

Cardiovascular Health Among Pregnant Women, Aged 20 to 44 Years, in the United States

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Background—Pregnancy is a cardiometabolic stressor and thus a critical period to address women's lifetime cardiovascular health (CVH). However, CVH among US pregnant women has not been characterized.

Methods and Results—We analyzed cross-sectional data from National Health and Nutrition Examination Surveys 1999 to 2014 for 1117 pregnant and 8200 nonpregnant women, aged 20 to 44 years. We assessed 7 CVH metrics using American Heart Association definitions modified for pregnancy; categorized metrics as ideal, intermediate, or poor; assigned these categories 2, 1, or 0 points, respectively; and summed across the 7 metrics for a total score of 0 to 14 points. Total scores 12 to 14 indicated high CVH; 8 to 11, moderate CVH; and 0 to 7, low CVH. We applied survey weights to generate US population-level estimates of CVH levels and compared pregnant and nonpregnant women using demographic-adjusted polytomous logistic and linear regression. Among pregnant women, the prevalences (95% CIs) of ideal levels of CVH metrics were 0.1% (0%–0.3%) for diet, 27.3% (22.2%–32.3%) for physical activity, 38.9% (33.7%–44.0%) for total cholesterol, 51.1% (46.0%–56.2%) for body mass index, 77.7% (73.3%–82.2%) for smoking, 90.4% (87.5%–93.3%) for blood pressure, and 91.6% (88.3%–94.9%) for fasting glucose. The mean total CVH score was 8.3 (95% CI, 8.0–8.7) of 14, with high CVH in 4.6% (95% CI, 0.5%–8.8%), moderate CVH in 60.6% (95% CI, 52.3%–68.9%), and low CVH in 34.8% (95% CI, 26.4%–43.2%). CVH levels were significantly lower among pregnant versus nonpregnant women; for example, 13.0% (95% CI, 11.0%–15.0%) of nonpregnant women had high CVH (adjusted, comparison $P=0.01$).

Conclusions—From 1999 to 2014, <1 in 10 US pregnant women, aged 20 to 44 years, had high CVH. (*J Am Heart Assoc.* 2020;9:e015123. DOI: 10.1161/JAHA.119.015123.)

Key Words: cardiovascular health • Life's Simple 7 • pregnancy

In 2018, the American Heart Association (AHA) and the American College of Obstetricians and Gynecologists released a joint advisory, highlighting the role of obstetricians and gynecologists in promoting women's cardiovascular health (CVH) across the life course.¹ The authors described pregnancy as a physiological “stress test” that reveals underlying risk for cardiovascular disease (CVD),¹ a phenomenon that is increasingly recognized in AHA guidelines

and statements for women's cardiovascular care.^{2–4} Gestation is also increasingly recognized as a critical period for developmental programming of offspring CVD risk.^{5,6} For example, maternal obesity in pregnancy has been associated with offspring CVD risk factors (adiposity, blood pressure, lipids, and insulin resistance), CVD events, and premature all-cause mortality.⁶

The 2018 AHA/American College of Obstetricians and Gynecologists advisory highlighted the utility of “Life's Simple 7” CVH metrics to monitor women's CVH across the life course.¹ As defined by the AHA in 2010, the 7 CVH metrics include diet, physical activity, nonsmoking, body mass index (BMI), blood pressure, total cholesterol, and fasting glucose.⁷ Thus defined, better CVH has been shown to powerfully predict CVD-free longevity and other positive health outcomes in nonpregnant adults.⁸ Levels of CVH in the US population have been characterized across most of the life course, from childhood through later adulthood.^{8,9} However, to our knowledge, CVH based on the AHA-defined construct has not previously been described in pregnant women in the United States.

We sought to characterize CVH, defined using Life's Simple 7, among pregnant women, aged 20 to 44 years, in the United

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Clinical Perspective

What Is New?

- Cardiovascular health (CVH), as defined by the American Heart Association with modifications for pregnancy, was examined among pregnant women in the United States for the first time.
- Among pregnant women, CVH was far from optimal: 4.6% had high CVH, 60.6% had moderate CVH, and 34.8% had low CVH.
- CVH was worse among pregnant women compared with nonpregnant women.

What Are the Clinical Implications?

- Further study is warranted to determine the relevance of total CVH during pregnancy for maternal and offspring health outcomes.
- Formal development of pregnancy-specific guidelines and definitions for CVH metrics may aid in comprehensive CVH promotion in women across the life course, a stated goal of the American Heart Association and the American College of Obstetricians and Gynecologists.

States and compare it with that among nonpregnant women. We also compared CVH between subgroups of pregnant women defined by trimester of pregnancy, age, and race/ethnicity.

Methods

All data used for this study are publicly available from the National Center for Health Statistics at <https://www.cdc.gov/nchs/nhanes/index.htm>.

Study Design and Participants

We analyzed cross-sectional data from the National Health and Nutrition Examination Survey (NHANES), which uses a complex, multistage probability sampling design to select a sample representative of the civilian noninstitutionalized US population.¹⁰ In 1999 to 2006, pregnant women were oversampled. NHANES combines in-home interviews with mobile examinations and laboratory tests. Written informed consent was obtained from all participants.

We included women, aged 20 to 44 years, who attended an NHANES examination between 1999 and 2014 (continuous examination cycles) and had a urine pregnancy test result available (publicly released by NHANES for women aged 20–44 years only). The overall NHANES examination response rate for women aged 20 to 49 years was 76% (range, 70%–80% across cycles),¹¹ and urine pregnancy test results were

available in 98% of women (range, 97%–98% across cycles).¹² We analyzed all available data, excluding individuals from particular analyses if relevant variables were missing. The Northwestern University Institutional Review Board assigned a determination of research not involving human subjects.

Pregnancy Status and Trimesters

Urine pregnancy testing was performed with a rapid chromatographic immunoassay, which uses a combination of monoclonal and polyclonal antibodies to detect elevated levels of human chorionic gonadotropin.¹² Women were classified as pregnant or nonpregnant on the basis of the result. Month of pregnancy was self-reported in 1999 to 2012 (unavailable in 2013–2014); months 1 through 3 were considered first trimester, months 4 through 6 were second trimester, and months 7 through 9 were third trimester.

Demographics

For age-stratified analyses, age was categorized as 20 to 24, 25 to 34, and 35 to 44 years to preserve subgroup sample sizes among pregnant women. Race and ethnicity were self-reported from provided categories and coded in NHANES as Mexican, other Hispanic, non-Hispanic white, non-Hispanic black, or other race; starting in 2011, non-Hispanic Asian became separate from other race. For race/ethnicity-stratified analyses, data are presented only for Mexican, non-Hispanic white, and non-Hispanic black groups because of small sample sizes in the remaining groups. Education level was defined by the self-reported highest level of school completed and categorized as less than high school, high school, or more than high school. Annual self-reported family income/poverty level ratio was categorized as ≤ 1.30 , 1.30 to ≤ 1.85 , or > 1.85 , on the basis of national nutrition assistance program guidelines.¹³

Measurement of CVH Metrics

CVH behaviors, including diet, physical activity, and smoking status, were self-reported during in-person interviews. Dietary intake was assessed with a 24-hour dietary recall interview. Starting in 2003 to 2004, a second 24-hour recall interview was completed over the telephone; for 2003 to 2014, we averaged dietary data from the 2 recalls. The Food Patterns Equivalents Database¹⁴ (formerly MyPyramid Equivalents Database) was used to determine servings of dietary components consumed. Physical activity over the past 30 days (minutes moderate to vigorous) was assessed with questions about frequency and duration of recreational physical activities, such as exercise, sports, and physically active hobbies, at either a vigorous (heavy sweating or large increases in

breathing or heart rate) or a moderate (light sweating or small increase in breathing or heart rate) level. Smoking status was assessed with interviewer-administered questions about current and former smoking of cigarettes.

CVH factors, including BMI, blood pressure, total cholesterol, and fasting blood glucose, were measured by trained personnel. BMI was calculated as the weight in kilograms divided by the square of the height in meters from standardized height and weight measurements. Blood pressure was measured manually after 5 minutes of quiet, seated rest and determination of the maximal inflation level; 3 measurement attempts (or 4, if the third was incomplete) were recorded, and we averaged available measurements. Before venous blood draw, fasting status was assessed, and

individuals assigned to morning examinations were specifically requested to fast. Venous blood was frozen and shipped to standardized laboratories. Total cholesterol and fasting plasma glucose were each measured enzymatically; however, glucose was only reported if fasting time was between 8 and 24 hours (otherwise, values were set as missing). Prescription medications were assessed during the household interview, and medication containers were examined when available.

Classification of CVH

Table 1 shows the definitions of CVH metric levels for pregnant and nonpregnant women. For diet, we used AHA

Table 1. CVH Metric Definitions for Pregnant and Nonpregnant Women

Metric	Pregnant Women		
	Ideal	Intermediate	Poor
Diet*	4–5 Components Diet components: (1) fruits and vegetables: ≥ 4.5 cups/d; (2) fish*: 2–3 3.5-oz servings/wk; (3) whole grains (ie, ≥ 1.1 g fiber per 10 g carbohydrate): ≥ 3 1-oz equivalent servings/d; (4) sodium: < 1500 mg/d; (5) sugar-sweetened beverages: ≤ 450 kcal/wk	2–3 Components	0–1 Component
Physical activity	≥ 150 min/wk moderate or ≥ 75 min/wk vigorous intensity or combination	1–149 min/wk moderate+vigorous or 1–74 min/wk vigorous	None
Smoking	Never or quit > 12 mo ago	Former ≤ 12 mo	Current
BMI*	Less than or equal to maximum possible if top-normal prepregnancy BMI and maximal recommended gestational weight gain (see Methods)	All others “nonideal”	
Blood pressure [†]	$< 120 / < 80$ mm Hg untreated	SBP 120–139 mm Hg or DBP 80–89 mm Hg or treated to goal	SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg
Total cholesterol	< 200 mg/dL untreated	200–239 mg/dL or treated to goal	≥ 240 mg/dL
Fasting plasma glucose*	Month of pregnancy 1–5: < 100 mg/dL untreated Month of pregnancy 6–9: < 92 mg/dL untreated	All others “nonideal”	
Metric	Nonpregnant Women		
	Ideal	Intermediate	Poor
Diet	4–5 Components Diet components: (1) fruits and vegetables: ≥ 4.5 cups/d; (2) fish: ≥ 2 3.5-oz servings/wk; (3) whole grains (ie, ≥ 1.1 g fiber per 10 g carbohydrate): ≥ 3 1-oz equivalent servings/d; (4) sodium: < 1500 mg/d; (5) sugar-sweetened beverages: ≤ 450 kcal/wk	2–3 Components	0–1 Component
Physical activity	≥ 150 min/wk moderate or ≥ 75 min/wk vigorous intensity or combination	1–149 min/wk moderate+vigorous or 1–74 min/wk vigorous	None
Smoking	Never or quit > 12 mo ago	Former ≤ 12 mo	Current
BMI*	< 25 kg/m ²	All others “nonideal”	
Blood pressure [†]	$< 120 / < 80$ mm Hg untreated	SBP 120–139 mm Hg or DBP 80–89 mm Hg or treated to goal	SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg
Total cholesterol	< 200 mg/dL untreated	200–239 mg/dL or treated to goal	≥ 240 mg/dL
Fasting plasma glucose*	< 100 mg/dL untreated	All others “nonideal”	

BMI indicates body mass index; CVH, cardiovascular health; DBP, diastolic blood pressure; SBP, systolic blood pressure.

*Different from American Heart Association CVH metric definitions for nonpregnant adults. See text (Methods) for details.

[†]Primary definition shown. In a sensitivity analysis, blood pressure was categorized as intermediate if SBP 120 to 129 mm Hg and DBP < 80 mm Hg or treated to goal and as poor if SBP ≥ 130 mm Hg or DBP ≥ 80 mm Hg, per recent American Heart Association/American College of Cardiology blood pressure guidelines for nonpregnant adults.

Table 2. Sample Sizes, Characteristics, and Missingness of Data Among Pregnant Women, by Survey Cycle: NHANES, 1999 to 2014

Variable	Survey Cycle							
	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010	2011–2012	2013–2014
N	218	233	187	289	46	46	38	60
Demographic characteristics								
Age, y	27.5 (4.9)	27.8 (5.1)	28.4 (5.0)	27.3 (4.6)	26.9 (5.1)	29.2 (6.8)	29.4 (6.1)	27.2 (5.6)
Race/ethnicity								
White (non-Hispanic)	101 (46.3)	116 (49.8)	96 (51.3)	136 (47.1)	9 (19.6)	16 (34.8)	11 (28.9)	21 (35.0)
Black (non-Hispanic)	19 (8.7)	25 (10.7)	30 (16.0)	34 (11.8)	8 (17.4)	5 (10.9)	10 (26.3)	17 (28.3)
Mexican	65 (29.8)	59 (25.3)	47 (25.1)	93 (32.2)	19 (41.3)	14 (30.4)	5 (13.2)	4 (6.7)
Other Hispanic	18 (8.3)	14 (6.0)	5 (2.7)	12 (4.2)	7 (15.2)	3 (6.5)	4 (10.5)	7 (11.7)
Non-Hispanic Asian	7 (18.4)	7 (11.7)
Other race	15 (6.9)	19 (8.2)	9 (4.8)	14 (4.8)	3 (6.5)	8 (17.4)	1 (2.6)	4 (6.7)
Education								
Less than high school	58 (28.4)	60 (26.8)	48 (26.1)	80 (29.0)	18 (39.1)	11 (23.9)	6 (16.7)	9 (15.3)
High school graduate	42 (20.6)	44 (19.6)	41 (22.3)	55 (19.9)	9 (19.6)	9 (19.6)	7 (19.4)	15 (25.4)
Greater than high school	104 (51.0)	120 (53.6)	95 (51.6)	141 (51.1)	19 (41.3)	26 (56.5)	23 (63.9)	35 (59.3)
Family income/poverty ratio								
≤1.30	52 (28.0)	65 (29.1)	62 (33.5)	91 (33.1)	15 (37.5)	14 (36.8)	10 (27.0)	26 (46.4)
1.30–≤1.85	22 (11.8)	27 (12.1)	23 (12.4)	34 (12.4)	7 (17.5)	7 (18.4)	6 (16.2)	7 (12.5)
>1.85	112 (60.2)	131 (58.7)	100 (54.1)	150 (54.5)	18 (45.0)	17 (44.7)	21 (56.8)	23 (41.1)
No. (proportion) with missing data								
Diet	7 (3.2)	2 (0.9)	5 (2.7)	5 (1.7)	1 (2.2)	0	2 (5.3)	3 (5.0)
Physical activity	0	0	0	0	0	0	0	0
Smoking status	0	0	0	0	0	0	0	0
BMI	0	1 (0.4)	1 (0.5)	1 (0.3)	0	0	0	...*
Blood pressure	18 (8.3)	12 (5.2)	20 (10.7)	14 (4.8)	0	1 (2.2)	5 (13.2)	10 (16.7)
Total cholesterol	14 (6.4)	11 (4.7)	15 (8.0)	14 (4.8)	5 (10.9)	4 (8.7)	3 (7.9)	4 (6.7)
Fasting plasma glucose	130 (59.6)	136 (58.4)	109 (58.3)	158 (54.7)	30 (65.2)	28 (60.9)	21 (55.3)	...*
Missing despite morning examination [†]	17 (16.2)	21 (17.8)	14 (15.2)	19 (12.7)	4 (20.0)	3 (14.3)	2 (10.5)	...*
Any CVH metric	138 (63.3)	141 (60.5)	120 (64.2)	167 (57.8)	31 (67.4)	28 (60.9)	26 (68.4)	...*
Missing despite morning examination [†]	25 (23.8)	26 (22.0)	25 (27.2)	28 (18.7)	5 (25.0)	3 (14.3)	7 (36.8)	...*

Data shown are for the sample (ie, survey weights not used). Mean (SD) is shown for continuous variables, and number (proportion) is shown for categorical variables. BMI and fasting plasma glucose data were only assessed in participants during survey years 1999 to 2012, as month of pregnancy information (needed for their assessment) was not available in 2013 to 2014. BMI indicates body mass index; CVH, cardiovascular health; NHANES, National Health and Nutrition Examination Survey.

*BMI and fasting plasma glucose were measured in 2013 to 2014, but they are not used in the present analyses because month of pregnancy was not reported in 2013 to 2014 and is needed for classification of those metrics.

[†]Only morning examination participants were eligible for fasting plasma glucose measurement; morning examination samples are designed with separate weights to be nationally representative. The number (proportion) listed herein indicate the number missing the measurement despite attending a morning examination and thus being eligible for all measurements.

definitions for 4 of 5 components: fruits and vegetables, whole grains, sodium, and sugar-sweetened beverages. For fish, although the AHA definition of ideal is at least two 3.5-ounce servings per week for nonpregnant women,⁷ we considered two to three 3.5-ounce servings per week ideal for pregnant women (ie, >3 per week not ideal), consistent

with Food and Drug Administration guidelines for pregnancy.¹⁵ For physical activity and smoking, we used standard AHA definitions, consistent with pregnancy guidelines.¹⁶ For BMI, only current measured BMI and self-reported month of pregnancy were available (ie, not prepregnancy BMI or gestational weight gain). Therefore, we considered BMI ideal

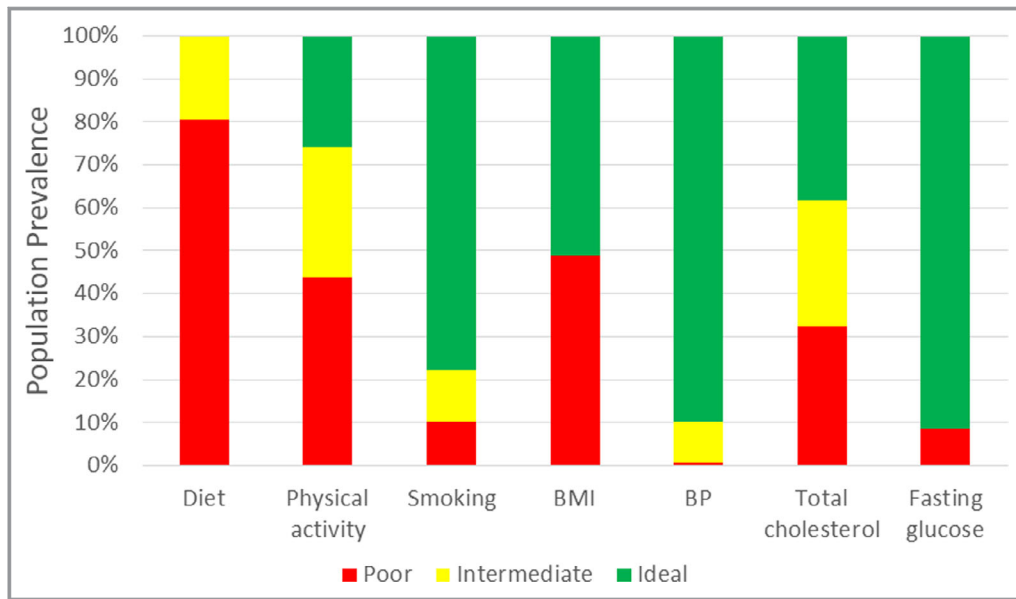


Figure 1. Status of individual cardiovascular health metrics among pregnant women, aged 20 to 44 years, in the United States, 1999 to 2014*. All estimates are based on population-weighted data from the National Health and Nutrition Examination Survey. *Body mass index (BMI) and fasting plasma glucose data are for 1999 to 2012, as month of pregnancy information was not available in 2013 to 2014. BP indicates blood pressure.

if current weight was less than or equal to the maximum allowable for current height, assuming a top-normal prepregnancy BMI (24.9 kg/m^2) and maximal recommended gestational weight gain per Institute of Medicine guidelines of up to 4.4 pounds total during the first trimester (months 1–3) and up to 5.1 pounds per month (1.0 lb/wk) thereafter.¹⁷ Otherwise, BMI was considered nonideal. For nonpregnant women, the standard AHA BMI definition was used,⁷ but intermediate and poor were collapsed to “nonideal” to mirror the categories for pregnant women. For blood pressure, primary analyses used the standard AHA definition, consistent with pregnancy guidelines,¹⁸ and sensitivity analyses used a stricter definition based on the 2017 American College of Cardiology/AHA blood pressure guideline (see Table 1 footnote).¹⁹ For total cholesterol, there are no guidelines on risk thresholds during pregnancy. On the basis of limited data that higher cholesterol levels in pregnancy are associated with adverse maternal and offspring effects,^{20,21} we chose to retain the standard AHA definition for total cholesterol in the primary analyses. For fasting glucose, we used the standard AHA definition of ideal levels for earlier pregnancy (ie, $<100 \text{ mg/dL}$ untreated for months 1–5)^{7,22} and a lower threshold for later pregnancy ($<92 \text{ mg/dL}$ untreated for months 6–9), consistent with international pregnancy guidelines²³; all others were considered nonideal. The standard AHA definition was used for ideal glucose in nonpregnant women, but intermediate and poor were collapsed to nonideal to mirror the classification in pregnant women.

We calculated total CVH scores by assigning 2 points for each ideal metric, 1 point for intermediate, and 0 points for poor or nonideal. We summed points across the 7 metrics for a range of total CVH scores of 0 to 14 and classified CVH scores of 12 to 14 as high, 8 to 11 as moderate, and 0 to 7 as low CVH.²⁴ In sensitivity analyses, we excluded the cholesterol metric (given uncertainty about ideal levels during pregnancy) to create total CVH scores ranging from 0 to 12 and classified CVH scores of 10 to 12 as high, 6 to 9 as moderate, and 0 to 5 as low CVH.

Statistical Analysis

We used survey procedures in SAS, version 9.3 (SAS Institute, Cary, NC), to account for the complex NHANES design; and we applied survey weights to generate US population-level estimates. Estimates were calculated from pooled data across all NHANES cycles (1999–2014), except trimester-specific estimates and estimates for BMI, glucose, and total CVH were calculated from 1999 to 2012 data (month of pregnancy was unavailable in 2013–2014). In primary analyses, we calculated estimates according to pregnancy status (pregnant versus nonpregnant) and trimester. In secondary analyses, we calculated estimates for pregnant women according to age category and race/ethnicity.

We calculated the proportions of women (by pregnancy status, trimester, age category, and race/ethnicity) with ideal, intermediate, and poor (or nonideal) levels of each CVH

Table 3. Demographic Characteristics and CVH Among Women, Aged 20 to 44 Years, in the United States, by Pregnancy Status, 1999 to 2014

Variable	Pregnancy Status		P Value for Comparison
	Pregnant	Not Pregnant	
	Population % Prevalence (95% CI) of Demographic Characteristics		
Demographic characteristics			
Age group, sample N	1117	8200	
20–24 y	28.4 (24.3–32.5)	20.2 (18.7–21.7)	<0.0001
25–34 y	55.9 (51.3–60.5)	37.5 (36.0–39.0)	
35–44 y	15.7 (11.8–19.6)	42.3 (40.7–44.0)	
Race/ethnicity, sample N	1117	8200	
White (non-Hispanic)	55.2 (49.7–60.6)	62.0 (60.2–65.4)	<0.0001
Black (non-Hispanic)	13.7 (10.5–16.9)	14.0 (11.9–14.8)	
Mexican	14.3 (11.5–17.0)	10.0 (8.6–11.3)	
Other Hispanic	5.8 (3.6–7.9)	8.0 (5.6–8.4)	
Other race	11.1 (7.7–14.6)	7.3 (6.1–7.7)	
Education, sample N	1075	7877	
Less than high school	18.6 (15.9–21.4)	17.3 (16.1–18.6)	0.10
High school graduate	19.1 (15.4–22.8)	23.0 (21.4–24.5)	
Greater than high school	62.3 (58.2–66.5)	59.7 (57.6–61.7)	
Family income/poverty ratio, sample N*	1040	7635	
≤1.30	23.9 (20.1–27.7)	27.1 (25.5–28.7)	0.33
1.30–≤1.85	12.7 (9.4–16.0)	11.5 (10.7–12.4)	
>1.85	63.4 (58.4–68.4)	61.4 (59.6–63.1)	
Variable	Pregnancy Status		P Value for Adjusted Comparison†
	Pregnant	Not Pregnant	
	Population % Prevalence (95% CI) of CVH Status		
Individual CVH metrics			
Diet, sample N	1092	7618	
Ideal	0.1 (0.0–0.3)	0.4 (0.3–0.6)	0.28
Intermediate	19.4 (15.5–23.3)	20.2 (19.0–21.5)	
Poor	80.5 (76.6–84.4)	79.3 (78.0–80.6)	
Physical activity, sample N	1117	8200	
Ideal	27.3 (22.2–32.3)	40.1 (38.4–41.8)	<0.0001
Intermediate	27.9 (23.1–32.8)	23.1 (21.9–24.4)	
Poor	44.8 (39.5–50.0)	36.8 (35.3–38.2)	
Smoking status, sample N	1117	8195	
Ideal	77.7 (73.3–82.2)	73.1 (71.7–74.6)	<0.0001
Intermediate	12.4 (8.6–16.1)	2.4 (2.0–2.9)	
Poor	9.9 (6.9–12.9)	24.4 (23.1–25.8)	
BMI, sample N	1054	6917	
Ideal	51.1 (46.0–56.2)	43.3 (41.4–45.1)	0.06
Nonideal	48.9 (43.8–54.0)	56.7 (54.9–58.6)	

Continued

Table 3. Continued

Variable	Pregnancy Status		P Value for Adjusted Comparison [†]
	Pregnant	Not Pregnant	
	Population % Prevalence (95% CI) of CVH Status		
Blood pressure, sample N	1037	5466	
Ideal	90.4 (87.5–93.3)	74.1 (72.7–75.5)	<0.0001
Intermediate	9.0 (6.1–11.9)	22.3 (21.0–23.6)	
Poor	0.6 (0.03–1.2)	3.6 (3.1–4.1)	
Total cholesterol, sample N	1047	7688	
Ideal	38.9 (33.7–44.0)	67.2 (66.0–68.5)	<0.0001
Intermediate	29.9 (25.6–34.1)	24.7 (23.5–25.9)	
Poor	31.3 (26.4–36.2)	8.1 (7.3–8.8)	
Fasting plasma glucose, sample N	445	2948	
Ideal	91.6 (88.3–94.9)	81.7 (79.9–83.5)	0.007
Nonideal	8.4 (5.1–11.7)	18.3 (16.5–20.1)	
Composite CVH			
No. of ideal CVH behaviors, mean (95% CI)	1.0 (0.9–1.1)	1.2 (1.1–1.2)	0.0003
No. of ideal CVH factors, mean (95% CI)	2.7 (2.5–2.9)	2.7 (2.6–2.7)	0.05
Total No. of ideal CVH metrics, mean (95% CI)	3.7 (3.4–3.9)	3.8 (3.8–3.9)	0.0005
Total CVH score, mean (95% CI)	8.3 (8.0–8.7)	8.6 (8.5–8.7)	0.004
Total CVH category prevalence (95% CI), sample N	406	2563	
High (CVH score 12–14)	4.6 (0.5–8.8)	13.0 (11.0–15.0)	0.01
Moderate (CVH score 8–11)	60.6 (52.3–68.9)	55.8 (53.4–58.2)	
Low (CVH score 0–7)	34.8 (26.4–43.2)	31.2 (28.7–33.7)	
Total CVH score, excluding cholesterol, mean (95% CI)	7.3 (6.9–7.6)	7.0 (6.9–7.1)	0.98
Total CVH category, excluding cholesterol, prevalence (95% CI), sample N	408	2589	
High (CVH score 10–12)	8.5 (3.9–13.1)	16.2 (14.2–18.2)	0.001
Moderate (CVH score 6–9)	78.2 (71.3–85.2)	59.3 (57.2–61.3)	
Low (CVH score 0–5)	13.2 (7.5–18.9)	24.6 (22.5–26.6)	

All estimates are based on population-weighted data from the National Health and Nutrition Examination Survey. BMI and fasting plasma glucose data are for 1999 to 2012, as month of pregnancy information was not available in 2013 to 2014. BMI indicates body mass index; CVH, indicates cardiovascular health.

*For 1999 to 2006, calculated on the basis of annual income (INDFMPIR); for 2007 to 2014, calculated on the basis of monthly income (INDFMPII).

[†]After adjustment for age and race/ethnicity.

metric and with high, moderate, or low total CVH scores. We also calculated the proportion of women attaining each of the 5 healthy diet components. We used polytomous logistic regression to compare the distributions of proportions across strata, after adjustment for demographic characteristics that were found to differ significantly across strata using χ^2 tests. Comparisons across pregnancy strata were thus adjusted for continuous age and race/ethnicity; comparisons across race/ethnicity strata were adjusted for age, education, and income; and comparisons across age strata were adjusted for race/ethnicity, education, and income. Comparisons across trimesters did not require adjustment and were performed using χ^2 tests.

We also calculated mean values for numbers of ideal CVH behaviors, factors, and metrics, as well as total CVH scores and total CVH scores excluding cholesterol. We used linear regression to compare means across strata, again adjusting for demographic characteristics that differed significantly across strata. We also calculated the proportions of pregnant and nonpregnant women with each CVH point score from 0 to 14 for illustration; statistical comparison of these distributions was not performed because of sample size limitations (N=0 for some cells).

For all analyses, we tested hypotheses using an α level of 0.05 based on a 2-tailed test, with no adjustment for multiple comparisons. Because this increased the potential for type 1 error, and because smaller sample sizes in some subgroups increased

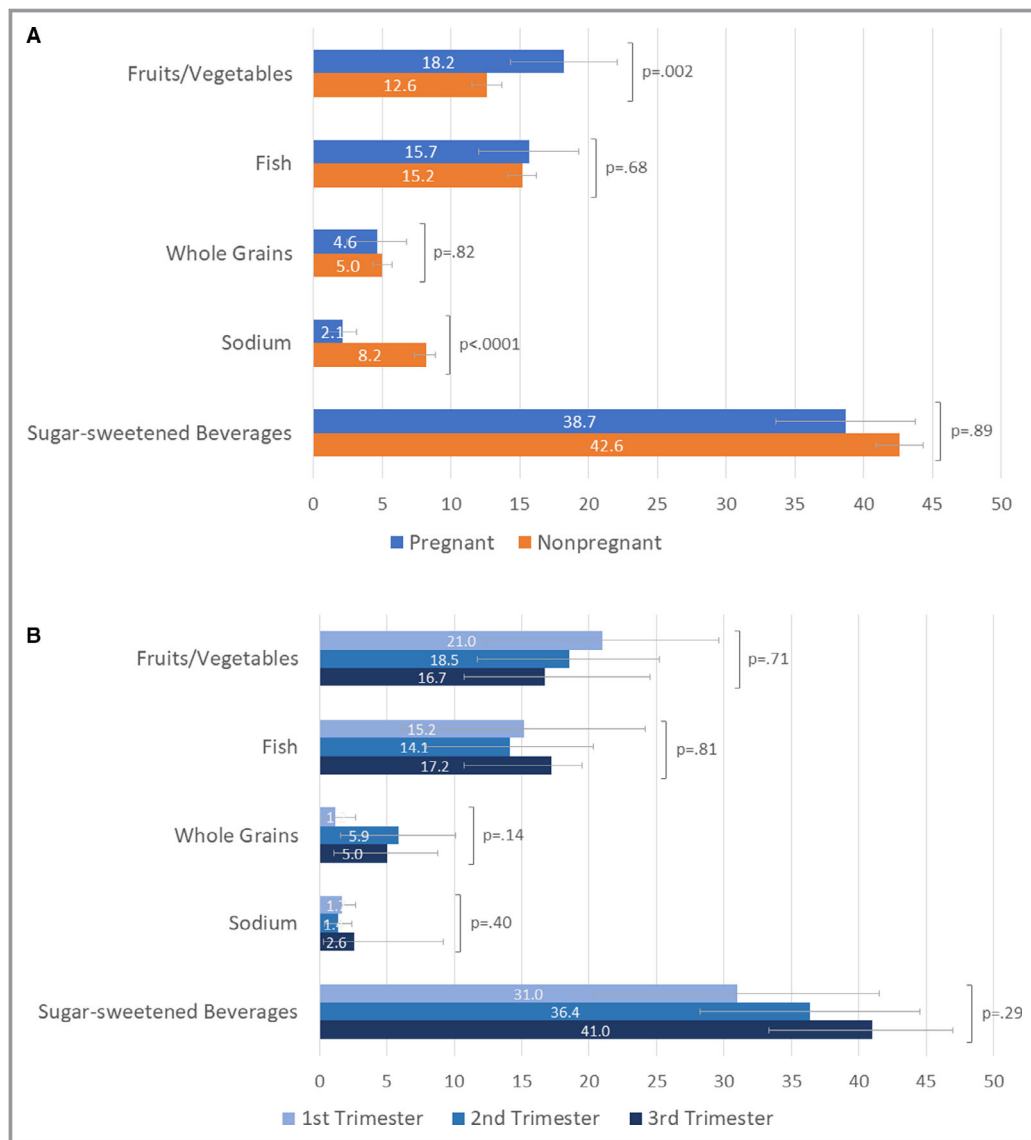


Figure 2. Prevalence of attaining individual healthy diet components among women, aged 20 to 44 years, in the United States, by **A.** pregnancy status and **B.** trimester, 1999 to 2014*. All estimates are based on population-weighted data from the National Health and Nutrition Examination Survey. Error bars show 95% CIs. *P* values for comparisons between pregnant and nonpregnant women were calculated after adjustment for age and race/ethnicity. Attainment of healthy diet components for pregnant women was defined as follows: (1) fruits and vegetables: ≥ 4.5 cups/day; (2) fish: two to three 3.5-oz servings/week; (3) whole grains (ie, ≥ 1.1 g fiber per 10 g carbohydrate): ≥ 3 1-oz equivalent servings/day; (4) sodium: < 1500 mg/d; (5) sugar-sweetened beverages: ≤ 450 kcal/wk. See Methods text for details. *Trimester-specific data are for 1999 to 2012, as month of pregnancy information was not available in 2013 to 2014.

the potential for type 2 error, we considered secondary analyses (stratified by age group and race/ethnicity) to be exploratory.

Results

Analytic Sample

A total of 1117 pregnant and 8200 nonpregnant women, aged 20 to 44 years, participated in an NHANES examination from

1999 to 2014 and were eligible for inclusion. Sample sizes and demographics of pregnant participants varied between cycles according to sampling strategy (eg, intentional oversampling of pregnant women in 1999–2006 and of non-Hispanic Asians in 2011–2014; Table 2).

Among pregnant participants, missingness was rare for CVH behaviors (0%–5.3% across NHANES cycles for diet and 0% for physical activity and smoking) but was more common for some CVH factors (0%–0.5% for BMI, 0%–16.7% for blood

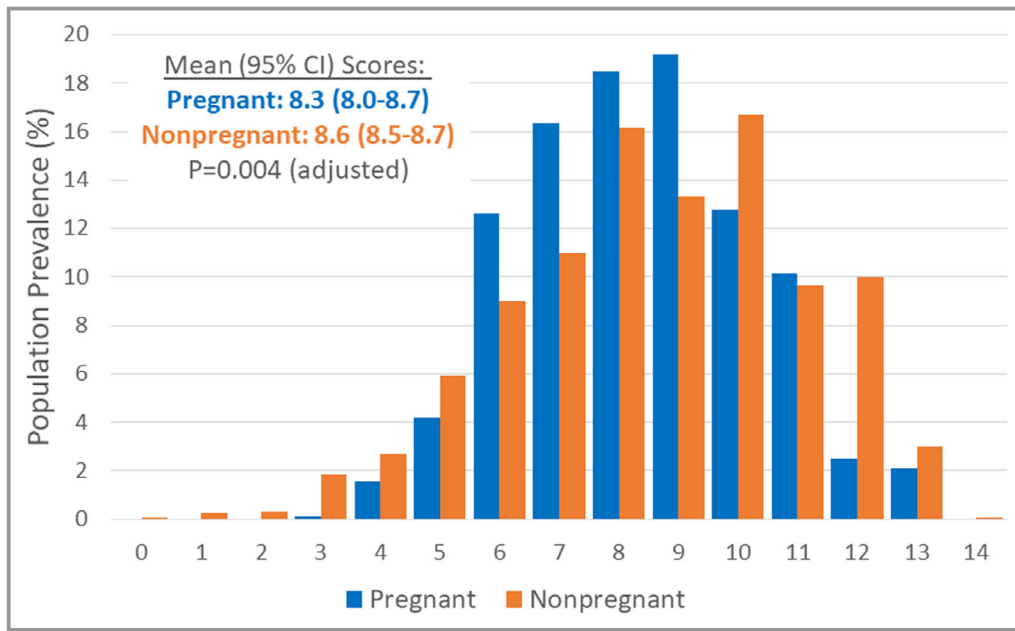


Figure 3. Cardiovascular health scores among women, aged 20 to 44 years, in the United States, by pregnancy status, 1999 to 2012. All estimates are based on population-weighted data from the National Health and Nutrition Examination Survey. Total sample sizes were 406 for pregnant women and 2563 for nonpregnant women. Comparison of mean scores by pregnancy status was adjusted for age and race/ethnicity.

pressure, 4.7%–10.9% for total cholesterol, and 10.5%–20.0% among morning examinees for fasting glucose; see Table 2). Compared with the 406 pregnant participants from 1999 to 2012 with complete data for all CVH metrics, the 119 with any missing CVH metric despite a morning examination tended to be slightly older (mean [SD] age, 28.7 [5.2] versus 27.5 [4.9] years), were less often Mexican (19% versus 32%), were more often non-Hispanic white (59% versus 44%), and more often had a higher income/poverty level ratio (>1.85 in 69% versus 54%); there were no significant differences in education level (data not shown).

Individual CVH Metrics

The distributions of ideal, intermediate, and poor or nonideal levels of individual CVH metrics among pregnant women overall are shown in Figure 1 and Table 3. Across CVH behaviors, the population prevalence of ideal levels varied from 0.1% (95% CI, 0%–0.3%) for diet and 27.3% (95% CI, 22.2%–32.3%) for physical activity, to 77.7% (95% CI, 73.3%–82.2%) for smoking. Among the 5 dietary components, attainment of healthy levels was lowest for limited sodium (<1500 mg/d in 2.1%) and adequate whole grains (≥ 3 1-oz equivalent servings/day in 4.6%) and highest for limited sugar-sweetened beverages (≤ 450 kcal/wk in 38.7%; Figure 2A). For CVH factors, the prevalence of ideal levels varied from 38.9% (95% CI, 33.7%–44.0%) for total cholesterol and

51.1% (95% CI, 46.0%–56.2%) for BMI to 90.4% (95% CI, 87.5%–93.3%) for blood pressure and 91.6% (95% CI, 88.3%–94.9%) for fasting glucose.

Compared with nonpregnant women, pregnant women tended to be younger and more often nonwhite, but there were no significant differences in education or income categories (Table 3). Pregnant (versus nonpregnant) women had less favorable levels for physical activity and total cholesterol, even after adjustment for age and race/ethnicity (Table 3). Conversely, pregnant (versus nonpregnant) women had more favorable levels for smoking, blood pressure, and fasting glucose, even after adjustment. The distribution of diet levels overall did not differ significantly by pregnancy status (Table 3), but pregnant women more frequently consumed adequate fruits and vegetables and less frequently limited sodium compared with pregnant women (Figure 2A). The distribution of ideal versus nonideal BMI levels did not differ significantly by pregnancy status.

In trimester-specific analyses of pregnant women, the distribution of total cholesterol levels varied significantly across trimesters; the proportion of pregnant women with ideal levels was 80.7% (95% CI, 73.0%–88.3%) in the first trimester but 33.8% (95% CI, 24.4%–43.2%) and 15.5% (95% CI, 9.4%–21.6%) in the second and third trimesters, respectively ($P < 0.0001$; Table 4). There were no statistically significant differences across trimesters for any of the other CVH metrics (Table 4), nor for any of the 5 dietary components (Figure 2B).

Table 4. Demographic Characteristics and CVH Among Pregnant Women, Aged 20 to 44 Years, in the United States, by Trimester of Pregnancy, 1999 to 2012

Variable	Population % Prevalence (95% CI)			P Value for Comparison
	First Trimester	Second Trimester	Third Trimester	
Demographic characteristics				
Age group, sample N	210	433	414	
20–24 y	26.7 (18.9–34.6)	30.5 (23.6–37.4)	23.1 (16.9–29.4)	0.26
25–34 y	61.3 (51.9–70.6)	55.3 (47.1–63.4)	55.6 (47.3–63.9)	
35–44 y	12.0 (4.5–19.5)	14.3 (8.5–20.0)	21.3 (13.2–29.3)	
Race/ethnicity, sample N	210	433	414	
White (non-Hispanic)	60.0 (49.4–70.6)	53.3 (45.4–61.1)	54.6 (46.3–63.0)	0.53
Black (non-Hispanic)	11.4 (6.6–16.3)	15.1 (10.2–20.1)	10.9 (6.0–15.8)	
Mexican	16.1 (10.8–21.3)	14.8 (10.7–19.0)	15.3 (11.1–19.5)	
Other Hispanic	4.7 (1.8–7.6)	3.9 (1.9–5.9)	7.6 (2.9–12.3)	
Other race	7.8 (2.2–13.3)	12.8 (7.5–18.1)	11.5 (4.6–18.5)	
Education, sample N	201	419	396	
Less than high school	18.1 (11.3–25.0)	20.5 (15.4–25.6)	19.9 (14.0–25.8)	0.34
High school graduate	18.0 (10.4–25.7)	22.4 (15.4–29.3)	14.0 (9.3–18.8)	
Greater than high school	63.8 (54.2–73.5)	57.2 (50.0–64.3)	66.0 (59.1–73.0)	
Family income/poverty ratio, sample N*	195	399	390	
≤1.30	22.6 (16.1–29.1)	25.9 (19.6–32.1)	17.2 (12.5–21.9)	0.19
1.30–≤1.85	15.8 (7.7–23.9)	10.5 (6.5–14.6)	12.5 (7.1–17.9)	
>1.85	61.6 (51.1–72.0)	63.6 (56.8–70.4)	70.4 (63.5–77.3)	
CVH metrics				
Diet, sample N	207	421	407	
Ideal	0	0	0	0.76
Intermediate	16.7 (8.4–25.1)	19.8 (12.3–27.3)	21.0 (14.3–27.7)	
Poor	83.3 (74.9–91.6)	80.2 (72.7–87.7)	79.0 (72.3–85.7)	
Physical activity, sample N	210	433	414	
Ideal	32.4 (21.5–43.3)	23.8 (16.5–31.2)	24.0 (16.3–31.7)	0.30
Intermediate	31.6 (20.4–42.7)	26.8 (19.1–34.5)	32.5 (25.2–39.8)	
Poor	36.1 (24.9–47.2)	49.4 (40.4–58.3)	43.5 (35.7–51.4)	
Smoking status, sample N	210	433	414	
Ideal	69.9 (59.1–80.7)	78.2 (72.3–84.0)	82.2 (76.5–87.9)	0.08
Intermediate	13.8 (5.8–21.7)	12.7 (7.3–18.1)	10.7 (5.7–15.7)	
Poor	16.3 (9.4–23.3)	9.1 (4.9–13.4)	7.1 (3.4–10.9)	
BMI, sample N	210	431	413	
Ideal	42.8 (32.5–53.2)	53.4 (45.5–61.3)	54.3 (46.8–61.8)	0.15
Nonideal	57.2 (46.8–67.5)	46.6 (38.7–54.5)	45.7 (38.2–53.2)	
Blood pressure, sample N	199	404	384	
Ideal	92.0 (88.2–95.8)	91.2 (86.9–95.4)	86.6 (80.0–93.3)	0.16
Intermediate	7.2 (3.6–10.8)	7.8 (3.5–12.0)	13.1 (6.4–19.8)	
Poor	0.8 (0–2.0)	1.1 (0.1–2.0)	0.3 (0–0.6)	

Continued

Table 4. Continued

Variable	Population % Prevalence (95% CI)			P Value for Comparison
	First Trimester	Second Trimester	Third Trimester	
Total cholesterol, sample N	190	412	389	
Ideal	80.7 (73.0–88.3)	33.8 (24.4–43.2)	15.5 (9.4–21.6)	<0.0001
Intermediate	16.1 (9.3–22.9)	39.3 (31.1–47.4)	28.4 (21.0–35.8)	
Poor	3.2 (0–6.9)	26.9 (20.1–33.7)	56.1 (47.6–64.6)	
Fasting plasma glucose, sample N	92	177	176	
Ideal	96.2 (92.9–99.5)	88.0 (82.7–93.3)	92.2 (85.8–98.5)	0.13
Nonideal	3.8 (0.5–7.1)	12.0 (6.7–17.3)	7.8 (1.5–14.2)	
No. of ideal CVH behaviors, mean (95% CI)	0.9 (0.7–1.0)	1.0 (0.8–1.1)	1.0 (0.9–1.2)	0.02
No. of ideal CVH factors, mean (95% CI)	3.2 (3.0–3.4)	2.7 (2.4–2.9)	2.4 (2.2–2.5)	<0.0001
Total No. of ideal CVH metrics, mean (95% CI)	4.0 (3.8–4.3)	3.7 (3.2–4.1)	3.4 (3.2–3.5)	<0.0001
Total CVH score, mean (95% CI)	9.0 (8.5–9.5)	8.4 (7.7–9.1)	7.8 (7.5–8.2)	0.0004
Total CVH category, prevalence (95% CI), sample N	82	162	162	
High (CVH score 12–14)	4.4 (2.4–6.5)	8.6 (0–18.4)	0.3 (0–0.8)	<0.0001
Moderate (CVH score 8–11)	79.4 (70.5–88.3)	49.9 (37.4–62.5)	58.7 (46.5–70.9)	
Low (CVH score 0–7)	16.1 (8.1–24.2)	41.4 (28.4–54.4)	41.0 (28.8–53.2)	
Total CVH score, excluding cholesterol, mean (95% CI)	7.1 (6.6–7.6)	7.4 (6.9–8.0)	7.2 (6.9–7.5)	0.06
Total CVH category, excluding cholesterol, prevalence (95% CI), sample N	83	163	162	
High (CVH score 10–12)	6.4 (3.8–9.1)	15.0 (4.8–25.2)	2.9 (1.2–4.6)	0.0009
Moderate (CVH score 6–9)	79.6 (71.0–88.3)	68.9 (57.6–80.3)	87.6 (80.4–94.9)	
Low (CVH score 0–5)	13.9 (6.5–21.4)	16.1 (7.2–25.0)	9.4 (2.8–16.1)	

All estimates, including characteristics, are based on population-weighted data from the National Health and Nutrition Examination Survey. Trimester-specific data and overall BMI and fasting plasma glucose require month of pregnancy information, which was not available in 2013 to 2014. BMI indicates body mass index; CVH, cardiovascular health.

*For 1999 to 2006, calculated on the basis of annual income (INDFMPIR); for 2007 to 2014, calculated on the basis of monthly income (INDFMMPPI).

Composite CVH

Composite CVH indicators among pregnant women overall are shown in Table 3 and Figure 3. The mean number of ideal CVH behaviors achieved by pregnant women was 1.0 (95% CI, 0.9–1.1; of 3: diet, physical activity, and smoking), and the mean number of ideal CVH factors was 2.7 (95% CI, 2.5–2.9; of 4: BMI, blood pressure, total cholesterol, and fasting glucose; Table 3). The mean total CVH score was 8.3 (95% CI, 8.0–8.7) of 14 (Table 3 and Figure 3). High CVH (score 12–14) was least frequent at 4.6% (95% CI, 0.5%–8.8%), whereas moderate CVH (score 8–11) was most frequent at 60.6% (95% CI, 52.3%–68.9%) and low CVH (score 0–7) was present in 34.8% (95% CI, 26.4%–43.2%). In sensitivity analyses excluding the cholesterol metric, high CVH remained least frequent at 8.5% (95% CI, 3.9%–13.1%), moderate CVH remained most frequent at 78.2% (95% CI, 71.3%–85.2%), and low CVH was present in 13.2% (95% CI, 7.5%–18.9%; Table 3 and Figure 3).

Compared with nonpregnant women, the distribution of CVH scores was overall lower among pregnant women (Figure 3 and

Table 3). Pregnant (versus nonpregnant) women had lower mean numbers of ideal CVH behaviors, a lower mean total CVH score, and a lower prevalence of high CVH, even after adjustment for age and race/ethnicity. However, in sensitivity analyses excluding the cholesterol metric, there was no significant difference in mean CVH scores by pregnancy status; and pregnant women less frequently had both high CVH (8.5% [95% CI, 3.9%–13.1%] versus 16.2% [95% CI, 14.2%–18.2%]) and low CVH (13.2% [95% CI, 7.5%–18.9%] versus 24.6% [95% CI, 22.5%–26.6%]), but more frequently had moderate CVH, compared with nonpregnant women ($P=0.001$ after adjustment; Table 3).

Across trimesters of pregnancy, the mean total number of ideal CVH metrics and total CVH score were lower in later trimesters, driven by fewer ideal CVH factors (but not behaviors; Table 4). The distribution of total CVH categories was also less favorable in later trimesters, with a much lower prevalence of low CVH in the first trimester compared with the second and third trimesters. However, in sensitivity analyses excluding the

Table 5. Demographic Characteristics and CVH Among Pregnant Women, Aged 20 to 44 Years, in the United States, by Age Group, 1999 to 2014

Variable	Age Group, y			P Value for Comparison
	20–24	25–34	35–44	
	Population % Prevalence (95% CI) of Demographic Characteristics			
Race/ethnicity, sample N	350	640	127	
White (non-Hispanic)	45.3 (36.9–53.6)	58.3 (51.7–64.8)	62.0 (49.9–74.1)	<0.0001
Black (non-Hispanic)	25.1 (18.0–32.2)	9.9 (6.9–13.0)	6.2 (1.5–10.8)	
Mexican	17.8 (12.9–22.8)	13.2 (10.2–16.2)	11.7 (6.6–16.8)	
Other Hispanic	5.5 (2.7–8.2)	5.7 (3.1–8.4)	6.5 (0–13.7)	
Other race	6.3 (2.2–10.4)	12.9 (8.0–17.8)	13.6 (5.6–21.6)	
Education, sample N	329	625	121	
Less than high school	28.6 (22.2–35.0)	14.5 (11.2–17.7)	15.9 (7.3–24.5)	<0.0001
High school graduate	29.4 (23.6–35.2)	16.1 (11.4–20.8)	11.0 (3.0–19.0)	
Greater than high school	42.0 (35.1–48.9)	69.4 (64.2–74.7)	73.1 (61.5–84.6)	
Family income/poverty ratio, sample N*	319	605	116	
≤1.30	44.0 (35.3–52.8)	16.9 (12.9–20.8)	12.7 (6.5–18.9)	<0.0001
1.30–≤1.85	15.4 (9.4–21.5)	12.4 (7.9–16.9)	8.9 (4.8–13.0)	
>1.85	40.5 (31.8–49.3)	70.8 (64.7–76.8)	78.5 (70.4–86.5)	
Variable	Age Group, y			P Value for Adjusted Comparison†
	20–24	25–34	35–44	
	Population % Prevalence (95% CI) of CVH Status			
Diet, sample N	338	631	123	
Ideal	0	0.2 (0–0.5)	0	<0.0001
Intermediate	6.2 (2.8–9.7)	20.9 (15.2–26.7)	37.6 (24.8–50.4)	
Poor	93.8 (90.3–97.2)	78.9 (73.2–84.6)	62.4 (49.6–75.2)	
Diet components‡				
Adequate fruits and vegetables	10.6 (5.8–15.4)	19.2 (14.2–24.1)	28.4 (16.7–40.1)	0.14
Adequate fish	10.8 (6.3–15.3)	14.4 (9.6–19.1)	29.0 (15.5–42.5)	0.09
Adequate whole grains	2.3 (0–5.3)	6.0 (2.7–9.4)	3.8 (0–8.4)	0.004
Limited sodium	1.5 (0–3.3)	2.5 (1.0–4.0)	1.7 (0–3.3)	0.37
Limited sugar-sweetened beverages	25.4 (18.3–32.4)	39.9 (33.1–46.7)	58.4 (44.9–71.9)	0.04
Physical activity, sample N	350	640	127	
Ideal	23.1 (16.1–30.0)	29.5 (23.0–35.9)	27.1 (15.7–38.6)	0.87
Intermediate	23.9 (17.1–30.7)	29.6 (23.7–35.5)	29.1 (17.7–40.5)	
Poor	53.0 (44.8–61.1)	40.9 (34.5–47.3)	43.7 (31.6–55.9)	
Smoking status, sample N	350	640	109	
Ideal	63.3 (54.5–72.2)	81.6 (76.5–86.7)	89.8 (81.7–97.9)	0.0003
Intermediate	20.0 (11.9–28.2)	10.3 (6.3–14.2)	5.9 (0–12.6)	
Poor	16.6 (10.4–22.8)	8.1 (5.1–11.2)	4.3 (0–9.1)	
BMI, sample N	322	611	121	
Ideal	53.1 (45.4–60.9)	49.9 (44.0–55.8)	52.0 (38.4–65.5)	0.56
Nonideal	46.9 (39.1–54.6)	50.1 (44.2–56.0)	48.0 (34.5–61.6)	

Continued

Table 5. Continued

Variable	Age Group, y			P Value for Adjusted Comparison [†]
	20–24	25–34	35–44	
	Population % Prevalence (95% CI) of CVH Status			
Blood pressure, sample N	324	598	115	
Ideal	86.6 (80.9–92.3)	93.3 (90.3–96.3)	87.0 (77.2–96.7)	0.0005
Intermediate	13.2 (7.5–18.9)	6.0 (2.8–9.2)	11.7 (2.0–21.5)	
Poor	0.2 (0–0.5)	0.7 (0–1.5)	1.3 (0.9–1.7)	
Total cholesterol, sample N	324	604	119	
Ideal	37.6 (28.5–46.7)	41.0 (34.5–47.6)	33.5 (19.3–47.6)	0.02
Intermediate	39.9 (31.9–47.8)	28.5 (22.5–34.5)	17.3 (7.4–27.1)	
Poor	22.5 (15.2–29.9)	30.5 (24.5–36.5)	49.3 (36.3–62.3)	
Fasting plasma glucose, sample N	137	256	52	
Ideal	88.2 (79.1–97.3)	92.8 (87.0–98.6)	91.0 (84.0–98.0)	0.39
Nonideal	11.8 (2.7–20.9)	7.2 (1.4–13.0)	9.0 (2.0–16.0)	
No. of ideal CVH behaviors, mean (95% CI)	0.7 (0.5–0.9)	1.1 (0.9–1.2)	1.2 (1.0–1.4)	0.13
No. of ideal CVH factors, mean (95% CI)	2.7 (2.4–2.9)	2.7 (2.5–2.9)	2.7 (2.4–3.0)	0.78
Total No. of ideal CVH metrics, mean (95% CI)	3.3 (3.0–3.5)	3.8 (3.5–4.1)	3.9 (3.3–4.4)	0.0002
Total CVH score, mean (SD)	7.8 (7.5–8.1)	8.6 (8.0–9.1)	8.7 (7.8–9.5)	0.02
Total CVH category, prevalence (95% CI), sample N	127	235	44	
High (CVH score 12–14)	0.1 (0–0.3)	5.2 (0.1–10.2)	13.0 (0–33.8)	0.0002
Moderate (CVH score 8–11)	54.1 (43.7–64.5)	62.5 (52.0–73.0)	66.9 (45.3–88.6)	
Low (CVH score 0–7)	45.8 (35.4–56.2)	32.3 (22.3–42.4)	20.1 (7.7–32.4)	
Total CVH score, excluding cholesterol, mean (95% CI)	6.6 (6.3–6.9)	7.5 (7.1–7.9)	7.8 (7.2–8.4)	0.01
Total CVH category, excluding cholesterol, prevalence (95% CI), sample N	127	237	44	
High (CVH score 10–12)	1.9 (0.6–3.3)	10.2 (4.4–16.1)	16.1 (0–36.6)	0.004
Moderate (CVH score 6–9)	74.0 (65.6–82.5)	80.1 (71.0–89.3)	78.5 (57.3–99.6)	
Low (CVH score 0–5)	24.1 (15.3–32.8)	9.6 (1.9–17.3)	5.5 (0–13.0)	

All estimates are based on population-weighted data from the National Health and Nutrition Examination Survey. BMI and fasting plasma glucose data are for 1999 to 2012, as month of pregnancy information was not available in 2013 to 2014. BMI indicates body mass index; CVH, cardiovascular health.

*For 1999 to 2006, calculated on the basis of annual income (INDFMPIR); for 2007 to 2014, calculated on the basis of monthly income (INDFMMPPI).

[†]Comparisons of metric statuses between age groups are adjusted for race/ethnicity, income, and education; and comparisons of metric statuses between race/ethnicity groups are adjusted for continuous age, income, and education.

[‡]Attainment of healthy diet components was defined as follows: (1) fruits and vegetables: ≥ 4.5 cups/day; (2) fish: two to three 3.5-oz servings/week; (3) whole grains (ie, ≥ 1.1 g fiber per 10 g carbohydrate): ≥ 3 1-oz equivalent servings/day; (4) sodium: < 1500 mg/d; (5) sugar-sweetened beverages: ≤ 450 kcal/wk. See Methods text for details.

cholesterol metric, total CVH was most favorable during the second trimester. For example, the prevalence of high CVH was 6.4% (95% CI, 3.8%–9.1%) in the first trimester, 15.0% (95% CI, 4.8%–25.2%) in the second trimester, and 2.9% (95% CI, 1.2%–4.6%) in the third trimester ($P=0.0009$; Table 4).

Secondary Analyses by Age and Race/Ethnicity Among Pregnant Women

In secondary analyses, there were statistically significant differences between age strata of pregnant women in the

distribution of levels for diet, smoking, blood pressure, and total cholesterol (Table 5). Diet and smoking status were generally more favorable in older age strata, even after adjustment for race/ethnicity, education, and income. Conversely, for blood pressure and total cholesterol, poor levels were most frequent in older pregnant women, and ideal levels were most frequent in the middle-age stratum. There were no statistically significant differences by age strata for the status of physical activity, BMI, or fasting glucose. Total CVH was more favorable in older age strata; for example, mean (95% CI) total CVH scores were 7.8

Table 6. Demographic Characteristics and CVH Among Pregnant Women, Aged 20 to 44 Years, in the United States, by Race/Ethnicity, 1999 to 2014

Variable	Race/Ethnicity			P Value for Comparison
	White (Non-Hispanic)	Black (Non-Hispanic)	Mexican	
	Population % Prevalence (95% CI) of Demographic Characteristics			
Age group, sample N	506	148	306	
20–24 y	23.3 (17.9–28.8)	52.2 (42.6–61.9)	35.5 (28.7–42.2)	<0.0001
25–34 y	59.0 (52.5–65.5)	40.6 (31.8–49.5)	51.6 (45.0–58.2)	
35–44 y	17.7 (12.0–23.3)	7.1 (2.0–12.3)	12.9 (8.4–17.4)	
Education, sample N	497	145	280	
Less than high school	7.2 (3.7–10.7)	23.8 (16.1–31.5)	53.1 (44.8–61.3)	<0.0001
High school graduate	17.6 (11.8–23.3)	24.6 (17.5–31.7)	26.1 (18.3–34.0)	
Greater than high school	75.3 (69.4–81.1)	51.6 (42.8–60.4)	20.8 (14.3–27.4)	
Family income/poverty ratio, sample N*	483	138	275	
≤1.30	11.0 (6.6–15.4)	45.4 (36.0–54.9)	54.0 (45.9–62.1)	<0.0001
1.30–≤1.85	8.9 (4.9–12.9)	11.1 (4.7–17.5)	23.5 (17.3–29.8)	
>1.85	80.1 (74.2–86.0)	43.5 (32.9–54.0)	22.5 (15.3–29.6)	
Variable	Race/Ethnicity			P Value for Adjusted Comparison†
	White (Non-Hispanic)	Black (Non-Hispanic)	Mexican	
	Population % Prevalence (95% CI) of CVH Metric Status			
Diet, sample N	498	142	298	
Ideal	0	0	0	0.75
Intermediate	19.6 (13.4–25.9)	13.5 (6.8–20.3)	11.8 (6.5–17.1)	
Poor	80.4 (74.1–86.6)	86.5 (79.7–93.2)	88.2 (82.9–93.5)	
Diet components‡				
Adequate fruits and vegetables	15.2 (10.0–20.3)	13.2 (5.5–20.9)	21.4 (15.2–27.6)	0.008
Adequate fish	11.8 (6.6–17.0)	22.5 (14.4–30.7)	16.2 (10.5–21.8)	0.001
Adequate whole grains	6.4 (2.6–10.2)	1.4 (0–3.6)	0.4 (0–0.8)	0.02
Limited sodium	0.7 (0.2–1.1)	3.1 (0–7.0)	6.0 (1.6–10.5)	0.0002
Limited sugar-sweetened beverages	43.3 (35.7–51.0)	22.9 (14.2–31.6)	25.3 (18.8–31.7)	0.14
Physical activity, sample N	506	148	306	
Ideal	36.3 (28.6–44.1)	18.6 (11.1–26.0)	16.5 (9.6–23.3)	0.003
Intermediate	29.4 (22.6–36.2)	21.5 (13.4–29.5)	23.4 (16.7–30.1)	
Poor	34.2 (27.3–41.2)	60.0 (50.9–69.1)	60.2 (52.6–67.8)	
Smoking status, sample N	506	148	306	
Ideal	74.5 (67.8–81.2)	75.4 (67.1–83.7)	89.2 (84.0–94.4)	<0.0001
Intermediate	14.6 (8.9–20.3)	7.0 (2.7–11.2)	8.4 (3.6–13.2)	
Poor	11.0 (6.3–15.6)	17.7 (10.0–25.3)	2.4 (0.1–4.7)	
BMI, sample N	484	130	302	
Ideal	53.4 (47.2–59.6)	38.6 (29.3–47.8)	45.4 (38.0–52.9)	0.03
Nonideal	46.6 (40.4–52.8)	61.4 (52.2–70.7)	54.6 (47.1–62.0)	

Continued

Table 6. Continued

Variable	Race/Ethnicity			P Value for Adjusted Comparison [†]
	White (Non-Hispanic)	Black (Non-Hispanic)	Mexican	
	Population % Prevalence (95% CI) of CVH Metric Status			
Blood pressure, sample N	465	135	291	
Ideal	92.3 (88.8–95.8)	85.8 (79.0–92.7)	94.6 (91.8–97.3)	0.006
Intermediate	7.6 (4.1–11.1)	11.9 (5.7–18.1)	4.0 (1.2–6.7)	
Poor	0.1 (0–0.3)	2.3 (0–5.4)	1.4 (1.1–1.8)	
Total cholesterol, sample N	478	132	289	
Ideal	38.2 (30.8–45.5)	39.3 (29.1–49.5)	39.0 (32.5–45.4)	0.25
Intermediate	28.0 (22.0–33.9)	39.2 (29.9–48.5)	31.3 (24.8–37.7)	
Poor	33.8 (27.4–40.2)	21.5 (11.8–31.2)	29.8 (22.7–36.8)	
Fasting plasma glucose, sample N	200	49	141	
Ideal	91.1 (85.8–96.3)	96.3 (90.4–100)	87.9 (82.4–93.3)	0.21
Non-ideal	8.9 (3.7–14.2)	3.7 (0–9.6)	12.1 (6.7–17.6)	
No. of ideal CVH behaviors, mean (95% CI)	1.0 (0.9–1.1)	0.9 (0.7–1.1)	1.0 (1.0–1.1)	0.003
No. of ideal CVH factors, mean (95% CI)	2.8 (2.5–3.0)	2.4 (2.2–2.6)	2.8 (2.6–3.0)	0.0005
Total No. of ideal CVH metrics, mean (95% CI)	3.7 (3.5–4.0)	3.2 (2.9–3.5)	3.8 (3.7–4.0)	<0.0001
Total CVH score, mean (95% CI)	8.6 (8.1–9.1)	7.6 (6.8–8.3)	8.4 (8.1–8.7)	0.0002
Total CVH category, prevalence (95% CI), sample N	179	43	131	
High (CVH score 12–14)	6.5 (0–14.0)	0.8 (0–2.3)	0.4 (0–0.9)	0.03
Moderate (CVH score 8–11)	65.5 (55.0–76.1)	44.9 (26.3–63.5)	70.7 (61.5–79.9)	
Low (CVH score 0–7)	28.0 (19.5–36.5)	54.3 (35.7–72.9)	28.9 (19.6–38.2)	
Total CVH score, excluding cholesterol, mean (95% CI)	7.5 (7.1–8.0)	6.5 (5.8–7.2)	7.3 (7.1–7.6)	0.0007
Total CVH category, excluding cholesterol, prevalence (95% CI), sample N	181	43	131	
High (CVH score 10–12)	11.4 (3.2–19.6)	0.8 (0–2.3)	5.3 (3.4–7.1)	0.003
Moderate (CVH score 6–9)	78.7 (69.0–88.4)	72.7 (55.4–90.0)	87.3 (81.8–92.8)	
Low (CVH score 0–5)	9.9 (3.7–16.1)	26.5 (9.3–43.8)	7.4 (2.4–12.5)	

All estimates are based on population-weighted data from the National Health and Nutrition Examination Survey. BMI and fasting plasma glucose data are for 1999 to 2012, as month of pregnancy information was not available in 2013 to 2014. BMI indicates body mass index; CVH, cardiovascular health.

*For 1999 to 2006, calculated on the basis of annual income (INDFMPIR); for 2007 to 2014, calculate on the basis of monthly income (INDFMMPPI).

[†]Comparisons between age groups are adjusted for race/ethnicity, income, and education; and comparisons between racial/ethnic groups are adjusted for continuous age, income, and education.

[‡]Attainment of healthy diet components was defined as follows: (1) fruits and vegetables: ≥ 4.5 cups/day; (2) fish: two to three 3.5-oz servings/week; (3) whole grains (ie, ≥ 1.1 g fiber per 10 g carbohydrate): ≥ 3 1-oz equivalent servings/day; (4) sodium: <1500 mg/d; (5) sugar-sweetened beverages: ≤ 450 kcal/wk. See Methods text for details.

(7.5–8.1) for age 20 to 24 years, 8.6 (8.0–9.1) for age 25 to 34 years, and 8.7 (7.8–9.5) for age 35 to 44 years ($P=0.02$ after adjustment; Table 5). In sensitivity analyses excluding the cholesterol metric, these age-related differences in total CVH persisted.

There were also statistically significant racial/ethnic differences in the distribution of levels for physical activity, smoking, BMI, and blood pressure among pregnant women (Table 6). Physical activity was most favorable among whites (and comparable between blacks and Mexicans), and smoking status was most favorable among Mexicans. BMI was most favorable among whites and least favorable

among blacks, and blood pressure was also least favorable among blacks (and comparable between whites and Mexicans). There were no statistically significant differences in the distributions of levels for diet (despite some differences for individual dietary components), total cholesterol, or fasting glucose. CVH behaviors and factors and total CVH were all least favorable among blacks; for example, mean (95% CI) total CVH scores were 8.6 (8.1–9.1) for whites, 7.6 (6.8–8.3) for blacks, and 8.4 (8.1–8.7) for Mexicans ($P=0.0002$; Table 6). In sensitivity analyses excluding the cholesterol metric, these racial/ethnic differences in total CVH persisted.

Table 7. CVH Among Women, Aged 20 to 44 Years, in the United States Using Alternative Blood Pressure Categories, by Pregnancy Status and Trimester, 1999 to 2014

Variable	Population % Prevalence (95% CI)		P Value for Adjusted Comparison*
	Pregnant	Not Pregnant	
Blood pressure, sample N	1037	7428	
Ideal	90.4 (87.5–93.3)	74.1 (72.7–75.5)	0.04
Intermediate	5.4 (3.5–7.2)	10.9 (10.1–11.8)	
Poor	4.2 (2.0–6.5)	14.9 (13.8–16.1)	
Total No. of ideal CVH metrics, mean (95% CI)	3.7 (3.4–3.9)	3.8 (3.8–3.9)	0.003
Total CVH score, mean (95% CI)	8.3 (7.9–8.7)	8.5 (8.4–8.6)	0.06
Total CVH category prevalence (95% CI), sample N	406	2563	
High (CVH score 12–14)	4.6 (0.5–8.8)	12.9 (10.9–14.9)	0.13
Moderate (CVH score 8–11)	59.5 (51.5–67.6)	54.7 (52.3–57.0)	
Low (CVH score 0–7)	35.9 (27.7–44.0)	32.4 (30.1–34.8)	
Total CVH score, excluding cholesterol, mean (95% CI)	7.2 (6.9–7.5)	6.9 (6.8–7.0)	0.24
Total CVH category, excluding cholesterol, prevalence (95% CI), sample N	408	2589	
High (CVH score 10–12)	8.5 (3.9–13.1)	15.8 (13.8–17.8)	0.003
Moderate (CVH score 6–9)	76.0 (68.1–83.8)	58.4 (56.4–60.5)	
Low (CVH score 0–5)	15.5 (8.6–22.4)	25.7 (23.6–27.8)	

Variable	Population % Prevalence (95% CI)			P Value for Comparison
	First Trimester	Second Trimester	Third Trimester	
Blood pressure, sample N	199	404	384	
Ideal	92.0 (88.2–95.8)	91.2 (86.9–95.4)	86.6 (80.0–93.3)	0.58
Intermediate	4.5 (1.6–7.4)	4.9 (2.0–7.9)	6.8 (2.6–11.1)	
Poor	3.4 (1.1–5.8)	3.9 (0.7–7.2)	6.5 (1.0–12.1)	
Total No. of ideal CVH metrics, mean (95% CI)	4.0 (3.8–4.3)	3.7 (3.2–4.1)	3.4 (3.2–3.5)	<0.0001
Total CVH score, mean (95% CI)	8.9 (8.4–9.5)	8.4 (7.7–9.1)	7.7 (7.4–8.0)	<0.0001
Total CVH category prevalence (95% CI), sample N	82	162	162	
High (CVH score 12–14)	4.4 (2.4–6.5)	8.6 (0–18.4)	0.3 (0–0.8)	<0.0001
Moderate (CVH score 8–11)	79.4 (70.5–88.3)	49.9 (37.4–62.5)	55.6 (43.6–67.6)	
Low (CVH score 0–7)	16.1 (8.1–24.2)	41.4 (28.4–54.4)	44.1 (32.1–56.0)	
Total CVH score, excluding cholesterol, mean (95% CI)	7.1 (6.6–7.6)	7.4 (6.8–8.0)	7.1 (6.8–7.4)	0.43
Total CVH category, excluding cholesterol, prevalence (95% CI), sample N	83	163	162	
High (CVH score 12–14)	6.4 (3.8–9.1)	15.0 (4.8–25.2)	2.9 (1.2–4.6)	0.003
Moderate (CVH score 8–11)	79.6 (71.0–88.3)	68.9 (57.6–80.3)	81.1 (73.4–88.7)	
Low (CVH score 0–7)	13.9 (6.5–21.4)	16.1 (7.2–25.0)	16.0 (9.0–23.0)	

All estimates are based on population-weighted data from the National Health and Nutrition Examination Survey. Compared with the primary analyses, a more restrictive definition was used for intermediate blood pressure: systolic 120 to 129 mm Hg and diastolic <80 mm Hg or treated to goal. See Table 1 and text (Methods) for details. Trimester-specific data as well as total CVH data are for 1999 to 2012, as month of pregnancy information was not available in 2013 to 2014. CVH indicates cardiovascular health.

*After adjustment for age and race/ethnicity.

Sensitivity Analysis With Alternative Blood Pressure Definition

Using the more restrictive blood pressure definition (Table 1, footnote), the proportions of pregnant women overall and by trimester with poor blood pressure levels were higher, but

patterns were similar (Table 7). The patterns of findings for total CVH were also unchanged (Table 7).

Discussion

Among pregnant women, aged 20 to 44 years, in the United States from 1999 to 2012, CVH was far from optimal: 4.6%

had high CVH, 60.6% had moderate CVH, and 34.8% had low CVH. Gestational diet and physical activity were especially poor (0.1% and 27.3%, respectively, with ideal levels), followed by total cholesterol and BMI (38.9% and 51.3%, respectively, with ideal levels). Total CVH levels were worse in pregnant women compared with nonpregnant women, driven mainly by physical activity and total cholesterol levels; when total cholesterol was excluded, both high and low (versus moderate) CVH were less frequent in pregnant women compared with nonpregnant women. In exploratory analyses of subgroups of pregnant women, total CVH was more favorable in older age strata, driven by behaviors, and total CVH was least favorable among blacks compared with whites and Mexicans, driven by a combination of behaviors and factors.

To our knowledge, this is the first study to examine total CVH based on Life's Simple 7 among pregnant women in the United States. One prior study assessed CVH during early pregnancy (median, 13 weeks) using 5 metrics (no diet or physical activity) in the population-based Generation R Study in the Netherlands.²⁵ In 1924 mostly white and highly educated women with a mean age of 30.8 years, the median CVH score was 8.0 of 10, and ideal levels were found in 74% to 75% for smoking, 47% to 68% for BMI, 41% to 63% for blood pressure, 60% to 64% for cholesterol, and 86% to 91% for glucose (ranges combine women who did or did not develop a hypertensive disorder of pregnancy). Moreover, better CVH during early pregnancy was associated with better CVH and lower carotid intima-media thickness 10 years later.²⁵ Our findings for CVH among US women in their first trimester of pregnancy were somewhat less favorable for BMI (ideal in 43%), more favorable for blood pressure (92%) and total cholesterol (81%), and similar for smoking (70%) and glucose (96%).

Previous studies have examined individual CVH behaviors and factors in US women during pregnancy. Overall dietary quality among pregnant women was assessed using NHANES 2003 to 2012, and consistent with the findings reported herein, dietary quality was generally poor (mean [SEM] Healthy Eating Index-2010: 50.7 [0.9] of 100).²⁶ Physical activity during pregnancy has been examined in various NHANES cycles from 1999 to 2014 based on self-report²⁷ and accelerometer data.²⁸ Physical activity levels were overall suboptimal,^{27,28} with statistically significant declines in later trimesters for continuous physical activity measures^{27,28} but not categorical measures²⁷ (as in our study). Smoking was examined using self-reported data from birth certificates in 2016, which indicated that 7.2% of mothers smoked at any point during pregnancy.²⁹ Using different methods (including earlier years), we found a slightly higher prevalence (9.9%) of current smoking in pregnant women.

The 2 components of pregnancy BMI, prepregnancy BMI and gestational weight gain, have been examined in US women using self-reported data from birth certificates. In 2014, just over half

of women giving birth reported prepregnancy overweight (25.6%) or obesity (24.8%).³⁰ In 2012 to 2013, gestational weight gain was estimated as appropriate in 32.1%, inadequate in 20.4%, and excessive in 47.5% of women giving birth to full-term singletons.³¹ Our estimate of nonideal BMI during pregnancy (49%) is similar to reported prevalences for both prepregnancy overweight/obesity and excessive gestational weight gain, although our method may have underestimated true nonideal BMI prevalence (eg, overweight women with inadequate weight gain may have been labeled "ideal"). Maternal hypertension prevalence was previously estimated at 6.9%, including 1.6% with chronic hypertension and 5.3% with pregnancy-related hypertension (including preeclampsia), using clinician-recorded data from 2014 to 2015 birth certificates.³² By comparison, we estimated that 9.6% of women had elevated blood pressure or medication-controlled hypertension at a single point in pregnancy. Similarly, clinician-recorded data from 2016 birth certificates yielded a prevalence of 6.0% for gestational diabetes mellitus and 0.9% for pregestational diabetes mellitus³³; we estimated that 8.4% of women had nonideal fasting glucose levels at a single point in pregnancy. In addition to obvious outcome differences (hypertension versus blood pressure, diabetes mellitus versus fasting glucose) and the lower reliability of a single measurement versus diagnostic criteria, these discrepancies may be partly related to underreporting on birth certificates.³⁴ To our knowledge, no prior study has reported total cholesterol levels during pregnancy using nationally representative data, but prior studies of pregnant women have also shown increases in cholesterol levels across gestation.²¹

Currently, data on the clinical implications of total CVH during pregnancy are limited to the above-described study, demonstrating associations with later maternal carotid intima-media thickness.²⁵ However, total CVH during pregnancy is likely to have important implications for health, as extensive data support the relevance of the individual CVH metrics. Gestational diet quality,^{35–37} physical activity,^{36,38} smoking,³⁹ BMI,^{6,17} hypertension,^{40,41} and diabetes mellitus^{2,20,42} have well-established associations with pregnancy outcomes as well as longer-term maternal and offspring health outcomes. Although less well-studied, gestational hypercholesterolemia has been associated with preeclampsia²⁰ and offspring atherosclerosis.²¹ In nonpregnant adults, similarly, each of the 7 CVH factors has independent associations with health outcomes,⁸ but moreover, total CVH powerfully predicts health outcomes in a way that seems to be more than the sum of its parts.⁴³ Total CVH may similarly provide insights into health during pregnancy beyond counting traditional risk factors, such as preeclampsia and gestational diabetes mellitus. For example, nonoptimal levels of blood pressure and glucose that are below diagnostic thresholds have also been associated with adverse pregnancy outcomes,^{44,45} and when gestational hypertension and diabetes mellitus are jointly present, their

association with subsequent maternal diabetes mellitus, hypertension, CVD, and mortality is more than additive.⁴⁶ These data, combined with our observation that <10% of pregnant women in the United States had high CVH (even when cholesterol was excluded from the score), suggest the need for future research examining the implications of the full spectrum of gestational CVH for maternal and offspring health. Currently, few data sets are available to this end, but we look to future opportunities to measure CVH in women before, during, and after gestation, along with subsequent health outcomes for mothers and offspring, to better define temporal relationships.

Conceptually, CVH provides a unifying construct for health promotion that may prove useful during pregnancy. Although women report increased motivation during pregnancy for healthful changes,⁴⁷ diet or exercise counseling has generally been provided at low rates (17.9% among preventive prenatal visits in the United States in 2005–2010), even lower than for nonpregnant women of childbearing age (22.6%; $P<0.02$ for comparison).⁴⁸ Even CVH metrics that are routinely tracked, such as weight, are not always discussed. On the basis of data from the Pregnancy Risk and Assessment Monitoring System 2010 to 2011, just 26% of women reported receiving Institute of Medicine–consistent gestational weight gain advice from a clinician and 26% reported receiving no advice.⁴⁹ Moreover, clinician advice below Institute of Medicine recommendations was associated with inadequate gain, advice above Institute of Medicine recommendations was associated with excessive gain, and no advice was associated with both.⁴⁹ The American College of Obstetricians and Gynecologists and AHA have recently assigned priority to comprehensive CVH promotion in women by obstetricians and gynecologists,¹ and clinical use of the CVH construct may have utility in operationalizing this goal.⁵⁰ Formal development of pregnancy-specific definitions for CVH metrics (such as will be available for diet in the 2020 Dietary Guidelines for Americans³⁵) and further development of treatment options (such as for hypercholesterolemia in pregnancy⁵¹) would also be useful.

The strengths of this study include the generalizability related to use of nationally representative data and the comprehensive assessment of all 7 CVH metrics across all 3 trimesters of pregnancy. This study also has several limitations. First, the 7 CVH metrics have not been defined by the AHA for use in pregnant women, and NHANES does not collect all data that might be relevant for CVH metrics during pregnancy (eg, prepregnancy weight versus gestational weight gain), so we used modified metric definitions. All modifications were based on established pregnancy guidelines, except for total cholesterol, for which guidelines are not available and sensitivity analyses without cholesterol were conducted. Second, although evidence supports the relevance of each individual CVH metric during pregnancy for maternal and offspring health outcomes, total gestational CVH has not been

extensively studied and further investigation is required to determine its relevance to health outcomes. Third, to increase sample sizes and statistical power, we pooled data from 1999 to 2014 NHANES cycles together for analysis, and we cannot exclude an influence of secular trends on our estimates. As NHANES no longer oversamples pregnant women (as of 2007–2008) nor collects month of pregnancy data (as of 2013–2014), it is not well suited to examine such trends. Fourth, despite pooling all available data, sample sizes remained limited, especially for some subgroups. Because of this and the potential for type 2 errors related to multiple testing, subgroup analyses should be interpreted with caution.

Conclusions

Among pregnant women, aged 20 to 44 years, in the United States from 1999 to 2012, <1 in 10 had high CVH.

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Disclosures

None.

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