REVIEW

Leveraging Observational Cohorts to Study Diet and Nutrition in Older Adults: Opportunities and Obstacles

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ABSTRACT

By 2060, the number of adults aged ≥65 y is expected to double, and the ≥85 y segment of the population is expected to triple in the United States. US federal nutrition guidance is based on the premise that healthy diets contribute to delaying the onset and progression of many age-related diseases and disability. Yet, little is known about the dietary intakes or nutritional needs across the older adulthood age span. This review aims to identify community-based cohorts that collected information on dietary intake of adults ≥65 y in the United States. Thirty-two cohorts met all inclusion criteria. We summarized information on the cohorts' design, demographics, and diet assessment. We also identified key gaps in the existing databases that, if filled, could enhance their utility to address certain research questions. This review serves as a valuable inventory of cohorts that can be leveraged to answer key questions about the diet and nutritional needs of the oldest old, who represent the fastest growing segment of the population in the United States. *Adv Nutr* 2022;13:1652–1668.

Statement of Significance: This review provides an overview of community-based cohorts that collected information on dietary intake of adults aged ≥65 y in the United States and summarizes information about design, demographics, and diet assessment. Key gaps in the existing databases are identified, that, if filled, could enhance their utility to address certain research questions and obtain more robust evidence about the diet and nutritional needs of older adults, who represent the fastest growing segment of the US population.

Keywords: older adults, aging, diet, nutrition, dietary intakes, epidemiology, cohort studies

Introduction

The United States is experiencing an unprecedented demographic shift toward an older population. By 2060, the number of adults aged ≥65 y will more than double and will make up nearly one-quarter of the US population. The ≥85 y segment of the population is the fastest growing group within this shift and is expected to triple in size by 2060 (1, 2).

This demographic shift is in part due to an increased lifespan related to advances in medicine. However, a longer lifespan is not necessarily synonymous with a longer health span, which can be defined as the number of years that a person is living a functional and disease-free life (3). Many noncommunicable diseases, such as heart disease, diabetes, chronic kidney disease, Alzheimer disease and related dementia, cancer, and chronic lung disease, increase dramatically with age (4). Over 85% of Americans aged ≥65 y have ≥1 chronic disease, and >63% have ≥2 (5). This high prevalence of chronic disease coupled with the rapidly growing numbers of older adults will create a significant burden on the health care system (6).

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Supplemental Material—Detailed Method and Supplemental Table 1 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/advances/.

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Abbreviations used: ARIC, Atherosclerosis Risk in Communities Study; CARDIA, Coronary Artery Risk Development in Young Adults; DGA, Dietary Guidelines for Americans; DRI, Dietary Reference Intakes; HAAS, Honolulu-Asia Aging Study; HCHS/SOL, Hispanic Community Health Study/Study of Latinos; HPFS, Health Professionals Follow-up Study; MESA, Multi-Ethnic Study of Atherosclerosis; NHS, Nurses' Health Study; Rush MAP, Rush Memory and Aging Project; SWAN, Study of Women Across the Nation.

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Federal nutrition guidance in the United States is based on the premise that healthy diets contribute to delaying the onset and progression of many age-related diseases and disability. However, a fundamental gap in our understanding of the role of nutrition in healthy aging is how dietary intakes change over time across the entire lifespan. The current Dietary Guidelines for Americans (DGAs), which provide recommendations to help individuals consume a healthy, nutritionally adequate diet across life stages, define older adults as those who are ≥60 y. Except for providing estimated calorie needs for subgroups of adults up to age 75, the DGAs do not distinguish other dietary recommendations for subgroups of adults aged >60 (4). The most recently updated DGAs did not find sufficient evidence for how dietary patterns can influence the progression of many age-related diseases and disability, so recommendations are not based on lowering chronic disease risk (4, 7). The Dietary Reference Intakes (DRIs) provide recommendations about nutrient intake for those aged >70 y, although the empirical data are very limited for the majority of macro- and micronutrients in this age group (8). Further, the DGAs and the majority of DRIs are created for those who are healthy and in a normal weight range, rather than those living with chronic disease. The National Academies of Sciences, Engineering, and Medicine have now recommended that DRIs be evaluated for specific nutrients or other food substances in the context of chronic disease outcomes (9). However, chronic diseases have only been considered for setting recommendations for a limited number of nutrients (9–11). Evidence-based research on the role of food and nutrition in older adults, an age group that currently can span ≥50 y, depending on the criteria used, is needed to fill research gaps that currently limit the ability to make more specific dietary recommendations for age-specific subgroups of older adults.

One of the challenges in defining the nutritional needs of older adults is the temporal relation between critical exposure to nutrients and other dietary components and the corresponding effect on health outcomes. Randomized clinical trials and feeding studies are integral for understanding interindividual responses to nutrients or other dietary exposures over a finite period of time (12). However, it is unrealistic to expect that feeding studies and clinical trials will be conducted for all nutrients and dietary components over every decade of age and with sufficient follow-up time to observe the health outcomes of interest. Instead, well-phenotyped longitudinal cohorts with data about dietary intakes, nutritional status, and validated chronic disease outcomes can provide a resource to begin to fill these knowledge gaps.

This review provides a comprehensive summary of dietary data available in longitudinal observational studies conducted in the United States, which represent a resource for research on diet, nutrition, and healthy aging using available cohorts. We also identify key gaps in the existing databases that, if filled, could enhance their utility to address certain research questions.

Current Status of Knowledge

Cohort selection

We searched MEDLINE (Ovid) and PubMed to identify studies that assessed dietary intakes within community-based cohorts featuring older adults. The search strategy (**Supplemental Material—Detailed Method**) combined Medical Subject Headings (MeSH), keywords, and specific filters to describe the following concepts:

- dietary intake and/or diet
- aging and/or older adults
- selected study designs (i.e., cohort).

Search results were limited to longitudinal observational population-based cohorts that were conducted within the United States and had ≥1 publication since January 1, 2006. Inclusion criteria for cohorts were as follows: US community-based cohorts that included ≥1 measurement of dietary intake and enrolled adults ≥65 y at baseline or enrolled younger participants who were followed to ≥65 y of age. [We chose 65 y and older to be consistent with the US CDC Indicator Definition (13).] We located individual cohorts' websites to obtain references from their list of publications that provided details about participant demographics, dietary assessment, and follow-up. For cohorts that did not have available websites or publications lists, additional references were located via PubMed and/or were previously identified by the authors. We summarized the cohorts' demographic characteristics and available dietary data. Because the NHANES is currently conducting longitudinal follow-up on previous participants (14), we also included NHANES in our summary. We then identified existing gaps that could be filled to enhance the use of the identified cohorts to address unanswered questions about dietary changes in older adulthood.

Cohort characteristics

Several observational cohorts have been established and continue to provide valuable data to fill important knowledge gaps about healthy aging (15). Our initial search identified 51 US-based population-based cohorts that included older adults. Twenty were excluded due to insufficient diet data (**Supplemental Table 1**). The 32 cohorts that met the inclusion criteria were comprised of nearly 1 million individuals from across the United States (**Table 1**). For the purposes of this review, the Framingham Heart Study was counted as 1 study, but it is important to note that this study contains 6 unique cohorts underneath the Framingham Heart Study umbrella. A similar approach was adopted for the Nurses' Health Study (NHS) and Adventist Health Study, which are now comprised of 3 separate groups, and the NHANES, which is a program of studies designed to assess the health and nutritional status of noninstitutionalized US citizens (16). Thirteen NHANES cycles have been conducted to date, beginning in 1971–1974 with NHANES I, followed by NHANES II in 1976–1980, and NHANES III in 1988–1994. NHANES is now conducted continuously in 2-y cycles (17, 18).

Table 1 Characteristics of US population-based observational studies with dietary intake data

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years		Dietary intake assessment	URL	References
					Baseline	Follow-up			
Framingham Heart Study									
Original cohort	$n = 5209$ from Framingham MA, free of symptomatic cardiovascular disease	28–74 y (<5% ≥65 y)	55% female	>95% white	1948–1953	Through 2014, 32 follow-up exams	FFQ exam 20 (1986–1990)	https://framinghamheartstudy.org/	(29, 76–78)
Offspring	$n = 5124$ offspring of original cohort and their spouses	5–70 y (<2% ≥65 y)	52% female	>95% white	1971–1975	Through 2014, 9 follow-up exams	FFQ exams 3, 5, 6, 7, 8,9 (1983–2014)		(29, 31, 79, 80)
Omni Cohort I	$n = 507$	27–78 y (<2% ≥65 y)	58% female	28% African-American, 42% Hispanic, Asian, 24% Indian, Pacific Islander, or Asian Indian	1994	Through 2014, 4 follow-up exams	FFQ exams 2, 3, 4 (1999–2014)		(29)
Third Generation (Gen 3)	$n = 4095$ offspring of Offspring cohort	19–72 y (<2% ≥65 y)	53% female	>95% white	2002–2005	Through 2019, 3 follow-up exams	FFQ exams 1, 2, 3 (2002–2019)		(29, 81, 82)
New Offspring Spouse (NOS)	$n = 103$ spouses of Offspring cohort participants	47–85 y (<2% ≥65 y)	54% female	>95% white	2003–2005	Through 2019, 3 follow-up exams	FFQ exams 1, 2, 3 (2003–2019)		(29)
Omni Cohort II	$n = 410$	20–80 y (<2% ≥65 y)	57% female	28% African-American, 42% Hispanic, Asian, 24% Indian, Pacific	2003–2005	Through 2019, 3 follow-up exams	FFQ exams 1, 2, 3 (2003–2019)		(29)
Adventist Health Studies									
Adventist Mortality Study (AMS)	$n = 23{,}000$ non-Hispanic Seventh-Day Adventists from California	≥25 y (28% ≥65 y)	65% female	Mostly white	1958	Through 1966	FFQ at baseline	https://adventisthealthstudy.org/	(83, 84)
Adventist Health Study 1 (AHS-1)	$n = 34{,}192$, non-Hispanic Seventh-Day Adventists from California	≥25 y (27% ≥65 y)	60% female	75% white	1974	Through 1988	FFQ at baseline	https://adventisthealthstudy.org/studies/AHS-1	(85, 86)

(*Continued*)

Table 1 (*Continued*)

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years		Dietary intake assessment	URL	References
					Baseline	Follow-up			
Adventist Health Study 2 (AHS-2)	$n = 96{,}194$ Seventh-Day Adventists living in the United States and Canada	≥30 y (33% ≥65 y)	65% female	65% non-Hispanic white, 27% African-American	2002–2005	Ongoing, every 2 y	FFQ at baseline	https://adventisthealthstudy.org/studies/AHS-2	(87–90)
The Rancho Bernardo Study of Healthy Aging	$n = 6726$, from Rancho Bernardo, CA	30–79 y (36% ≥65 y)	54% female	Almost all white	1972–1974	12 clinic visits through 2016; annual follow-up for vital status by mail/phone	FFQ in 1984–1987, 1988–1992, 1992–1996 clinic visits	https://knit.ucsd.edu/ranchobernardostudy/	(91–93)
NHANES (National Health and Nutrition Examination Surveys)									
NHANES I	$n = 28{,}043$ (19% ≥65 y old)	1–74 y	53% female	89% white 10% African-American	1974–1975	1982–1984, 1986–1987, 1992 (in $n = 14{,}407$ who were 25–74 y old at enrollment)	24-h recall FFQ at enrollment	https://www.cdc.gov/nchs/nhanes/about_nhanes.htm	(16, 24, 94)
NHANES II	$n = 27{,}801$ (15% ≥65 y old)	6 mo to 74 y	52% female	85% white, 13% African-American	1976–1980	Not available	24-h recall FFQ		(16, 94)
NHANES III	$n = 39{,}695$ (19% ≥65 y old)	2 mo to >80 y	52% female	40% non-Hispanic white, 28% non-Hispanic black, 28% Mexican-American	1988–1994	Not available	Two 24-h recalls, FFQ		(16, 94, 95)
NHANES Continuous	n ~10,000 per 2-y cycle (exam cycles from 1999 to 2018) (14% ≥65 y old)	All ages	~50% female	Representative of US population, some race and ethnic groups are oversampled	1999 to present	Not available	Two 24-h recalls, FFQ		(16)
Nurses' Health Studies									
Nurses' Health Study—original (NHS)	$n = 121{,}700$ married nurses	30–55 y	100% female	98% white	1976	Ongoing, questionnaires every 2 y	FFQ in 1980, 1984, 1986, and every 4 y thereafter	https://www.nurseshealthstudy.org/	(28, 30, 43, 96–99)

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Table 1 (*Continued*)

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years		Dietary intake assessment	URL	References
					Baseline	Follow-up			
Nurses' Health Study II (NHS-II)	$n = 116{,}430$	24–42 y	100% female	95% white	1989	Ongoing, questionnaires every 2 y	FFQ every 4 y beginning in 1991		(28, 30, 43, 96, 98, 99)
Coronary Artery Risk Development in Young Adults (CARDIA)	$n = 5115$ (Birmingham, AL; Chicago, IL; Minneapolis, MN; Oakland, CA	18–30 y	55% female	52% black, 48% white	1985–1986	Ongoing, ≤9 follow-up visits through 2020	Diet history at baseline, year 7, year 20	https://www.cardia.dopm.uab.edu/	(33, 100–104)
Iowa Women's Health Study (IWHS)	$n = 41{,}836$ women from Iowa	55–69 y (57% ≥65 y)	100% female	99% white	1986	Follow-up surveys administered in 1987, 1989, 1992, 1997, and 2004; subsequent surveillance through State Health Registry of Iowa or the National Death Index	FFQ at baseline and in 2004	Not found	(105–107)
Health Professionals Follow-up Study (HPFS)	$n = 51{,}529$ men in health professions	40–75 y (15% ≥65 y)	100% male	97% white	1986	Ongoing, questionnaires every 2 y	FFQ every 4 y	https://sites.sph.harvard.edu/hpfs/	(30, 43, 96, 108)
Study of Osteoporotic Fractures (SOF)	$n = 10{,}366$ Baltimore, MD; Minneapolis, MN; Pittsburgh, PA; and Portland, OR	≥ 65 y	100% female	>90% white	1986–1987	Nine follow-up clinic exams through 2017	FFQ in 1997–1998 (visit 6)	https://sofonline.ucsf.edu/	(109)
Atherosclerosis Risk in Communities Study (ARIC)	$n = 15{,}792$ from 4 US clinic centers (Forsyth County, NC; Jackson, MS; Greater Minneapolis, MN; Washington County, MD)	45–64 y	56% female	73% white, 25% African-American	1986–1990	Ongoing, 8 clinic exams	FFQ in 1986–1990 (full cohort), 1993–1995 (full cohort), 1990–1993 (subgroup), 1995–1999 (subgroup)	https://sites.cscc.unc.edu/aric/	(32, 110, 111)

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Table 1 (*Continued*)

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years		Dietary intake assessment	URL	References
					Baseline	Follow-up			
Georgia Centenarian Study (phases 1 and 2)	$n = 321$ community-dwelling, cognitively intact	≥100, 80–89, 60–69 y	68% female	70% white, 30% African-American	1988–1992	1992–1998	FFQ and 24-h recalls at baseline	Not found	· (112–114, 115)
Cardiovascular Health Study (CHS)	$n = 5888$ community-dwelling adults from 4 clinic centers in the United States (Sacramento County, CA; Washington County, MD; Forsyth County, NC; Pittsburgh, PA)	≥65 y	58% female	84% white, 16% African-American	1989–1990, 1992–1993 (supplemental African-American cohort)	1989–1999: yearly clinic exams with phone calls 6 mo between clinic visits; 2000 to present: phone calls every 6 mo	FFQ in 1989–1990 and 1995–1996 clinic visit	https://chs-nhlbi.org/	(116–118)
Honolulu-Asia Aging Study (HAAS)	$n = 3734$; surviving participants from the Honolulu Heart Program	71–93 y	100% male	100% Japanese-American	1991	Follow-up clinic exams every 2–3 y through 2012	24-h recall at baseline	https://www.kuakini.org/wps/portal/kuakini-research/research-home/kuakini-research-programs/kuakini-honolulu-asia-aging-study	(119–121)
Health and Retirement Study (HRS)	$n > 37{,}000$; enrollment occurs every 2 y	>50 y (at retirement) (53% ≥65 y)	52% female	Representative of US population	1992	Ongoing, surveys every 2 y	Modified FFQ in 2013, $n = 8073$	https://hrs.isr.umich.edu/about	(122–125)
Women's Health Initiative (WHI) Observational Study	$n = 93{,}676$	50–79 y (46% ≥65 y)	100% female	83% white, 9% African-American, 4% Hispanic, 3% Asian/Pacific Islander	1993–1998	One clinic visit 3 y after baseline, annual follow-up by mail ongoing	FFQ at baseline and follow-up clinic visit	https://www.whi.org/ https://www.nhlbi.nih.gov/science/womens-health-initiative-whi	(126–131)
Einstein Aging Study (EAS)	$n \sim 2000$ from Bronx County, NY	≥70 y	62% female	67% non-Hispanic white, 27% African-American	1993 to ongoing	Annual data collection and recruitment	Brief diet assessment in 2006–2007	https://www.einsteinmed.edu/departments/neurology/clinical-research-program/eas/	(132, 133)

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Table 1 (*Continued*)

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years		Dietary intake assessment	URL	References
					Baseline	Follow-up			
Chicago Health and Aging Project (CHAP)	$n > 10{,}000$, based in 3 neighborhoods on the south side of Chicago	≥65 y	60% female	60% African-American	1993–2012	Ongoing, in-home interviews conducted every 3 y	FFQ 1–2 y from the baseline or 1–3 y before the clinical evaluations for incident Alzheimer disease	https://dss.niagads.org/cohorts/chicago-health-and-aging-project-chap/	(134–136)
Geisinger Rural Aging Study (GRAS)	$n > 20{,}000$ from rural northeastern and central PA	≥65 y	53% female	>99% white	1994–1996	1997–1998, 2005–2006, 2009, ongoing	Diet Quality Screening Questionnaire (n ≈ 2000–4000); 24-h recalls ($n \approx$ 200–400 subgroup) at baseline and follow-up	https://portal.nifa.usda.gov/web/crisprojectpages/0427231-rural-aging-study-geisinger.html	(137–140)
Study of Women Across the Nation (SWAN)	$n = 3302$ from Ann Arbor, MI; Boston, MA; Chicago, IL; Alameda and Contra Costa County, CA; Los Angeles, CA; Jersey City, NJ; Pittsburgh, PA	42–52 y, pre-menopausal	100% female	46% white, 28% African-American, 9% Hispanic, 9% Japanese, 8% Chinese	1996–1997	16 follow-up visits through 2018	FFQ at baseline, 2001–2003, 2005–2007; information on supplement use obtained at every visit	https://www.swanstudy.org/	(45, 141)
Health, Aging, and Body Composition Study (Health ABC)	$n = 3075$ from Pittsburgh, PA or Memphis, TN, reported being able to walk $\frac{1}{4}$ mile or climb 10 steps without difficulty	70–79 y	58% female	45% African-American, 55% white	1997–1998	Yearly clinical exams for 6 y, with intermittent phone calls every 6 mo; additional clinic visits in 2004–2005, 2006–2007, 2007–2008, 2012–2013; ≤16 y of follow-up	FFQ collected at 12-mo clinic visit	https://healthabc.nia.nih.gov/	(142–144)
Rush Memory and Aging Project (Rush MAP)	$n = 1466$ recruited from retirement communities around Chicago, IL	Mean ± SD 79 ± 8 y (98% ≥65 y)	73% female	88% non-Hispanic white	1997–2011	Ongoing, annual in-person assessments, 80% decedents' brains harvested at autopsy	FFQs collected annually	https://www.radc.rush.edu/	(145–148)

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Table 1 (*Continued*)

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years: Baseline	Years: Follow-up	Dietary intake assessment	URL	References
University of Alabama at Birmingham Study of Aging	$n = 1000$ Medicare beneficiaries living in central Alabama	≥65 y	50% female	50% African-American; 50% white	1999–2001	In-home assessments at baseline and in 2004 Telephone follow-up every 6 mo	Three unannounced 24-h dietary recalls conducted by trained interviewers in 2004	Not found	(149, 150)
The Osteoporotic Fractures in Men Study (MrOS)	$n = 5994$ from Birmingham, AL; Minneapolis, MN; Palo Alto, CA; Pittsburgh, PA; Portland, OR; and San Diego, CA	≥65 y	100% male	89% non-Hispanic white	2000	Four clinic exams, ≤17 y of follow-up	FFQ at baseline	https://mrosonline.ucsf.edu/	(151, 152)
Jackson Heart Study (JHS)	$n = 5306$ from Jackson, MS metropolitan area	35–84 y (25% ≥65 y)	63% female	100% African-American	2000–2003	Clinic visits in 2005–2008, 2009–2013; ongoing annual follow-up by phone	Region specific FFQ at baseline	https://www.jacksonheartstudy.org/	(36, 153, 154)
Multi-Ethnic Study of Atherosclerosis (MESA)	$n = 6814$ from 6 clinical centers across the United States (New York, NY; Baltimore, MD; Forsyth County, NC; Chicago, IL; Twin Cities, MN; Los Angeles, CA	45–84 y (44% ≥65 y)	53% female	38% white, 28% African-American, 22% Hispanic, 12% Chinese-American	2000–2002	Ongoing; participants contacted every 9–12 mo to assess clinical morbidity and mortality Clinic exams in: 2002–2004, 2004–2005, 2005–2007, 2010–2011, 2016–2018	FFQ at baseline and in 2010–2011	https://www.mesa-nhlbi.org/	(155–158)
Baltimore Longitudinal Study of Aging (BLSA)	$n = 3207$; continuous enrollment; generally healthy adults, BMI <40	>20 y (35% ≥65 y)	40% female	80% Caucasian, 16% African-American, 4% other	2003–2004	Ongoing; participants <60-y-old assessed every 4 y, 60–79-y-old assessed every 2 y, ≥80-y-old assessed annually	7-d diet records prior corresponding to each clinic visit	https://www.blsa.nih.gov/	(44, 49, 159, 160)

(*Continued*)

Table 1 (*Continued*)

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years		Dietary intake assessment	URL	References
					Baseline	Follow-up			
Reasons for Geographic and Racial Differences in Stroke cohort (REGARDS)	*n* = 30,239 from southeast and south central United States	≥45 y (51% ≥65 y)	57% female	40% African-American	2003–2007	Ongoing, every 6 mo participants are contacted by phone to ask about stroke symptoms, hospitalizations, and general health status. In-home physical exams at baseline and 10 y later	FFQ at baseline	https://www.uab.edu/soph/regardsstudy/about	(161–163)
Osteoarthritis Initiative (OAI)	*n* = 4796 adults with or at risk of knee osteoarthritis, from Baltimore, MD; Columbus, OH; Pawtucket, RI; Pittsburgh, PA; and surrounding areas	45–79 y (38% ≥65 y)	57% female	79% white, 18% African-American	2004–2008	Ongoing; follow-up clinic visits at 12, 24, 36, 48, 72, 96 mo	FFQ at baseline	https://nda.nih.gov/oai/	(164–166)
Boston Puerto Rican Health Study (BRPHS)	*n* = 1500 self-identified Puerto Ricans from greater Boston area	45–75 y (34% ≥65 y)	70% female	100% Puerto Rican	2004–2009	Follow-up visits at 2 and 5 y, phone calls every 6 mo in between	FFQ at baseline	https://www.uml.edu/research/uml-cph/research/bprhs/	(167–169)
Long Life Family Study	*n* = 4559 in 539 pedigrees enriched in longevity from Boston, MA; New York, NY; and Pittsburgh, PA (and Odense Denmark)	31–110 y (50% ≥65 y)	56% female	99% non-Hispanic white	2006–2009	Follow-up in person 2014–2017, 2021 to present (ongoing); telephone follow-up 2009 to present	FFQ at 2021 to present follow-up visit	https://longlifefamilystudy.wustl.edu/	(170)
LonGenity Study	*n* = 845 Ashkenazi Jewish from northeastern United States, recruited based on parents' lifespan	≥65 y	54% female	100% Ashkenazi Jewish	2008–2016	Follow-up visits every 12–18 mo	FFQ at baseline in subgroup (*n* = 234)	https://einsteinmed.org/centers/aging/research/longenity-longevity-genes-projects/longenity.aspx	(171, 172)

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Table 1 (*Continued*)

Name	Enrollment sample size	Enrollment age	Sex	Race and/or ethnicity	Years		Dietary intake assessment	URL	References
					Baseline	Follow-up			
Hispanic Community Health Study / Study of Latinos (HCHS/SOL)	$n = 16{,}415$ from Bronx, NY; Chicago, IL; Miami, FL; San Diego, CA	18–74 y (8% ≥65 y)	60% female	100% Hispanic/Latino: 15% Cuban, 9% Dominican, 41% Mexican, 17% Puerto Rican, 11% Central American, 7% South American	2008–2011	Clinic visits 2014–2017, 2020–2023 (ongoing); annual phone calls	Two 24-h dietary recalls, first in-person at baseline visit, second unannounced <30 d later via phone; Food Propensity Questionnaire administered via phone 1 y later	https://sites.cscc.unc.edu/hchs/	(173–175)

In addition to demographic characteristics, information on health status, chronic disease conditions, and clinical measures is available in nearly all cohorts. However, the data collection methods are highly variable, ranging from self-reported health conditions to clinic- or home visit–based evaluations. Twenty-five cohorts continue to follow participants, although level of follow-up varies from phone calls to more thorough in-person interviews and/or clinical exams (Table 1). Because it is becoming increasingly important to better understand the nutritional needs of older adults across the age span, including the oldest old, we have summarized the availability of dietary data in existing community-based cohorts in the United States that include older adults.

Participants' characteristics

Age.

Age at enrollment ranged from 5 y (the Framingham Offspring) to 100 y (the Georgia Centenarians study). Follow-up duration ranged from 5 y (Boston Puerto Rican Study) to 66 y (Framingham Heart Study). Most of the identified cohorts were not designed to study older adults specifically, but were established with an overall goal of identifying risk factors for age-related diseases and disability. In these cohorts, the proportion of those aged ≥65 y at enrollment ranged from 0% [Atherosclerosis in Communities (ARIC) study, Coronary Artery Risk Development in Young Adults (CARDIA) study, NHS, and Study of Women Across the Nation (SWAN)] to 98% [the Rush Memory and Aging Project (Rush MAP)] (Table 1). Adults aged >74 y were not included in NHANES I (19) or NHANES II (20). NHANES III subsequently oversampled adults ≥60 y (21, 22) and there is now no upper age limit for NHANES participation. The most recent cycle (2017 to prepandemic 2020) included 680 adults aged >80 y (23). NHANES is comprised of a series of cross-sectional population-based surveys currently administered in 2-y cycles (17). Although this design limits the use of the majority of currently available NHANES data for prospective analyses, follow-up data are available through 1992 for NHANES I participants who were 25–74 y old at the enrollment examination (24, 25). Moreover, NHANES is currently enrolling past participants for longitudinal follow-up (14), so future prospective analyses ought to be feasible using NHANES.

Sex, race, and ethnicity.

Most cohorts include men and women. Five include only women (Iowa Women's Health Study, NHS and NHS-II, Women's Health Initiative, SWAN, and the Study of Osteoporotic Fractures), and 3 include only men [Health Professionals' Follow-up Study (HPFS), the Osteoporotic Fractures in Men Study, and the Honolulu-Asia Aging Study (HAAS)] (Table 1). Nineteen cohorts are ≥80% white and 13 are ≥20% African-American, with 1 following only African Americans (Jackson Heart Study). Hispanic/Latinos comprise ≥15% of 4 cohorts, with 2 exclusively following participants of Hispanic/Latino descent [the Boston

Puerto Rican study and the Hispanic Community Health Study/Study of Latinos (HCHS/SOL)]. Asian Americans are included as separate race and ethnic groups in the Framingham OMNI cohorts, HAAS, and the Multi-Ethnic Study of Atherosclerosis (MESA). Except for the HAAS, which was comprised of all Japanese-American men, the overall representation of Asian Americans in the identified cohorts is small compared with other race and ethnic groups, and Asian Americans remain an understudied segment of the US population. Participants in NHANES I (19) and NHANES II (20) were ≥85% white. Mexican Americans and non-Hispanic blacks were oversampled in NHANES III (1988–1994) (21). Currently NHANES uses a complex, multistage, probability sampling design to select participants representative of the civilian, noninstitutionalized US population that includes race and ethnicity. However, some subgroups are oversampled to enhance subgroup estimate precision (26, 27).

Food preferences vary across race and ethnic groups. Of the 14 cohorts with repeated measures of dietary intakes, 10 were >80% non-Hispanic white, and the majority of reported evidence about longitudinal changes in diet intake and quality comes from primarily white cohorts (28–31). The ARIC, CARDIA, and SWAN studies administered repeated dietary assessments to blacks, and MESA included a repeat assessment in blacks, Hispanics, and Asian Americans (32–34). In CARDIA, diet quality improved similarly in blacks and whites (33), whereas in ARIC more improvements were reported in blacks than whites (32). However, the dietary follow-up in these studies did not extend into older adulthood so changes that occur beyond 60–70 y of age have not yet been captured. As the older adult population becomes more racially and ethnically diverse (1, 2), it will be important to evaluate how diet changes in different racial and ethnic groups throughout older adulthood. In studies that use FFQs, it is important to use culturally appropriate FFQs, because those developed for the general population might not fully capture diet intakes of minority groups (35). Tucker et al. (35) adapted the National Cancer Institute Block FFQ to use in Puerto Rican Hispanics and Southern blacks (36, 37) and found the culturally adapted versions performed better in these racial and ethnic groups than the original questionnaires. Although 24-h recalls or diet histories can be more flexible with respect to recording intakes of diverse foods, it will be important to incorporate nutrient data for foods consumed in racially and ethnically diverse groups into food composition databases. In the United States, biannual updates to the USDA Food Data Central include ethnic foods, which will enhance the reliability and accuracy of dietary data collected in racially and ethnically diverse groups (38, 39). However, data derived from the database should be interpreted in the context of inherent limitations. For example, nutrient composition of the same foods can vary due to growing, processing, and preparation practices, and ongoing changes in our food supply might not be readily incorporated into the database (39, 40).

Dietary assessment

Frequency.

Most studies, including NHANES, evaluated diet intakes at a single time point. Because NHANES surveys are conducted every 2 y, NHANES is a vital resource for studying secular trends in dietary intake, including in older adults (41, 42). However, the cross-sectional design of NHANES precludes its use to study intraindividual change. Including dietary assessments in the ongoing NHANES Longitudinal Study (14) would enhance its utility for studying within-person dietary changes throughout adulthood. Thirteen of the identified cohorts have ≥2 diet assessments over the cohort's follow-up. Several continue to evaluate dietary intakes at regular intervals (e.g., every 1 to 4 y) (28, 29, 31, 32, 43, 44). Studies with repeated dietary assessments can provide insight of how habitual dietary intake (31, 45, 46) and how changes in dietary intake (47, 48) are associated with age-related disease and disability. Currently, most of the available data about how diet changes in adulthood are limited to dietary data collected during middle age. Using data from the Baltimore Longitudinal Study of Aging, Talegawkaret al. (49) reported diet quality improved "moderately" or "greatly" from 1978 to 2008, corresponding to the 30–59-y-old age span. In the ARIC cohort, diet quality improved slightly but significantly over a 6-y period (between the late 1980s and mid-1990s). Participants were 54 ± 6 y old at baseline (32). In MESA, Healthy Eating Index scores did not appreciably change over 10 y of follow-up in adults from 60 to 70 y old (34). In the CARDIA cohort, which assessed dietary intakes 3 times over 20 y (1985–1986 to 2005–2006), diet quality improved from young adulthood to middle age (from ∼25 to 45 y of age). The improvements were attributed primarily to age, and occurred despite reported secular trends in decreased diet quality over that same time period (33). Although available evidence suggests that diet quality tends to improve with age (32, 33, 49), little is known about how diet quality changes throughout older adulthood. This is an important gap to fill in light of the physiological, lifestyle, psychosocial, and environmental changes that impact what older adults eat (50–53). These changes continue during the older adult period, so that older adults' food choices can change from when they are 65 y (early old) to >80 y (older old). It will be important to better characterize these changes to inform the development of new, age-specific recommendations (54). Repeated dietary recalls from cohorts that evaluated adults in early old age can be leveraged to address this gap (e.g., ARIC, Cardiovascular Health Study, HPFS, MESA, and Rush MAP). In some cohorts (e.g., CARDIA, SWAN) the follow-up duration between the dietary assessments combined with participants' age at enrollment precluded the ability to examine dietary intake changes over older adulthood. Consideration of such study design characteristics is important when selecting cohorts to address questions focused on diet changes during older age. Alternatively, CARDIA, SWAN, and similarly designed cohorts can be utilized in studies focused on how changes in diet during younger and middle age are associated with health and disease in older age. Additionally, incorporating assessments of eating behavior and food preferences into existing cohorts would provide important insight about how behavioral changes relate to changes in dietary intake throughout older adulthood (52).

Assessment tools.

The FFQ was the most commonly used diet assessment tool (Table 1), followed by the 24-h recall. Seventeen cohorts administered a FFQ or 24-h recall at a single time point, whereas repeat diet assessments were obtained in 13 cohorts (Table 1). The dietary assessment component of NHANES, known as What We Eat in America, includes multiple 24-h recalls and a FFQ. The NHANES dietary assessment methods, as well as their strengths, limitations, and analytical considerations, are reviewed in detail elsewhere (16).

Dietary assessment that is largely based on self-report presents some unique challenges in older adults (55). Declines in cognitive and/or motor function can influence response to dietary questionnaires. These impairments become more prevalent in older adulthood, which can necessitate additional diet assessment validation in this segment of the population. The Harvard FFQ used in the NHS, NHS-II, and HPFS was validated against 7-d diet records and using biomarkers for a number of dietary components (56–58). Similar validation estimates were reported for women aged 45–60 y and 61–80 y (58), and for men aged ≤70 y and >70 y (57). Validation estimates for those aged >80 y specifically were not reported, and because the participants in these studies were mostly white and generally healthy, the findings might not generalize to nonwhites or those with comorbid conditions. Morris et al. (59) evaluated the comparative validity of a modified version of the Harvard FFQ in a biracial sample of community-dwelling adults aged ≥65 y and found the validity coefficients for 15 nutrients to be similar in blacks and whites, in 68–78-y-olds, and in those aged ≥79 y, and across tertile categories of cognitive ability scores. As diet assessment tools are modified to complement and/or enhance current approaches (60–62), it will be important to ensure their validity in age-specific subgroups, including the oldest old, and in those with comorbidities common in older adults (5). Because the number of older adults not involved in their own meal preparation tends to increase with age, caretakers' assistance helps improve accuracy.

Underreporting is a fundamental limitation of self-reported dietary intake, and the extent of underreporting can depend on the dietary assessment tool used, dietary component evaluated, and participant characteristics, including age (63, 64). There are conflicting data about whether underreporting increases or decreases with age (63, 65–68). Freedman et al. (63) compared energy intakes reported using a FFQ and 24-h recalls with energy intake assessed objectively using doubly labeled water, which measures energy expenditure over 10–14 d and is used to measure average daily energy intake over the same period in weight-stable individuals. They found adults >80 y old were less likely than 50–59-y-olds to underreport energy intake on a FFQ than a 24-h recall (63). In a subgroup of participants of the HCHS/SOL cohort, which is comprised of 46–74-y-old Hispanics/Latinos residing in the United States, age was not a significant predictor of the difference in energy intake reported using 24-h recalls and assessed using doubly labeled water (69). Other studies have indicated increased underreporting with age (65, 67). However, older adults were generally defined as ≥60 or ≥65 y old in these studies, which makes it difficult to know how reporting accuracy changes throughout older adulthood. These studies also compared energy intake reported on 24-h recalls with energy requirements calculated using age-, sex-, and weight-based equations, which are not direct measures of energy expenditure. Underreporting is more common in obese adults (70), and >40% of US adults ≥60 y old are obese (71). Conversely, undereating can also become more common in older adults, which can be mistaken for energy underreporting in some situations (72). Misreporting is not limited to energy intake, and has also been reported for certain macro- and micronutrients (58, 63, 64, 66). Future studies focused on evaluating reporting accuracy of specific subgroups of older adults (e.g., based on age, BMI, race, ethnicity, present comorbidities) will allow for accurate calibration of self-reported dietary intake data derived from older adult populations (66). These studies would be strengthened by the use of recovery biomarkers or other objective indicators of dietary intake, including metabolomics, as reference methods (73–75).

Summary and Conclusions

This review summarizes information available from longitudinal observational studies of community-based adults living in the United States that can be leveraged to answer research questions about diet and nutrition in older adults. We also identified limitations to the existing data that need to be considered when leveraging these resources. Our search was limited to US-based longitudinal studies. Several international cohorts exist that can provide important information about dietary intakes in older adults not living in the United States. Although we used a systematic approach combined with manual searching, it is possible some cohorts were overlooked. Obtaining detailed information about how and when diet information was collected was a challenge in some instances, because this information was not always readily available on studies' websites, which could hinder future studies that seek to leverage existing dietary data. However, we obtained the missing information from published studies and we have cited those references accordingly.

Although the role of diet and nutrition in preventing or delaying the onset of age-related disease and disability has received considerable research attention, less is known about the dietary intakes of older adults—the segment of the population most likely to have chronic diseases. We identified 31 cohorts that, in some capacity, evaluated dietary intakes in community-dwelling adults across the United States and have resources that can be leveraged to determine formal estimates of how diet changes throughout older adulthood. This might require incorporation of new dietary questionnaires with additional validation in subgroups of older adults. Most of the identified cohorts have collected and continue to collect detailed information about participants' health and disease status. Their data access and resource sharing policies are provided on the studies' websites (included in Table 1). Incorporating dietary data collection into future follow-up visits represents a cost- and time- efficient strategy to fill research gaps about the diet in older adulthood, instead of establishing new cohorts focused on diet whose participants would not be so well characterized in terms of comorbid disease development and progression. Such efforts will help provide more robust evidence needed to fill knowledge gaps about the nutritional needs of the oldest old, who represent the fastest growing segment of the population in the United States (2).

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