Fruit and vegetable intake among older adults: a scoping review

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Abstract
Older adults are the fastest growing segment of the world population. Older adults are also at heightened risk of chronic conditions (such as diabetes, heart disease, and cancer) and specific geriatric conditions (such as cognitive impairment, frailty, and falls). Research studies have examined the relationship between fruit and vegetable intake and subsequent health outcomes and the correlates of fruit and vegetable intake in the U.S. population. However, relatively few studies have specifically examined health impacts and correlates of fruit and vegetable intake among older adults, who have unique biophysical and socioeconomic circumstances.

Evidence is reviewed to (1) describe findings related to consumption and chronic, geriatric, and other health outcomes among older adults and (2) describe patterns in fruit and vegetable consumption among older adults and how these patterns vary within and among populations. This review addresses specific barriers faced by older adults in obtaining and consuming fruits and vegetables in community settings. Recommendations for practice and policy are discussed.

Keywords
Fruits and vegetables; Carotenoids; Risk factors; Food access; Elderly; Gender; Race/ethnicity; Socioeconomic status; Neighborhoods; Nutritional knowledge

“•The doctor of the future will no longer treat the human frame with drugs, but rather will cure and prevent disease with nutrition.” - Thomas Edison

1. Introduction
There is a consensus among researchers and the general public that eating fruits and vegetables leads to life-long health benefits. Improved population nutrition is one of the key

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Contributors
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Conflict of interest
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factors underlying increased longevity in the past century [1]. Fruits and vegetables are often identified as the most important part of a diet in preventing age-related disease [2,3]. Throughout decades of nutritional guideline transitions from food groups to pyramids to plates, fruits and vegetables have maintained a prominent place in the daily nutritional guidelines set by departments and ministries of health worldwide [4,5]. Because of the recognized health benefits of eating fruits and vegetables, there are widespread policy and program initiatives to increase the availability and consumption of these foods, particularly among children. The older adult population, however, has unique nutritional needs and barriers [6].

This scoping review examines the outcomes associated fruit and vegetable intake in older adulthood and how these vary by individual and community-level characteristics. This review will discuss evidence of health-related benefits of fruit and vegetable intake in later life from epidemiologic and intervention studies. Studies were reviewed that examined fruit and vegetable intake among community-dwelling (non-institutionalized) older adults. Studies were excluded from the scoping analysis that addressed diet quality generally (without specific examination of fruit and vegetable intake or markers). Studies were also excluded from the analysis that examined the impact of early-life fruit and vegetable on health outcomes in later life. While such lifecourse studies do provide valuable information on the cumulative impact of diet, such studies are out of the scope of this review. The majority of studies reviewed were conducted in the United States, although a sizeable number of English-language studies are included that examine fruit and vegetable intake of older adults in other countries.

2. Health Outcomes Associated with Fruit and Vegetable Intake among Older Adults

Most research studies offer support that a positive relationship exists between fruit and vegetable intake and health outcomes across the lifespan, including the prevention and management of chronic illnesses, disease-specific mortality, and general mortality. However, the extent to which eating fruit and vegetables in old age is associated with these health benefits has received much less attention. The majority of studies on the health benefits of fruits and vegetables are cross-sectional or do not include older adults in the sample. As older adults have unique social and health circumstances, more research is needed in this area generally to provide necessary evidence for lifestyle-based interventions among older adults. This section reviews the findings from research studies that examine the health-related benefits of fruit and vegetable intake among older adults.

1.1 Mortality

Research has effectively linked fruit and vegetable consumption to reduced risk of mortality among older adults. Studies have found that fruit and vegetable intake promotes a longer life span and lowers the risk of disease-specific and all-cause mortality, whether intake is measured by self-report, food frequency questionnaires, or serum carotenoid levels in the blood [7-12]. One recent study found that the tertile of women with the highest serum carotenoid concentrations were 50% more likely to survive a five-year period compared with their counterparts in the lowest tertile [12]. Fruit and vegetable consumption is also predictive of disease-specific mortality, such as cancer- and cardiovascular-specific mortality [10]. Some of these health benefits are linked to specific foods; cruciferous (green and leafy) vegetables are particularly predictive of longevity [7].
1.2 Chronic Diseases

Nutrition is linked to the function and quality of life for older adults with chronic disease [1,13,14]. Fruit and vegetable consumption during older adulthood is associated with reduced likelihood of chronic disease [2]. A number of studies offer support to the linkage between fruit and vegetable intake during older adulthood and cardiovascular health. These dietary characteristics are protective against hypertension [8,15], coronary heart disease [2,15-17], atherosclerosis [18-20], and stroke [21] among older adults. Research also suggests fruit and vegetable intake in older adulthood is protective against the development or exacerbation of several kinds of cancer for men and women [10,23-27].

Evidence is also emerging regarding the relationship between diet and osteoporosis. Numerous studies have linked vitamin D and calcium consumption to improved bone mineral density. Additional research suggests that a diet rich in magnesium, potassium, vitamin C, and vitamin K (acquired from consuming a variety of fruits and vegetables) may also aid in the prevention of bone loss in both sexes [28,29].

1.3 Geriatric Conditions and Functional Impairments

Emerging research suggests that fruit and vegetable intake in older adulthood can prevent against the onset or exacerbation of cognitive impairment, falls/walking disability, and other geriatric-associated conditions.

Research has begun to examine the role of fruit and vegetable consumption in the aging brain. Emerging evidence indicates that fruit and vegetable intake is protective against cognitive decline and related conditions. Several prospective studies found that participants who consume greater levels of fruits and vegetables scored higher on cognitive and neuropsychological evaluations [30,31] and showed improvements in verbal fluency, memory, and rate of learning from such dietary changes [32]. In addition, a Mediterranean-style diet that is rich in nuts, oils, fruits, and vegetables has also been shown to be predictive of good heart health and of cognitive benefit for risk reduction of Alzheimer's disease and dementia [31-33].

Older adults who maintain physical function and avoid falls are less likely to be hospitalized or institutionalized and may have reduced risk of injury and mortality. While this field of research has only recently begun to emerge, studies have suggested that fruit and vegetable intake protects against physical decline and associated disability. Higher serum carotenoid levels predict improved muscle strength and bone density among older adults [29,34,35]. Fruit and vegetable consumption has also been found to improve physical function and walking speed while reducing walking disability and frailty among elders [34,36,37]. Older adults who maintain physical function and avoid falls are less likely to be hospitalized or to require assisted living.

There is evidence that fruit and vegetable consumption could protect against the onset or progression of other geriatric conditions. This is demonstrated by the discovery of a moderate association with a decrease in cataracts for older women [39]. Increased intake has also been connected to increased vaccination antibody response [40] and may be a risk reduction factor for inflammation with specific regard to fruit and vegetable intake variety, rather than quantity [34,41].

Associated health outcomes of a diet rich in fruits and vegetables appear to be largely positive, though further research might be conducted to determine the effects of different fruit and vegetables on elders of various social and cultural backgrounds as a foundation for appropriate intervention strategies.

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3. Trends in Fruit and Vegetable Intake

Compared with younger adults, older adults tend to eat fewer high-energy sweets and fast food and eat more grains, fruit, and vegetables. On average, older adults eat more servings of fruits and vegetables, which might be nutritionally necessary given the change in metabolic processes that occurs in old age [6,13]. Although the majority of adults incorporate at least one serving of fruits and vegetables into their daily diet (85 and 95%, respectively), less than half of older adults eat the recommended five servings of fruit and vegetables per day [13]. Major studies have estimated that only 21 to 37% of men and 29 to 45% of women aged 65 and older achieve the recommended servings per day (depending on the study methodology) [14,42-45]. Older adults (aged 65 and older) tend to score well on the Healthy Eating Index in consumption of total fruit (and whole fruit in particular) and total vegetables, but have low scores in consumption of dark green and orange vegetables and legumes [46]. There are also noticeable differences by age among the older adult population as well; elders aged 75 and older are more likely to eat fruit, while elders aged 65-74 tend to eat more vegetables [46]. It is particularly important for older adults to be aware of fruit and vegetable consumption because they tend to eat smaller quantities of food overall, which can lead to deficiency of important vitamins and minerals [14].

4. Predictors of Fruit and Vegetable Intake among Older Adults

Although older adults tend to eat more fruits and vegetables than the general population, several trends warrant concern. First, as discussed above, the intake does not approach recommended levels. Second, the most nutritious and health-promoting foods are under-consumed. Starchy vegetables make up a large proportion of daily vegetable consumption per day, likely due to the ease of preparation and consumption (e.g., boiled and mashed potatoes). Dark green and orange vegetables, which tend to be more nutrient-rich, account for only 12 to 15% of total vegetable consumption among older adults [13]. Further, some research suggests that consumption has declined among older adults in the past decade [46].

Older adults’ eating habits are also heterogeneous, and the determinants of fruit and vegetable intake among older adults are complex. With population aging, the number and intensity of barriers in accessing and consuming fruits and vegetables increase. The literature suggests that fruit and vegetable intake is influenced by numerous group- and individual-level predictors. Many of these are unique to situations and circumstances in older adulthood. The following predictors are discussed: (a) health status, (b) geographic/physical environment, (c) gender, marital status, and household composition, (d) social support, (e) race/ethnicity, (f) socioeconomic status, and (g) dietary knowledge. Although this is not an exhaustive discussion of predictors, these characteristics have been found to influence the access to—and consumption of—fruit and vegetables among older adults.

4.1 Health Status

Older adults are at heightened risk of functional limitations, disability, and chronic disease onset and complications. While fruit and vegetable intake protects against the development and exacerbation of these conditions, ironically, being affected by these conditions makes accessibility, preparation, and consumption of these important nutrients problematic.

Old age is often accompanied by changes in appetite, and compromised oral health could reduce fruit and vegetable intake. Appetite loss is influenced by changes in perception of hunger [47], taste acuity, and sense of smell [48]; concern about digestive problems [49]; diminished pleasure associated with food [50]; and everyday emotions [51]. Older adults suffer from gum disease, tooth loss, decay, and mouth infections. Compromised oral and dental health is associated with decreased consumption of fruits and vegetables [52]. Older
adults typically eat fruit and vegetables in their whole form [13], and textures of these foods become difficult to bite, chew, swallow, and prepare, particularly among older adults who are missing posterior teeth and/or have dentures [45,53,54]. In sum, older adults are particularly affected by certain physiological changes related to appetite and oral health, which in turn influence nutrient intake.

Older adults who have functional limitations and disabilities confront unique barriers in acquiring, preparing, and consuming foods. Mobility-impaired older adults, in particular, confront challenges in accessing fresh fruits and vegetables [45,55], and home-bound older adults who must rely on home-delivered meals or other assistance are particularly vulnerable to under-nutrition [56].

Physical health decline is typically accompanied by a subsequent deterioration in dietary quality [45,57]. This association is explained by reduced access to fruits and vegetables as well as more difficulty in preparing and eating nutrient-rich foods. For example, older adults with severe arthritis are confronted by challenges in the physical requirements of cooking as well as the effort required to take part in food-related social activities [49]. One possible exception is that adults—young and old—tend to increase fruit and vegetable intake after diagnosis of cancer. Studies have found that fruit and vegetable intake increases after diagnosis of breast, prostate, and colorectal cancer [25-27]. Studies have found that these diet changes are often due to personal beliefs and preferences (such as having control over that aspect of their lives) rather than in response to a doctor or other provider’s recommendation [58-61].

4.2 Geographic and Environmental Characteristics

Health disparities in the United States are at least partially explained by differences in food access by geographic location. Stark disparities exist in urban environments where access to fresh fruits and vegetables varies by neighborhood, with greater access in more affluent and predominantly white neighborhoods [62-64]. Food stores in less affluent and in minority-segregated communities tend to have fewer fresh food options available [62,65,66]. In disadvantaged neighborhoods, food is not only more difficult to access, but prices are often higher for the same products [64,67].

However, it is important to note that these characteristics are not uniform across regions and countries [68]. Consumption of fruit and vegetables also varies greatly according to region and country [e.g. 69]. The physical environment and food culture influences consumption. For example, older adults eat more servings of fruit and vegetables in regions where the Mediterranean diet is predominant, particularly in Spain, Italy, and Greece [70]. In contrast, older adults living in rural areas of the United States face unique challenges in accessing fruits and vegetables. If unable to drive, rural elders have limited transportation options to food stores [71], and greater distance to such stores has been found to result in lower fruit and vegetable intake among rural elders [72]. Further, government programs that provide food to older adults (such as Meals on Wheels) have less reach in some rural areas due to lower tax bases and demanding transportation requirements for community volunteers [73]. Therefore, older adults living in urban and rural settings confront unique, and different, barriers to fruit and vegetable consumption.

4.3 Gender, Marital Status, and Household Composition

A number of studies have found that older women eat more fruit and vegetables than older men, even though older men eat more food overall [74-77]. This disparity is heavily influenced by differences in nutrition-related knowledge and the degree of confidence in accessing and preparing nutrient-rich foods. While older men and women both recognize
that balanced meals benefit health, on average, men are less aware of dietary recommendations and the linkages between dietary intake, health, and disease [75,78,79]. Older adults gain knowledge about the nutritional benefits of fruit and vegetables from health care providers and in commercial settings such as grocery stores; across the lifespan, women are more likely to be at these settings than men [75]. This gendered difference in nutrition-related knowledge could explain up to half of the fruit-vegetable consumption disparity between men and women [75]. Older men with better cooking skills, who cook a greater variety of foods, and who have greater access to information, tend to consume more fruit and vegetables [76,79]. Access to meals containing fruit and vegetables that are the appropriate portion size and are easy to open, prepare, and cook are also predict higher intake among older men [76].

Marriage is positively associated with fruit and vegetable intake among older men and older women. A study of the relationship between marriage and fruit and vegetable intake in Canada found that older adults who were married were most likely to achieve recommended portions (48%), followed by seniors who were widowed, divorced, or separated (46%), and by seniors who were single or in a cohabiting common-law relationship (43%) [81]. Single men are at particularly high risk of low intake [76]. Marriage is particularly beneficial for older mens’ fruit and vegetable intake [80], and the presence of a woman in the household is associated with higher fruit and vegetable intake of male household members [76]. However, the benefits of marriage for fruit and vegetable intake are difficult to separate from the benefits related to companionship and eating meals together [81].

The experience of widowhood heightens risk of inadequate diet for both men and women. Older women are more likely to confront different barriers than are older men following the death of a spouse. Widowers are at risk because they often lack skills in the process of choosing and preparing nutrient-rich foods if this was previously their spouse's domain [76]. Following the death of a spouse, women are particularly socioeconomically vulnerable and at risk of social isolation. Older women, who might be more accustomed to cooking for others, are often less inclined to prepare food and cook complete meals for themselves—a process that might be reserved for shared special occasions [49,82].

4.4 Social Support

Research that has examined the social correlates of fruit and vegetable intake among older adults generally agrees that social isolation is a strong risk factor for fruit and vegetable intake, and social interaction and support are associated with higher levels of fruit and vegetable intake, with some exceptions [77,83]. The benefits of social engagement on fruit and vegetable intake are multifactorial; socialization and companionship are key predictors [45,81,84], particularly since many social gatherings involve food [49]. Social interaction itself provides a motivation for older adults to go to congregate eating sites for meals [49]. Older adults with functional limitations experience restricted life-space, which is associated with nutritional risk [71]. As social support and social interaction are strong predictors of fruit and vegetable intake, further research should examine the specific kinds of support that protect against inadequate intake in older adulthood, and how this varies by race/ethnicity, functional status, and gender.

4.5 Race/Ethnicity

There are differences in fruit and vegetable consumption across the lifespan by race/ethnicity, as defined by respondents and according to U.S. census categories. In the United States, African Americans are less likely to meet recommended intake of fruits and vegetables than non-Hispanic whites and Hispanics/Latinos. On average, African American adults consume nearly one serving of fruits or vegetables less than do non-Hispanic whites
or Hispanics/Latinos [85]. These disparities continue in old age; older African Americans are at heightened risk of low fruit and vegetable intake. Racial/ethnic differences are partly due to individual and neighborhood-level socioeconomic status [85-88]; however, research studies suggest that this relationship remains even after taking socioeconomic status into consideration [45,74,89]. Older African American men and women are at risk for social isolation and have limited social support and capital [71]. Fruit and vegetable consumption is particularly low among African Americans in minority-segregated neighborhoods [87,90,91]. Further, living in an economically deprived neighborhood is a particularly strong predictor of inadequate fruit and vegetable intake for African Americans compared to other racial/ethnic groups [63,85]. Fruit and vegetable access is limited in minority-segregated neighborhoods relative to availability in predominantly white and racially integrated neighborhoods, largely due to differences in the food retail environments [87,91,92]. However, the presence or magnitude of racial/ethnic disparities in intake varies by country and region [69].

4.6 Socioeconomic Status

Among consumers who face economic constraints, older adults are likely to differ from their younger counterparts in the degree to which fruit and vegetables are considered priority purchases. The patterns and decisions behind food purchases differ between younger and older adults [93]. Fruit and vegetable purchases are influenced by cohort and age-related factors, such as food scarcity during childhood and transitions to retirement. However, the majority of research that examines the influence of socioeconomic status on fruit and vegetable consumption examines the general population or does not include older adults in the sample. Fruit and vegetables are generally considered priority purchases among older adults, even in food-insecure households [94]. However, research suggests that there are pervasive and strong socioeconomic determinants of fruit and vegetable intake among older adults. Elders with lower individual and household educational attainment are at heightened risk of not eating daily recommended values [45,69]. Individual and household income level also predicts intake [69,95,96]. In a recent study on income differences in eating patterns among older adults, individuals in the low and medium household income groups ate significantly fewer fruits and vegetables than those in the higher income group (0%-350% of poverty) to those in medium and higher income groups (above 350% of poverty) [96]. Fruit intake was progressively higher by income group as well [64]. Mechanisms operate for socioeconomic disparities in fruit and vegetable consumption at both community and individual levels. Individuals from low-income households spend a greater proportion of their income on food compared to higher-income households [64]. Fruits and vegetables (particularly in their preferred fresh form) are costly, and the retail prices have increased more rapidly than the prices of other food types over the past several decades [97].

Individuals with fewer resources are more likely to live in poorer neighborhoods, while people who live in poorer neighborhoods consume fewer fruits and vegetables [85-87]. Resource-deprived neighborhoods typically have fewer large grocery stores available and instead have smaller stores with fewer fruit and vegetable options [62,65-67,98,99]. In addition to being less available, fruits and vegetables in poorer neighborhoods usually cost more than they do in socially advantaged neighborhoods [64]. For older adults across the socioeconomic spectrum, the price and perceived worth of food are important considerations in food purchases [49].

4.7 Knowledge

Although there is limited support for nutritional knowledge resulting in changed dietary behaviors in the general population [100], some research suggests that nutritional knowledge does predict fruit and vegetable intake among older adults [101,102] and particularly among
older men [75,79]. Many older adults do not think they are at risk for poor nutrition [103], and perceptions of what constitutes a healthy or balanced meal vary [49]. However, fruit and vegetable consumption remains challenging for older adults who are aware of its many benefits. As older adults confront unique barriers to acquiring, preparing, and eating fruits and vegetables, food intake is a balance of tradeoffs. In a qualitative research study, one participant describes such a tradeoff: “I’m very interested in nutrition and I read everything that I can get about it. And I try to do what I think is right, except when it conflicts with the difficulty of doing it. Or the cost of doing it. Those are the two things that I think influence the way I plan my meals” [49, pg. 262]. Interventions to increase diet-related knowledge should be tailored to the older adult population, given their unique experiences, barriers, and learning processes [1].

In sum, the literature suggests that older adults face unique challenges and barriers in obtaining, preparing, and consuming fruits and vegetables. These barriers exist at the individual- and group/environmental levels. Older adults with declining health, functional limitation, loss of appetite, and dentition problems tend to eat fewer fruit and vegetables. The communities in which older adults reside can provide opportunities for or impose barriers on fruit and vegetable consumption. Older men are at the highest risk for inadequate intake, but living alone and widowhood are risk factors for reduced fruit and vegetable consumption among all older adults. Social support is a protective factor, since company provides incentive to eat, and assistance breaks down barriers to acquiring and preparing food. Older African American adults and older adults with limited socioeconomic resources eat fewer fruits and vegetables than other groups, which is at least partially due to neighborhood environment and food availability. Increased knowledge about the benefits of fruit and vegetables—as well as what constitutes a healthful meal—is associated with higher levels of consumption; however, the barriers confronted by older adults can outweigh the perceived benefits.

5. Recommendations for Practice and Policy

Nutrition is one of the few modifiable predictors of health in old age [104]. This review discussed the current evidence regarding benefits of and barriers to fruit and vegetable access and consumption among older adults. In this review, we have discussed emerging literature that connects fruit and vegetable intake to improved health outcomes, including mortality, disability, chronic disease, and other geriatric conditions. While these studies provide compelling evidence, additional prospective epidemiologic studies on elder cohorts are needed; these should include detailed dietary information at baseline and at follow-up. Additional studies that identify the benefits of fruit and vegetable consumption in later-life health outcomes will be beneficial on several fronts. First, these data will provide older adults and their providers with evidence-based suggestions for preventing negative health outcomes and coping with chronic disease. Second, additional evidence is needed to promote policies for health-promotion interventions. In order to inform these interventions, it is particularly important that these studies examine late-life eating habits.

The literature review identified certain groups at heightened risk of inadequate fruit and vegetable consumption. In particular, older adults who are disabled or mobility impaired confront severe barriers in acquiring, preparing, and eating fruits and vegetables. The conditions are exacerbated by the intersection of health problems, social isolation, and inadequate transportation. Older men, African Americans, and adults living in homes and communities lacking socioeconomic resources also eat fewer fruits and vegetables. Interventions should continue to focus on knowledge-building, particularly among socially and economically vulnerable older adults.
Interventions to increase fruit and vegetable intake among older adult populations have generally been successful, whether they occur in community settings or in the home [105-108]. It is particularly important that interventions be planned and tailored specifically for older adults to address age-specific barriers in access or knowledge. Such interventions should aim to improve older adults’ knowledge or access [46, 109]. More effective interventions also incorporate an individual’s desire or readiness to change dietary behaviors [110]. Nutritional screening can help raise awareness, identify needs, and target limited resources for those in need. More systematic screening of the older adult population can help identify older adults in need of nutrition-related resources [1,111].

There are several federal resources available to older adults to improve access and intake of fruit and vegetables; however, studies suggest that the programs are limited in reach. The Supplemental Nutrition Assistance Program (SNAP) is the largest food assistance program in the United States, but participation is low among older adults. SNAP is an entitlement program that provides enrollees with electronic benefit transfer cards and, in many cases, nutrition education. Older adults have the lowest participation rates compared to all other demographic groups [112]. Eligible older adults would be more likely to enroll in SNAP benefits through simplification of the eligibility criteria, increased application assistance, and the provision of commodity alternatives [112,113]. The Elderly Nutrition Program (ENP), within the Older Americans Act, is the largest program to coordinate nutrition services to older adults. Its original intent was to provide nutritionally sound meals and promote physical and social well-being [114]. The food services provided to older adults (such as Meals on Wheels) rely on community members and local volunteers. However, there is inadequate funding for such programs, as less than 10% of older adults at nutritional risk participate in the Elderly Nutrition Program [115].

Private and community-based organizations have long recognized the benefit of providing locally available fruits and vegetables, particularly to socially disadvantaged populations [116]. Increasingly, community-based approaches have been promoted to link locally grown food to segments of the population at risk of under-nutrition. The integration of community-based approaches with federal funding mechanisms can improve fruit and vegetable access and intake among older adults. Successful approaches include promoting SNAP benefit use in farmers’ markets and developing programs to promote Meals on Wheels delivery through drivers’ education programs [105,117]. Unfortunately, relatively few programs that aim to enhance the availability of fruits and vegetables are prospectively evaluated [e.g., 118,119]. Even fewer community-driven programs that specifically target seniors have been adequately evaluated [105]. It is important for practitioners and researchers to engage in the evaluation process of promoting innovative strategies to meet the fruit and vegetable needs of seniors alongside community-initiated strategies. Such strategies will enhance the evidence base and will assist stakeholders in promoting policies that promote fruit and vegetable access and intake among older adults.

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