (NAS): This scale is a validated self-rated questionnaire with 17 items that assesses individuals' understanding, attitudes and nutrition-related behavior (van Dillen *et al*, 2008). Respondents rate their agreement to each statement using a 5-point Likert scale ranging from 1 = "strongly disagree" to 5 = "strongly agree". The scale encompasses two primary domains: the cognitive domain, which evaluates knowledge and comprehension of nutritional concepts, and the skill domain, which measures functional, interactive and critical skills essential for making informed dietary choices. The total score is calculated by summing the individual item scores, which range from 17 to 85. Higher scores indicate a greater level of nutritional awareness and understanding. The total score is converted to percent maximum score and categorized as "Low" <60%, "Moderate" = 60-70% and "High" >70% (Alhazmi *et al*, 2024; Yi *et al*, 2022). The NAS was translated into Arabic and

validated using exploratory and confirmatory factor analyses (Flora and Flake, 2017). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.96, indicating excellent sampling adequacy. Exploratory analysis indicated that the 17 items accounted for 66.32% of variance, with loadings from 0.78 to 0.89. Confirmatory analysis indicated the NAS structure had acceptable fit indices: (chi-square to degrees of freedom ratio (χ^2/df) = 3.15, root mean square error of approximation (RMSEA) = 0.007, Comparative Fit Index (CFI) = 0.931, and Tucker-Lewis index (TLI) = 0.925). Cronbach's alpha of 0.88 indicated high reliability in assessing nutrition awareness.

Sustainable Healthy Eating Behaviors Scale (SHEBS): SHEBS measures adults' understanding of sustainable and healthy eating (SHE) concepts through a self-reported assessment of their dietary behaviors (Zakowska-Biemans *et al*, 2019). SHEBS is based on the FAO definition (WHO and FAO, 2019), the LiveWell approach (WWF-UK, 2011), and guidelines

for sustainable and healthy eating practices (WHO and FAO, 2019). It consists of eight Factors, with Factor 1 containing ten items, Factor 2 five items, Factor 3 four items, and Factors 4-8 three items. Participants respond to each item using a 7-point Likert scale ranging from 1 = "never" to 7 = "always", which allows a nuanced self-assessment of their eating habits. The Factor scores are calculated by averaging the responses within each Factor, and the total SHEBS score is derived from the averages of all Factor scores. Cronbach's alpha values for the overall scale and its subscales ranged from 0.764 to 0.912, indicating good internal consistency. SHEBS was translated into Arabic and back-translated to confirm accuracy. Content validity was assessed using exploratory and confirmatory factor analyses (Flora and Flake, 2017). KMO was 0.96, showing excellent factorability. Exploratory factor analysis revealed that 19 items accounted for 72.92% variance, with loadings ranging from 0.68 to 0.85. Confirmatory factor analysis

supported the SHEBS structure with acceptable fit indices: $\chi^2/df = 2.46$, RMSEA = 0.014, CFI = 0.926, and TLI = 0.913. A Cronbach's alpha of 0.92 indicated high reliability. The total SHEBS score ranges from 34 to 238, with higher scores indicating more sustainable and health-conscious eating behaviors. The total score was converted to percent maximum score and categorized as "Low" <60%, "Moderate" = 60-70% and "High" >70% (Yi *et al*, 2022; Alhazmi *et al*, 2024).

Study reliability and validity

Both NAS and SHEBS tools underwent a structured translation and cultural adaptation process, which included forward translation into Arabic by two independent bilingual translators, reconciliation by a third reviewer, back-translation into English by a blinded translator, and review by a panel of five experts in nutrition, public health, gerontology, and psychology. The experts assessed validity, relevance, appropriateness, and clarity, and confirmed that the tools were suitable and understandable. A confirmatory factor analysis was

performed to verify content validity, ensuring the measurement model reflected the underlying constructs. To test the clarity, effectiveness and feasibility of the tools, a pilot study was conducted with 40 individuals, not included in the main research project, but from the same region, and whose demographic characteristics matched those of the main study. After obtaining approval from the Research Ethics Committee of King Khalid University, the pilot study was carried out, which indicated that the tools were understandable, successfully measured the constructs, and required no further changes.

Data collection

Trained researchers administered the Mini-Cog and BDI-II to screen for cognitive impairment and depression. Eligible participants then undertook confidential, structured interviews in private settings at primary healthcare centers in Abha. No incentives were provided for participation, and all responses were treated with the utmost confidentiality. The participants were informed that

their participation was optional and that they could withdraw at any time without any negative consequences.

Each interview lasted approximately 25-30 minutes. To minimize respondents' burden, participants were offered brief rest breaks between each questionnaire section (2-5 minutes as needed), and interviewers read items aloud upon request to reduce fatigue and cognitive load. Researchers checked responses *in situ* for completeness and clarified any ambiguities immediately. Researchers carefully examined the participants' answers in the collected data to ensure that the information was accurate and complete. Various strategies addressed potential biases in the study. Researchers recruited a diverse sample of elderly participants and carefully translated the survey questions to avoid leading language. The survey maintained the anonymity to promote honest responses, with trained researchers emphasizing neutrality. During analysis, confounding factors were

considered such as all relevant sociodemographic and lifestyle variables measured in the study, and validated analytical techniques were used to control for relevant variables, ensuring reliable findings (Rothman *et al*, 2008).

Statistical analysis

Normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests (Razali and Wah, 2011). Categorical variables were reported as numbers and percentages. Relationships between nutritional awareness, sustainable healthy eating behaviors, and barriers were analyzed using Spearman's rho and categorized as low, moderate, or high. An ordinal logistic regression was performed to examine the association between covariates and levels of awareness and behavior. Reliability was tested using Cronbach's alpha (Gliem and Gliem, 2023). Validity was confirmed through factor analyses that included correlation matrix, KMO, Bartlett's test, and Varimax rotation (Yong *et al*, 2013). Significance is accepted at p -value ≤ 0.050 and 0.010. Statistical

analyses were performed using Statistical Package for the Social Sciences (SPSS) Version 27 (IBM Corp, Armonk, NY).

Ethical consideration

The study protocols were approved by the Research Ethics Committee of King Khalid University (IRB no. ECM# 2024-3160). Prior written consent was obtained from each participant, and data were anonymized before analysis.

RESULTS

NAS and SHEBS score categories and demographic, clinical status, BMI, and lifestyle explanatory variables of participants

The mean age of participants was 71.7 ± 7.1 years. The percent participants showing high, moderate and low average NAS score were 54, 16 and 30, respectively, and showing high, moderate and low average SHEBS score were 54, 26 and 20, respectively.

The majority (71%) of respondents of 60-69 years of age had NAS score in the high category,

compared to only 2% of participants ≥ 80 years of age (p -value <0.010); for SHEB high score category, the proportion was 66% and 14% respectively (p -value <0.010) (Table 1). Unmarried participants (64%) obtained a high NAS score category compared to 32% of those married (p -value <0.010); for the SHEBS high score category, the proportion was 60% and 41% respectively (p -value <0.010). A higher proportion of females (57%) had nutrition awareness in the high category compared to males (44%, p -value <0.010); for the SHEBS high score category, the proportion is not significantly different (56% and 48% respectively). Participants living with children (56%) and those residing in urban area (64%) had NAS scores in the high category, a greater proportion than those living with spouse (46%) and those residing in rural area (1%) (p -value <0.010); for the SHEBS high score category, 56% were participants living with children and 44% those living with spouse, while 62% were urban residents and 16% rural dwellers (p -value <0.010).

Table 1

Association between NAs score and SHEB score categories and demographic, clinical status, BMI, and lifestyle explanatory variables of participants (N = 400), Abha district, Asir region, Saudi Arabia,
December 2024 - February 2025

Variable	Frequency in different levels of NAS score ^a n (%)	χ^2, p -value ^b		Frequency in different levels of SHEB score ^c n (%)	χ^2, p -value ^b		
		Low	Moderate			Low	Moderate
Age group^d							
60-69 years (N = 181)	27 (15)	25 (14)	129 (71)	15 (8)	47 (26)	119 (66)	92.96, <0.01
70-79 years (N = 162)	38 (23)	40 (25)	84 (52)	28 (17)	46 (28)	88 (55)	
≥80 years (N = 57)	56 (98)	0 (0)	1 (2)	37 (65)	12 (21)	8 (14)	
Marital status							
Married (N = 130)	62 (48)	26 (20)	42 (32)	47 (36)	30 (23)	53 (41)	
Unmarried (N = 270)	59 (22)	39 (14)	172 (64)	33 (12)	75 (28)	162 (60)	
Sex							
Male (N = 108)	25 (23)	36 (33)	47 (44)	20 (19)	36 (33)	52 (48)	
Female (N = 292)	96 (33)	29 (10)	167 (57)	60 (21)	69 (23)	163 (56)	
Living arrangement							
Living with children (N = 321)	104 (32)	39 (12)	178 (56)	61 (19)	80 (25)	180 (56)	3.53, 0.171
Living with spouse (N = 79)	17 (21)	26 (33)	36 (46)	19 (24)	25 (32)	35 (44)	

Table 1 (cont)

Variable	Frequency in different levels of NAS score ^a			χ^2, p -value ^b	Frequency in different levels of SHEB score ^c	χ^2, p -value ^b	
	Low	Moderate	High	n (%)	Low	Moderate	High
Residence location				187.72, <0.01			119.80, <0.01
Urban (N = 330)	52 (16)	65 (20)	213 (64)		33 (10)	93 (28)	204 (62)
Rural (N = 70)	69 (99)	0 (0)	1 (1)		47 (67)	12 (17)	11 (16)
Monthly income				210.84, <0.01			131.55, <0.01
Sufficient to cover all basic expenses (N = 321)	44 (14)	65 (20)	212 (66)		28 (9)	91 (28)	202 (63)
Not sufficient to cover all basic expenses (N = 79)	77 (97)	0 (0)	2 (3)		52 (66)	14 (18)	13 (16)
Education				66.76, <0.01			50.19, <0.01
Primary (N = 173)	87 (50)	26 (15)	60 (35)		46 (27)	66 (38)	61 (35)
Secondary (N = 186)	34 (18)	32 (17)	120 (65)		34 (18)	32 (17)	120 (65)
University (N = 41)	0 (0)	7 (17)	34 (83)		0 (0)	7 (17)	34 (83)
Chronic illness				18.18, <0.01			8.43, <0.05
Yes (N = 288)	99 (34)	54 (19)	135 (47)		68 (24)	73 (25)	147 (51)
No (N = 112)	22 (20)	11 (10)	79 (70)		12 (11)	32 (29)	68 (60)

Table 1 (cont)

Variable	Frequency in different levels of NAS score ^a n (%)				$\chi^2, p\text{-value}^b$	Frequency in different levels of SHEB score ^c n (%)	$\chi^2, p\text{-value}^b$
		Low	Moderate	High			
BMI category ^e					58.47, <0.01		49.74, <0.01
Normal (18.5-24.9 kg/m ²) (N = 138)	11 (8)	20 (15)	107 (77)		1 (1)	47 (34)	90 (65)
Overweight (25.0-29.9 kg/m ²) (N = 41)	15 (37)	7 (17)	19 (46)		12 (29)	11 (27)	18 (44)
Obese (\geq 30 kg/m ²) (N = 221)	95 (43)	38 (17)	88 (40)		67 (30)	47 (21)	107 (49)
Smoker				1.60, 0.45			1.38, 0.501
Yes (N = 29)	7 (24)	7 (24)	15 (52)		8 (27)	8 (27)	13 (46)
No (N = 371)	114 (31)	58 (16)	199 (53)		72 (19)	97 (26)	202 (55)
Physical exercise				22.51, <0.01			22.04, <0.01
Yes (at least \geq 3 times/ week; 30 minutes each time) (N = 35)	3 (9)	0 (0)	32 (91)		2 (6)	1 (3)	32 (91)
Not at all (N = 365)	118 (32)	65 (18)	182 (50)		78 (21)	104 (29)	183 (50)
Sleeping pattern				182.31, <0.01			122.01, <0.01
<5 hours (inadequate) (N = 122)	83 (68)	35 (29)	4 (3)		62 (51)	36 (29)	24 (20)
5-7 hours (adequate) (N = 278)	38 (14)	30 (11)	210 (75)		18 (6)	69 (25)	191 (69)

Table 1 (cont)

Variable	Frequency in different levels of NAS score ^a			χ^2, p -value ^b	Frequency in different levels of SHEB score ^c	χ^2, p -value ^b
	Low	Moderate	High			
Type of diet						
Ordinary (non-medically prescribed) (N = 158)	88 (56)	45 (28)	25 (16)	149.24, <0.01	63 (40)	46 (29)
Therapeutic (medically prescribed) (N = 242)	33 (14)	20 (8)	189 (78)		17 (7)	59 (24)
					166 (69)	

^aNutrition Awareness Scale (NAS) average scores were obtained from a self-reported questionnaire (van Dillen *et al*, 2008) containing 17 items rated using a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree") with a score <60, 60-70 and >70 considered low, moderate and high, respectively, from a total score ranging from 17 to 85, with higher scores reflecting greater nutrition awareness and understanding.

^b p -value <0.01 was considered significantly different.

^cSustainable Healthy Eating Behaviors Scale (SHEBS) average scores were obtained from a self-reported questionnaire (Zakowska-Biemans *et al*, 2019) containing 34 items rated on a 7-point Likert scale ranging from 1 ("never") to 5 ("always"), with a score <60, 60-70 and >70 considered low, moderate and high, respectively, from a total score ranging from 34 to 238, with higher scores reflecting more sustainable and health-conscious eating behavior.

^dAverage age (mean \pm SD) = 71.7 ± 7.1 years

^eAverage BMI (mean \pm SD) = $28.8 \pm 6.7 \text{ kg/m}^2$

BMI: body mass index; kg/m²: kilogram per square meter; SD: standard deviation; χ^2 : chi-square test

High NAS awareness category was also observed among participants with sufficient income (66%) compared to a much lower proportion among those with insufficient income (2%, *p*-value <0.010); for the SHEBS high score category, the proportion was 63% and 16% respectively (*p*-value <0.010). Education showed a strong positive relationship with NAS score, with 83% of university graduates in the high score category compared to 35% of primary-educated participants (*p*-value <0.010); for the SHEBS high score category, the percentages were the same. Individuals without chronic illness (70%) exhibited high nutrition awareness compared to 47% with chronic illness (*p*-value <0.010); for the SHEBS high score category, the proportion was similar, 60% and 51% respectively (*p*-value <0.050). Normal weight participants (77%) achieved a high NAS score category compared to those overweight (46%) or obese (40%) (*p*-value <0.010); for the SHEBS high score category, the proportion was 65%, 44% and

49%, respectively (*p*-value <0.010). The mean BMI of the participants was $28.8 \pm 6.7 \text{ kg/m}^2$, considered overweight. Smoking is not a significant factor associated with high NAS or SHEBS score categories. Those engaging in physical exercise (91%) and with adequate sleep duration (5-7 hours, 75%) were in the high NAS score category compared to sedentary individuals (50%) and those sleeping for short periods (3%, *p*-value <0.010); for the SHEBS high score category, the proportion for individuals who exercised was 91% *vs* 50% for those who did not, and 69% for those who slept 5-7 hours per night *vs* 20% for those with inadequate sleeping hours (*p*-value <0.010). Likewise, participants following a therapeutic diet (78%) were in the high NAS score category compared to those consuming ordinary diets (16%, *p*-value <0.010); for the SHEBS high score category, 69% were those on a therapeutic diet while 31% were on an ordinary diet (*p*-value <0.010).

A multinomial logistic regression model was employed to identify the aforementioned

explanatory variables that significantly influenced NAS and SHEBS scores (Table 2). Participants with significant positive NAS score association were those aged 60-69 ($\beta = 7.62$, p -value <0.001) and 70-79 years ($\beta = 7.81$, p -value <0.001), living in urban area ($\beta = 3.87$, p -value = 0.05), having sufficient income ($\beta = 8.22$, p -value <0.01), or exercising ($\beta = 6.83$, p -value <0.01); whereas significant negative NAS score association were observed for those were married ($\beta = -8.30$, p -value <0.01), with chronic illness ($\beta = -4.52$, p -value = 0.05), or following an ordinary diet ($\beta = -6.18$, p -value <0.01). Participants with significant positive SHEB score association were those with sufficient income ($\beta = 1.09$, p -value = 0.05) or who exercised ($\beta = 4.47$, p -value <0.01); whereas significant negative SHEB score association were found for those who were married ($\beta = -1.79$, p -value <0.01) or sleeping fewer than 5 hours ($\beta = -1.84$, $p <0.01$). Other variables did not show significant associations with NAS and SHEB scores.

Barriers to a sustainable, healthy

diet (Table 3). The highest mean scores for barriers to a sustainable, healthy diet were 0.98 ± 0.16 for "refusal to change dietary habit," 0.98 ± 0.16 for "loss of social support" and 0.98 ± 0.16 for "eating alone". The lowest mean scores were 0.27 ± 0.44 for "decreased cooking skill," 0.29 ± 0.45 for "impaired vision/medical condition" and 0.30 ± 0.46 for "unpleasant taste of healthy food". The overall mean barrier score was 0.55 ± 0.33 .

DISCUSSION

The present study assessed nutritional awareness, the extent of sustainable dietary behavior, related barriers, and other factors influencing sustainable dietary choices among community-dwelling older adults in Abha District. The study showed high NAS and SHEBS scores among the older adult participants. In contrast, Ghalib and Mahmood (2024) reported low nutrition awareness among the majority of older adult participants, especially regarding a balanced diet and nutrient intake. Our findings reflect the participants'

Table 2

Multinomial logistic regression of demographic, clinical, BMI, and lifestyle explanatory variables with NAS and SHEBS of the participants (N = 400), Abha district, Asir region, Saudi Arabia, December 2024 - February 2025

Variable	NAS				SHEBS			
	Estimated β	SE β	Wald test	95% CI p-value	Estimated β	SE	Wald test	95% CI p-value
Threshold/category								
Low (<60)	19.71	1250.80	0.00	-2431.82 - 471.23 0.987	22.40	0.86	680.32	20.72 - 24.09 <0.01
Medium (60-70)	23.75	1250.80	0.00	-2427.78 - 475.28 0.985	24.62	0.87	804.44	22.91 - 26.32 <0.01
Age group								
60-69 years	7.62	1.87	16.60	3.95 - 11.28 <0.01	0.56	0.6	0.87	-0.62 - 1.74 0.352
70-79 years	7.81	1.84	17.92	4.19 - 11.42 <0.01	0.19	0.55	0.12	-0.89 - 1.27 0.730
80-89 years	0 ^a	-	-	-	0 ^a	-	-	-
Marital status								
Married	-8.3	0.9	85.96	-10.06 - 6.55 <0.01	-1.79	0.37	23.64	-2.51 - 1.07 <0.01
Unmarried	0 ^a	-	-	-	0 ^a	-	-	-
Residence location								
Urban	3.87	1.82	4.52	0.30 - 7.43 <0.05	1.14	0.64	3.17	-0.11 - 2.40 0.075
Rural	0 ^a	-	-	-	0 ^a	-	-	-

Table 2 (cont)

Variable	NAS					SHEBS				
	Estimated β	SE	Wald test	95% CI	p-value	Estimated β	SE	Wald test	95% CI	p-value
Monthly income										
Sufficient to cover all basic expenses	8.22	1.9	18.64	4.49 - 11.95	<0.01	1.09	0.5	4.75	0.11 - 2.07	<0.05
Insufficient to cover all basic expenses	0 ^a	-	-	-	-	0 ^a	-	-	-	-
Chronic illness										
Yes	-4.52	1.46	9.64	-7.37 - 1.67	<0.05	0.39	0.35	1.22	-0.30 - 1.07	0.269
No	0 ^a	-	-	-	-	0 ^a	-	-	-	-
BMI category										
Normal (18.5-24.9 kg/m ²)	-0.76	0.55	1.91	-1.83 - 0.32	0.167	-0.47	0.31	2.28	-1.09 - 0.14	0.131
Overweight (25.0-29.9 kg/m ²)	-0.05	0.77	0.00	-1.55 - 1.45	0.945	-0.57	0.41	1.9	-1.37 - 0.24	0.168
Obese (≥30 kg/m ²)	0 ^a	-	-	-	-	0 ^a	-	-	-	-

Table 2 (cont)

Variable	NAS					SHEBS				
	Estimated β	SE	Wald test	95% CI	<i>p</i> -value	Estimated β	SE	Wald test	95% CI	<i>p</i> -value
Physical exercise										
Yes (at least ≥ 3 times/week; 30 minutes each time)	6.83	1.8	14.35	3.30 - 10.36	<0.01	4.47	1.13	15.51	2.24 - 6.69	<0.01
Not at all	0 ^a	-	-	-	-	0 ^a	-	-	-	-
Sleeping pattern										
<5 hours (inadequate)	0.42	1.44	0.08	-2.41 - 3.25	0.773	-1.84	0.51	13.14	-2.84 - -0.85	<0.01
5-7 hours (adequate)	0 ^a	-	-	-	-	0 ^a	-	-	-	-
Diet type										
Ordinary (non-medically prescribed)	-6.18	1.51	16.80	-9.14 - -3.23	<0.01	-0.22	0.42	0.27	-1.04 - -0.60	0.602
Therapeutic (medically prescribed)	0 ^a	-	-	-	-	0 ^a	-	-	-	-

Note: Predictors of high NAS and SHEBS levels were analyzed using multinomial logistic regression.

p-value <0.05 was considered statistically significant while *p*<0.01 was considered statistically highly significant.

^aReference category against which the other groups are compared

BMI: body mass index; CI: confidence interval; Estimated β : log odds coefficient; kg/m²: kilogram per square meter; NAS: Nutrition Awareness Scale; SE: standard error; SHEBS: Sustainable Healthy Eating Behavior Scale; Wald test: according to Agresti (1990) and Polit (1996)

Table 3

Evaluation of barriers to sustainable healthy diet among participants
($n = 400$), Abha district, Asir region, Saudi Arabia,
December 2024 - February 2025

Barrier to a sustainable healthy diet	Score (mean \pm SD) ^a
Refuse to change dietary habit	0.98 \pm 0.16
Loss of social support	0.98 \pm 0.16
Eating alone and feeling lonely	0.98 \pm 0.16
Unpleasant taste of healthy food	0.30 \pm 0.46
High cost of sustainable healthy food	0.30 \pm 0.46
Dental or GIT disease	0.30 \pm 0.46
Impaired vision/medical condition	0.29 \pm 0.45
Decrease in cooking skill	0.27 \pm 0.44
Overall	0.55 \pm 0.33

^aScore of a barrier to sustainable healthy diet was obtained from an 8-item checklist, with a score of 0 indicating “no, it is not a barrier” and 1 “yes, it is a barrier” (Miller and Steinle, 2020; Neuhouser *et al*, 2020).

GIT: gastrointestinal tract

awareness of health issues, leading to a healthy diet. Our findings revealed an interesting pattern where a high proportion exhibited sound awareness but did not adopt SHEB, indicating that knowledge is not often proportional to consistent healthy eating practices. This pattern among older adults may be due to physical limitations, social

isolation and economic constraints that restrict them from acquiring healthy eating habits (Kassis *et al*, 2023). A study by Dominguez *et al* (2024) demonstrated practical hindrances like accessibility to fresh food and preparing nutritious meals, resulting in the least compliance with recommended dietary guidelines.

We observed a significant correlation between nutritional awareness and various demographic, clinical, and lifestyle explanatory variables. Those respondents in their 60s showed higher nutritional awareness than the older respondents. This concurred with previous reports of an inverse relationship between health literacy and age, due to impaired cognition and difficulty in managing more than one health condition (Curtis *et al*, 2021). Several studies reported that older individuals tend not to maintain adequate health literacy, which negatively influences their food choices and overall nutritional status (Thompson *et al*, 2017; Curtis *et al*, 2021). We also noted a significant difference in marital status and living arrangement. Interestingly, being married, male, or living with a spouse is associated with a low NAS score, indicating that unmarried individuals, particularly women, may focus more on their health. Older adults living with children reported greater nutritional consciousness. Cooking together leads to talking about healthier foods and cooking

practices, with health-aware children influencing their parents to better eating habits. The younger generations can play an extremely important role in educating their parents on new health trends and nutrition information. The younger generation can introduce their parents to social media apps on health and educational resources, empowering them to learn more about nutrition appropriate for older people. This emotional support, in turn, encourages responsibility or task-sharing, and family meals help older adults to eat more balanced meals by focusing more on nutrition than taste. Previous research suggested that social networks, particularly family networks, have protective effects against unhealthy eating habits and enhance nutrition awareness (Moore *et al*, 2021; Hanna *et al*, 2023). Yoshikawa *et al* (2021) also reported on the role of social networks in supporting healthful eating behavior.

Socioeconomic factors, particularly higher income, influence nutritional awareness. We observed that higher-income

participants exhibit high NAS scores in agreement with an earlier study (Turner *et al*, 2024). This correlation can be explained by the direct financial capacity to afford often more expensive, nutritious foods, such as fresh produce and lean meats. Furthermore, adequate income reduces food insecurity, allowing individuals the ability and stability to seek out nutrition information and prioritize their long-term health behavior over immediate, less costly but non-nutritious food purchases. We found that obesity was linked to lower nutritional awareness, underscoring the relationship between health status and dietary cognizance. These findings emphasize the importance of addressing socioeconomic disparities and health-related obstacles when developing strategies to enhance nutritional awareness and promote healthier eating habits among older adults (Gropper, 2023).

Our results revealed an age-specific pattern of SHEBS among the participants. The SHEBS score was higher among the older adults of 60-69 years of age compared to

those of higher ages, indicating that the former group might be more adaptable and receptive to the adoption of healthy dietary norms. This was consistent with prior research suggesting that as people age, they face greater health constraints and difficulty in maintaining sustainable dietary practices (Abu-Hussein, 2017; Dent *et al*, 2023). These barriers can include a decline in cognitive function, decreased mobility and lack of access to healthy food (Rony *et al*, 2024). Further, marital status and income have a significant role in predicting the SHEBS score among their sample.

We found that older unmarried adults have a higher SHEBS score than those who were married, in agreement with the aforementioned findings related to NAS. This contrasts with a previous study that reported married older individuals typically eat better (DeSilva, 2021). One possible explanation for this discrepancy could be the differing dynamics of support systems and motivations in married versus unmarried individuals. There was a strong association between income

status and SHEBS score, as those with an adequate income presented significantly healthier eating habits. This finding underscored the urgent need for targeted interventions in lower-income populations to improve dietary habits. It highlighted the importance of addressing socioeconomic disparities in nutritional awareness and the potential for such interventions to significantly improve the health of older adults with less than adequate income (Phulkerd *et al*, 2023).

Lastly, lifestyle factors such as physical activity and sleep patterns are significantly correlated and predictive of SHEBS scores. Our data showed that older adults who engaged in regular physical exercise or had adequate sleep exhibited higher SHEBS scores. Hu (2024) reported that a lack of sleep is linked to unhealthy eating. These relationships suggested that a holistic approach to health, encompassing both physical activity and proper sleeping habits, was essential for fostering healthier dietary choices. Our results were consistent with a previous study

highlighting lifestyle factors that influence nutrition behaviors (Gherasim *et al*, 2020). Additionally, SHEBS was also significantly influenced by the type of diet; those following a therapeutic diet displayed a higher SHEBS score than those on an ordinary diet. This was supported by a study showing that most older adults, in general, accept recommendations on adopting a therapeutic diet, which significantly impacts healthy eating behavior, an often-overlooked aspect in nutrition research (Turner *et al*, 2024).

Our findings highlighted significant barriers to sustainable healthy eating behavior among older adults, with psychological and social factors emerging as primary barriers, including resistance to changing dietary habits, diminished social support, and feelings of isolation in having solitary meals. These results emphasized the significant influence of social interactions and emotional well-being on nutrition behavior. Other research consistently showed that social support is a key factor in promoting adherence to nutritional guidelines, with individuals more

likely to maintain healthy eating habits when encouraged by family and friends (Bloom *et al*, 2017). Conversely, social isolation can negatively impact food choices, as demonstrated by studies linking loneliness to poor nutrition in older adults (Moore *et al*, 2021).

We revealed that while factors, such as taste preferences, cost, and health conditions, including dental or gastrointestinal issues, impacted the eating habits of older adults, they appeared less significant than psychological barriers. The lower mean scores for these factors indicate that they were not the primary challenges for the participants, which contrasts with some research that emphasizes cost as a significant obstacle, especially for lower-income groups (Wang *et al*, 2023; Stone *et al*, 2024). Nevertheless, taste preferences and health-related issues, including impaired vision or reduced cooking ability, still influenced dietary choices to some extent. These findings suggested that addressing these barriers through targeted culinary education and personalized

nutritional interventions could enhance the appeal of healthy foods and better accommodate the specific health needs of older individuals, ultimately fostering improved dietary practices (Miller *et al*, 2020).

Our study revealed a strong inverse relationship between barriers to healthy nutrition and both NAS and SHEBS scores. As perceived obstacles increased, older adults exhibited lower levels of sustainable eating practices and nutritional knowledge. This finding underscored the significant impact that perceived barriers have on dietary choices and awareness. This agreed with previous studies that highlighted how factors, such as limited nutritional understanding, insufficient social support, and lack of motivation, can impede the adoption of healthier eating habits (Deslippe *et al*, 2023; Domosławska-Żylińska *et al*, 2023; Dominguez *et al*, 2024). These results indicated that addressing and reducing these perceived barriers could be crucial in promoting more sustainable and health-conscious dietary behaviors among older individuals. This

aligned with previous research emphasizing the crucial role of nutrition education in promoting healthy eating habits, particularly among older adults who may face specific challenges in accessing and understanding nutrition information (Ortiz Segarra *et al*, 2023). The findings further emphasized the need for targeted interventions to overcome these obstacles and enhance overall nutrition practices among the older population.

The study had several limitations. The cross-sectional design did not allow identification of the causal nature of the connections between nutritional awareness, sustainable healthy eating habits, and barriers. Self-reported metrics might introduce social desirability bias, which could result in a rise in consciousness levels. Generalizability is limited since only one area (Abha) in Saudi Arabia was used for sampling. Although key variables were adjusted for, unmeasured confounding variables such as cultural dietary habits or access to health services could still affect outcomes in some cases. Longitudinal studies

will be needed to test these associations over a wide range of regions to confirm their validity.

In conclusion, our study highlighted the crucial role of nutritional awareness and the adoption of sustainable, healthier eating habits among older adults in Abha, Saudi Arabia. Despite having their high nutrition knowledge and sustainable nutrition practices, our survey found certain socioeconomic and psychological barriers, revealing that knowledge alone did not ensure healthy eating behavior. Introducing targeted education and community programs, such as cooking classes and shared meals, can help to overcome the barriers, mitigate isolation and foster healthy eating habits. Incorporating nutritional assessments and counseling in healthcare centers will also be helpful. These strategies should improve nutrition health and promote healthier aging in the older population of the country.

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CONFLICT OF INTEREST DISCLOSURE

The authors report no conflict of interest.

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