Dietary Habits and Medications to Control Hypertension among Women of Child-bearing Age in the United States from 2001-2016

Lara C Kovell[a], Benjamin Maxner[b], Didem Ayturk[c], Tiffany A Moore Simas[c,d], Colleen M Harrington[a], David D McManus[a,c], Paula Gardiner[e], Gerard P Aurigemma[a], Stephen P Juraschek[f].

[a] Division of Cardiovascular Medicine, Department of Medicine, University of Massachusetts Medical School, Worcester, Massachusetts

[b] University of Massachusetts Medical School, Worcester, Massachusetts

[c] Department of Population and Quantitative Health Sciences, University of Massachusetts Medical School, Worcester, Massachusetts

[d] Department of Obstetrics and Gynecology, Pediatrics and Psychiatry, University of Massachusetts Medical School, Worcester, Massachusetts

[e] Department of Family Medicine and Community Health, University of Massachusetts Medical School, Worcester, Massachusetts

[f] Division of General Medicine, Beth Israel Deaconess Medical Center/Harvard Medical School, Boston, Massachusetts

Correspondence:

Lara C Kovell, MD

University of Massachusetts Medical School

55 Lake Avenue North, Worcester, MA 01655

Telephone: (508) 856-2722

Fax: (774) 441-7657

Email: lara.kovell@umassmemorial.org

ABSTRACT

Background: Hypertension in pregnancy is a leading cause of maternal morbidity and mortality in the United States. Although the Dietary Approaches to Stop Hypertension (DASH) diet is recommended for all adults with hypertension, rates of DASH adherence and anti-hypertensive medications use in women of child-bearing age is unknown.

Objectives: To determine DASH adherence and anti-hypertensive medication use in women of child-bearing age.

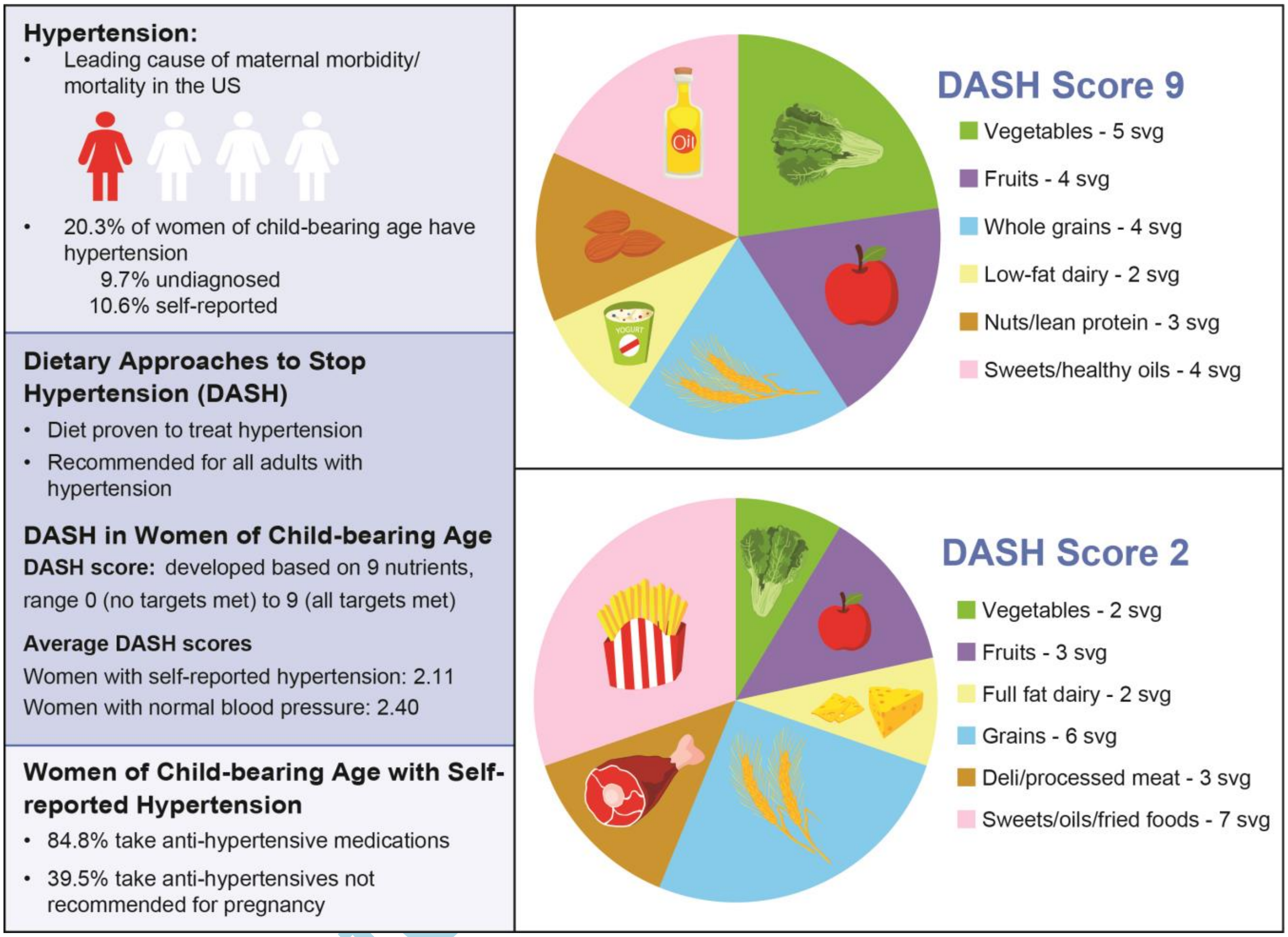
Methods: In the National Health and Nutrition Examination Surveys from 2001-2016, we estimated DASH adherence among women of child-bearing age (20-50 years). We derived a DASH score (0-9) based on 9 nutrients, with DASH adherence defined as DASH score ≥4.5. Hypertension was defined by blood pressure (BP) ≥130/80 mm Hg or anti-hypertensive medication use. DASH scores were compared across BP categories and anti-hypertensive medication use was categorized.

Results: Of the 7782 women, the mean age (SE) was 32.8 (0.2) years, 21.4% were non-Hispanic Black, and 20.3% had hypertension. The mean DASH score was 2.11 (0.06) for women with self-reported hypertension and 2.40 (0.03) for women with normal BP (P<0.001). DASH adherence was prevalent in 6.5% of women with self-reported hypertension compared to 10.1% of women with normal BP (P<0.05). Self-reported hypertension is predominantly managed with medications (84.8%), while DASH-adherence has not improved in these women from 2001-2016. Moreover, 39.5% of US women of child-bearing age are taking medications contraindicated in pregnancy.

Conclusions: Given the benefits of optimized BP during pregnancy, this study highlights the critical need to improve DASH adherence and guide prescribing among women of child-bearing age.

Key Words: DASH diet, anti-hypertensive therapy, women of child-bearing age, blood pressure, nutrition

Graphical abstract



Background

Hypertensive disorders of pregnancy are a leading cause of maternal morbidity and mortality in the United States (U.S.), affecting >10% of pregnancies.[1,2] Nearly 40% of maternal deaths occur in women with hypertension (HTN).[3] HTN diagnosed before pregnancy increases risk for pregnancy-related heart failure, renal failure, and stroke at least fivefold over normotensive women.[2,3] In pregnancy, HTN also affects fetal health, increasing risk for stillbirth, growth restriction, preterm birth, and congenital anomalies.[2,4] According to the definition in the 2017 American College of Cardiology (ACC) and American Heart Association (AHA) HTN guidelines, 19% of women of childbearing age have HTN.[5] Moreover, U.S. rates of HTN in pregnancy are increasing along with maternal age, obesity, diabetes, and multifetal pregnancies.[6]

Healthy blood pressure (BP) before pregnancy is important to prevent pregnancy loss, pregnancy-related hypertensive disorders, preterm birth, and high BP and obesity in offspring. Achieving healthy BP often requires both lifestyle strategies and medications. However, in pregnancy, many first-line anti-hypertensive medications are not recommended, poorly studied, or controversial safety profiles.[2,5] Furthermore, women with HTN often self-discontinue anti-hypertensive medications during pregnancy, putting themselves at risk for BP ≥ 160/110 mm Hg.[7] Therefore, lifestyle interventions remain an important strategy for BP reduction in women of child-bearing age.

One proven lifestyle strategy to reduce BP is the <u>D</u>ietary <u>A</u>pproaches to <u>S</u>top <u>H</u>ypertension (DASH) diet, a diet high in fruits, vegetables, whole grains, and lean proteins, while low in red meats, sweets, and saturated fat.[8] A recent meta-analysis showed that DASH decreased preeclampsia, macrosomia, and glucose levels in women with cardiometabolic disorders including HTN.[9] The long-term benefits of DASH adherence are lower risk of coronary heart disease and stroke in the 24-year follow-up of the Nurses' Health Study.[10] Though the DASH diet is safe and effective before and during pregnancy, the degree to which women of child-bearing aging in the U.S. follow the DASH diet is unknown.

We studied nationally representative data from U.S. women of child-bearing age to determine: 1) DASH adherence, 2) use of anti-hypertensive medications, and 3) trends in diet and medication use between 2001 and 2016.

Methods

Study Population

The National Health and Nutrition Examination Surveys (NHANES) are cross-sectional surveys of the health and dietary habits of the United States population. The study population was recruited from U.S. communities using a complex, multistage sampling design to collect data representative of U.S. age, sex, and racial/ethnic distribution.[11] All procedures were approved by the National Center for Health Statistics (NCHS) Research Ethics Review Board, and all participants provided written informed consent.[11] We used the dietary recalls, physical examinations, and laboratory measurements from NHANES surveys (2001-2016) from women of child-bearing age (20-50 years of age). Women currently pregnant, post-menopause or post-hysterectomy, without a valid 24-hour dietary recall, or with energy intakes ≤ 600 kcal or ≥ 4800 kcal were excluded from the main analysis (N = 2763).

Hypertension

BP was measured up to 4 times for each participant. If more than 1 BP was obtained, the first measurement was excluded, and the remaining measurements were averaged. HTN was defined based on the 2017 ACC/AHA HTN guidelines by systolic BP (SBP) ≥ 130 mm Hg or diastolic BP (DBP) ≥ 80 mm Hg or anti-hypertensive medication use.[5] The following BP categories were used: 1) **Normal BP**: SBP < 120 mm Hg and DBP < 80 mm Hg, 2) **Elevated BP**: SBP 120-129 mm Hg and DBP < 80 mm Hg, and 3) **Undiagnosed HTN**: SBP ≥ 130 mm Hg or DBP ≥ 80 mm Hg and no self-reported HTN diagnosis.[5] **Self-reported HTN** required an affirmative response to the question "Have you ever been told by a doctor or other health professional that you had hypertension, also called high BP?" and SBP ≥ 130, DBP ≥ 80 mm Hg, or an answer of "yes" to the question "Because of your high BP, have you ever been told to take prescribed medicine?”. We defined self-reported HTN as a separate category with the BP threshold for women not on medications to avoid including gestational HTN and to isolate changes in behavior following a diagnosis of HTN.[2,12]

Other Covariates

Age, sex, and race/ethnicity information were collected from all participants. Body mass index (BMI) was derived from height and weight, and waist circumference was measured. Socioeconomic factors examined were poverty-income-ratio (PIR), health insurance, and education level. Smoking status was categorized by never, former, or current. Current alcohol use was determined by dietary recall report. Gravidity was based on number of prior pregnancies, and parity number of live births.

Evaluation of Dietary Intake/DASH Score

Nutrition status was evaluated using 24-hour recalls administered by trained interviewers in which participants reported all food and beverages consumed using a multiple-pass recall method (2001), that changed to an automated fully computerized method in 2002.[11] Starting in 2003, a second 24-hour recall was conducted over the phone 3-10 days later.[11] For those with 2 reliable recalls, the recalls were averaged. In order to assess diet quality, we adapted the DASH score of Mellen et al. based on 9 target nutrients (total fat, saturated fat, protein, fiber, cholesterol, calcium, magnesium, sodium, and potassium).[12] Nutrient goals from DASH, except macronutrients, were indexed to total energy intake. The DASH score was then calculated by adding all of the nutrient goals attained (range 0-9), with a higher score indicating better adherence to the DASH diet. A score of 0.5 corresponded to individual nutrient intakes exceeding the intermediate goal between the DASH diet and DASH control diet.[12] DASH adherence was defined as a DASH score ≥ 4.5. Pregnant women (N = 1064), stratified by the BP categories above, were included in a supplemental analysis evaluating DASH scores, energy intake, and DASH adherence.

Medication Use

Anti-hypertensive medications used in the past 30 days were determined by medication inventory during the interview for participants with self-reported HTN. The drug classes associated with each drug and ingredient were assigned based on the Multum Lexicon Plus drug database.[13] We grouped medications in the following categories: angiotensin converting enzyme (ACE) inhibitors or angiotensin II receptor antagonists (ARBs), beta-adrenergic blocking agents (beta-blockers), calcium-channel blockers (CCBs), diuretics, methyldopa, and mineralocorticoid receptor antagonists. Use of anti-hypertensive medications was compared between those with controlled and uncontrolled HTN. Medications not recommended in pregnancy included ACE inhibitors/ARBs, mineralocorticoid receptor antagonists, and atenolol.[2,5]

Diet and Medication Use Trends

To evaluate the diet of women by BP category over time, we compared DASH scores and sodium intake of NHANES participants in 4-time periods (2001-04, 2005-08, 2009-12, and 2013-16). Trends in HTN prevalence, dietary habits, and HTN risk factors were compared across 4-year intervals from 2001-16.

Statistical Analysis

All analyses were performed using the sample weights, primary sampling units, and strata recommended by the NCHS to account for the NHANES complex sampling design. Standard errors were determined for all metrics using the Taylor series (linearization) method. DASH scores (range 0-9) and individual nutrient intakes were compared among participants by BP category with normal BP as the reference, and *P-values* reported for paired comparisons to normal BP. Multivariable logistic regression was used to model the odds of a DASH-adherent diet defined as a DASH score ≥ 4.5. The logistic regression model was adjusted for age, caloric intake, ethnicity, education, and poverty income ratio.

Analyses were performed with Statistical Analysis System software (v.9.4 SAS Institute, Cary, NC, U.S.). The significance level was set at $P < 0.05$, and all test hypotheses were two-sided.

Results

Of the 7782 women of child-bearing age included, the mean age (SE) was 32.8 (0.2) years, 21.4% were non-Hispanic Black, and 28.7% were Hispanic (**Table 1**). The prevalence of self-reported HTN in women of child-bearing age was 10.6% and undiagnosed HTN was 9.7%, giving an overall HTN prevalence of 20.3%. Compared to women with normal BP, women with self-reported HTN were older with higher rates of current smoking, diabetes, and non-private insurance ($P < 0.05$). A greater proportion of non-Hispanic Black women had self-reported HTN compared to normal BP (39.5% vs. 17.7%, $P < 0.05$), while a smaller proportion of Mexican or other Hispanic women had self-reported HTN compared to normal BP. Waist circumference and BMI were also higher in the women with self-reported HTN compared to those with normal BP ($P < 0.05$), with only 15.1% of women with self-reported HTN in the BMI < 25.0 kg/m^2 category.

Evaluation of Dietary Intake/DASH Score

Mean (SE) DASH scores (DASH as reference diet = 9) ranged from 2.11 (0.06) in women with self-reported HTN to 2.40 (0.03) in those with normal BP ($P < 0.001$), (**Table 2**). Fiber, magnesium, calcium, and potassium intake levels were lower in women with self-reported HTN compared to women with normal BP, while cholesterol and sodium intake were higher. Specifically, 88.7% of women with HTN exceeded the AHA recommended 2300 mg sodium/day. Furthermore, 6.5% of women with self-reported HTN were DASH-adherent compared to 10.1% of the normal BP group ($P < 0.05$). DASH scores and adherence were similar in pregnant women and there was no evidence of a difference by BP category (**Supplemental Table 1**). Hispanic ethnicity was associated with higher odds of DASH adherence compared to whites (OR 2.2, 95% CI: 1.1-5.2) (**Figure 1**), while age, income, education, and cardiovascular disease were not associated with DASH adherence.

Medication Use

For women with self-reported HTN, 87.2% with controlled HTN reported taking an anti-hypertensive medication (**Table 3**). ACE inhibitors/ARBs were the most common drug category used, and more women with controlled HTN used ACE inhibitors/ARBs, labetalol, and mineralocorticoid receptor antagonists for BP control compared to those with uncontrolled HTN ($P < 0.001$). Among all women of child-bearing age with self-reported HTN, 2.9% used first-line anti-hypertensive medications for pregnancy (labetalol, nifedipine, or methyldopa), while 39.5% used medications not recommended in pregnancy.

Diet and Medication Use Trends

Sodium intake and DASH adherence did not change from 2001-16 among women with self-reported HTN (**Figure 2**). Mean DASH scores did not improve in all women of child-bearing age or women with self-reported HTN from 2001-16 (**Table 4 and 5**). In all women of child-bearing age, mean daily sodium intake increased from 1601 mg/1000 kcal to 1709 mg/1000 kcal (*P-trend* < 0.001). With regards to BP trends, HTN prevalence decreased from 22.5% in 2001-04 to 18.4% in 2013-16, driven by a decline in undiagnosed HTN from 12.5% to 7.7% (**Table 4**).

Discussion

We undertook this study of HTN in U.S. women of child-bearing age to investigate DASH adherence, anti-hypertensive medication use, and trends in diet and medication use from 2001-16. Our principal findings are that one in five U.S. women of child-bearing age has HTN and fewer than 10% consume diets adherent with the DASH diet, despite national guidelines recommending DASH for all adults with HTN. DASH scores were low across all women of child-bearing age and pregnant women. From 2001 to 2016, no improvement was seen in DASH scores while sodium intake has risen. DASH adherence was associated with Hispanic race compared to white women, and higher in women with normal BP compared to those with self-reported HTN. There is a high prevalence of medical treatment despite low DASH adherence, with nearly 40% of women with self-reported HTN on anti-hypertensive medications not recommended in pregnancy. These findings highlight 1) tremendous gaps between the HTN guidelines and actual diet quality and 2) the need for a stepwise algorithm to guide anti-hypertensive therapy in women of child-bearing age with HTN.

HTN is a major risk factor for pregnancy complications, maternal mortality, and cardiovascular disease. While prior NHANES studies have also reported no change in self-reported HTN in women of child-bearing age over earlier NHANES cycles,[14] rates of HTN in pregnancy have increased over the past 4 decades with advancing maternal age and risk factors for cardiovascular disease.[6] Declining rates of undiagnosed HTN suggest increased awareness of the diagnosis in women of child-bearing age. Despite this awareness, Muntner et al. recently reported a decline in BP control in women with HTN of 13.6% from 2013-14 to 2017-18, compared to a 7% decline in men.[15] Another reason to target lifestyle changes for BP control is that women are more likely than men to have low adherence to anti-hypertensive medications, and low adherence is more common in younger age groups.[16]

DASH scores have not improved over time and sodium intake is rising in all women of child-bearing age. HTN is a common co-morbid disease with obesity, gestational diabetes, and diabetes, and the increasing prevalence of these cardiovascular risk factors in pregnant women parallels the increasing maternal mortality in the US. Black women are at higher risk for developing HTN than all other races both during pregnancy and child-bearing years, which contributes to higher rates of maternal morbidity and mortality in Black women.[6,17] Other studies also suggest higher diet quality and lower prevalence of HTN risk factors in Hispanic women prior to pregnancy, which supports our findings in Hispanic women.[18,19] Of note, DASH scores were modestly lower among women with HTN; however, these scores did not vary as much as other population characteristics (e.g., age or BMI), suggesting that DASH adherence is not sole contributor to HTN.

Several dietary interventions and supplements are proven to reduce BP in adults, including the DASH diet, sodium reduction, fruits/vegetables, plant-based protein, calcium, potassium, and magnesium.[5,20–23] Despite this evidence, the majority of women of child-bearing age and adults with HTN have sub-optimal DASH scores and low intake of micronutrients central to DASH (calcium, potassium, and magnesium).[12] Healthy diet patterns have been shown to reduce pregnancy complications and can affect multiple generations, as the diet of a young child is most commonly determined by the mother.[24,25] In pregnancy, the DASH diet,[9,26–28] increasing protein,[24] limiting carbohydrates (especially ultra-processed foods),[29] and calcium supplementation[30] are safe, reduce hypertensive disorders, and limit weight gain. Other diets, like the Mediterranean diet, also help to limit weight gain and risk for gestational diabetes, but have not been shown to reduce hypertensive disorders of pregnancy.[31]

We suspect that the reasons for poor DASH adherence in women of child-bearing age with HTN are multifactorial. While education, access to healthy food, and poverty could contribute to poor uptake of DASH, we did not find an association between education or poverty and DASH adherence. Though some diet patterns are expensive and difficult to achieve, the DASH diet was developed using commonly consumed food items to allow implementation among the general public.[20] Other barriers to DASH include conflicting dietary recommendations, pervasive unhealthy food advertising, and voluntary instead of mandatory industry food targets.[12,32] The low uptake of the DASH diet may also be due to low rates (<35%) of nutrition counseling and behavior modification strategies proven to lower BP for women with HTN.[33,34] Future studies should target diet screening and new implementation strategies to improve DASH adherence in women of child-bearing age.

Despite low DASH adherence, the majority of women of child-bearing age with self-reported HTN are taking anti-hypertensive medications, with nearly half of these medications not recommended in pregnancy. While these medications are not contraindicated in women of child-bearing age, their use requires counseling on fetal effects, close monitoring, and pre-conception planning. Although rates of unintended pregnancy in the United States are declining, 45% of pregnancies are still unintended.[35] Both the ACC/AHA and American College of Obstetricians and Gynecologists (ACOG) recommend nifedipine or labetalol as first-line treatment for women with HTN who are pregnant or planning pregnancy, while ACC/AHA also includes methyldopa.[2,5] The second ACC/AHA recommendation is to avoid ACE inhibitors/ARBs during pregnancy because of teratogenicity.[5] While CCBs like nifedipine are a first-line treatment for HTN, beta-blockers like labetalol are not first-line and have varying efficacy in different racial groups.[5,36] With very few women of child-bearing age on first-line medications for pregnancy, close monitoring and medication titration are often needed pre-conception. This highlights the importance of all health practitioners discussing pregnancy plans and contraception when managing HTN, to allow use of first-line anti-hypertensive medications and to avoid teratogens if considering pregnancy. With the aging maternal population, future HTN guidelines should develop a stepwise algorithm to guide anti-hypertensive therapy in women of child-bearing age and pregnant women of all races to decrease disparities in treatment.

There are some important limitations to this study that warrant discussion. First, our data are taken from 24-hour dietary recalls, which are subject to recall bias, underestimates of total energy and sodium intake, and are less valid in the absence of repeated measures.[37] As a result, DASH adherence was likely lower than reported here.[38] However, the 24-hour recall approach has been validated and can be applied to diverse groups with varied food intake.[38] These 24-hour recall surveys were consistent across the time periods of NHANES, administered by trained interviewers, and have been used by the Centers for Disease Control and Prevention to track dietary trends over time.[39] We also utilize self-report of a health professional to identify self-reported HTN, which may underestimate the prevalence of HTN given changing clinical definitions over time. While the DASH diet was not intended for weight loss, unhealthy diet often results in weight gain. This is evident in the higher BMI values observed among women with HTN. As a result, we are unable to isolate DASH from excess Calorie intake in this cross-sectional study. Another limitation is that medication use in women of child-bearing age was evaluated not knowing their plans for pregnancy. Finally, residual confounding and reverse causality is a concern with observational studies and participants altering reporting after knowing their BP was elevated.

Despite these limitations, our study has several notable strengths. The complex sampling design of NHANES minimizes selection bias, allowing for estimates of disease prevalence in the general U.S. population and trends over time. Additionally, the NHANES' comprehensive data assessments allow for a thorough examination of disease prevalence, risk factors, diet, and socioeconomic characteristics of the study participants.

This study has important public health implications. While recommended for all people with HTN, very few women of child-bearing age with HTN adhere to DASH, a diet proven to lower BP. Furthermore, many of these women with HTN are on anti-hypertensive medications not recommended in pregnancy and unintentional pregnancy is common in the U.S. While dietary counseling improves diet quality,[40] fewer than 1 in 3 women receive nutrition counseling to improve their diets. With so many downstream effects on maternal, fetal, and child health, pre-conception is a critical time to have women evaluate their diet and improve cardiovascular risk factors to improve BP control. These findings should mobilize primary care, obstetric, family medicine, and cardiology practitioners to screen all women with HTN for poor diet, counsel on the benefits of healthy diet, and refer to nutritionists with expertise in lifestyle interventions to reduce future risk of cardiovascular disease.[41]

Conclusions

HTN is common in women of child-bearing age in the U.S., a population with high utilization of anti-hypertensive medications but poor adherence to the DASH diet. Given the known benefits of the DASH diet and optimized BP during pregnancy, this study highlights the critical need for further efforts to improve DASH adherence among U.S. women of child-bearing age.

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Figure Legends:

Figure 1. Adjusted odds of DASH-adherent diet among U.S. women of child-bearing age with self-reported hypertension from NHANES, 2001-2016. Logistic regression model adjusted for age, caloric intake, ethnicity, education, and poverty income ratio. Reference groups for exposure variables include no cardiovascular disease, no diabetes mellitus, poverty income ratio ≤ 1.85, body mass index (BMI) < 30, race – white (compared to Other, Non-Hispanic Black, and All Hispanic), education level ≤ high school education, and age 20-34 years. Cardiovascular disease was defined by prior stroke, congestive heart failure, and coronary artery disease.

Figure 2: **Trends in dietary intake by blood pressure category among women of child-bearing age from NHANES 2001-2016. A)** DASH Adherence, which did not significantly change in any of the blood pressure (BP) categories from 2001-04 to 2013-16; **B)** Mean Sodium Intake, which increased in women with normal blood pressure ($P < 0.001$), elevated blood pressure ($P < 0.05$) and undiagnosed hypertension (HTN, $P < 0.001$) from 2001-04 to 2013-16. No significant change was seen in women with self-reported hypertension.

Table 1. Demographic characteristics of women of child-bearing age in NHANES 2001-2016 by blood pressure status*

	All (N = 7782)	Normal BP (N = 5624, 72.3%)	Elevated BP (N = 577, 7.4%)	Undiagnosed Hypertension (N = 757, 9.7%)	Self-reported Hypertension (N = 824, 10.6%)
U.S. population ‡	44,962,105	32,611,906	3,399,890	4,493,706	4,456,603
Age (yr)	32.8 (0.2)	31.5 (0.2)	33.3 (0.4) †	36.7 (0.4) †	37.9 (0.3) †
20-34	57.6	64.8	54.1†	37.1 †	29.1 †
35-50	42.4	35.2	45.9	62.9	70.9
Race/Ethnicity					
Mexican American	20.0	21.7	19.7†	14.8 †	13.6 †
Other Hispanic	8.7	9.4	8.5	6.6	6.3
Non-Hispanic White	40.2	41.0	38.6	41.5	33.7
Non-Hispanic Black	21.4	17.7	25.0	27.1	39.5
Other Race	9.7	10.2	8.2	10.0	6.9
Education level					
≤ High School	40.4	39.6	39.7	41.3	45.5 †
> High School	59.6	60.4	60.3	58.7	54.5
Insurance coverage	64.5	63.6	67.1	66.2	67.1
Private Insurance	52.7	52.5	57.0	56.3	48.3
Medicare	0.5	0.3	0.5	0.6	1.6†
Medicaid/CHIP	11.3	10.8	9.5	9.3	17.2 †
Poverty income ratio					
≤1.85	45.7	45.4	44.9	42.1	52.2†
>1.85	48.1	48.4	50.2	51.2	42.0
BMI (kg/m^2)	28.1 (0.1)	26.8 (0.1)	30.4 (0.4) †	30.7 (0.4) †	34.1 (0.3) †
<25.0	38.3	44.1	26.7 †	29.2 †	15.1 †
25-29.9	25.3	27.0	24.8	21.4	17.6
≥30.0	36.1	28.6	48.2	48.9	67.1
Waist circumference (cm)	92.4 (0.3)	89.3 (0.3)	97.0 (1.0) †	97.9 (0.9) †	106.3 (0.7) †
Current Alcohol	23.7	23.8	23.2	23.9	22.8
Alcohol (g/day) §	25.8 (0.7)	25.0 (0.9)	27.5 (2.6)	28.3 (2.2)	28.6 (2.4)
Smoking					
Never	67.0	68.3	67.7	66.6	57.6†

Former	11.2	10.8	12.6	10.8	13.5
Current	21.7	20.8	19.6	22.6	28.9
Hyperlipidemia ||	12.7	10.2	14.2	15.1	26.7
Diabetes	3.5	1.7	3.8†	5.1†	12.9†
Never Been Pregnant	24.3	26.1	30.4†	17.6†	13.7†
Gravidity	2.9 (0.03)	2.8 (0.04)	2.9 (0.10)	3.0 (0.09)	3.2 (0.08)
Parity ||					
0	39.2	40.4	42.7	33.5	25.5
1	16.5	17.1	13.3	14.5	17.6
≥2	44.3	41.5	43.0	52.0	56.9
Systolic BP ¶	111.9 (0.2)	106.5 (0.1)	122.9 (0.2) †	127.9 (0.6) †	126.3 (0.6) †
Diastolic BP ¶	68.9 (0.2)	65.6 (0.2)	70.5 (0.4) †	82.2 (0.3) †	77.7 (0.5) †

Abbreviations: BP, blood pressure; NHANES, National Health and Nutrition Examination Surveys; CHIP, Children's Health Insurance Program; BMI, body mass index

*Data are reported as mean percentage of subjects or mean (SE) number of indicated units. 41 women excluded for missing demographic or blood pressure data

† $P < 0.05$, reference group Normal BP

‡Based on the complex sampling design of NHANES to estimate prevalence in the U.S. population

§ Drinks per day from dietary recall for women responding yes to alcohol intake. Alcohol scored as grams of alcohol/day – g /day x 1 drink/14g = drinks/day

|| Missing data in 28.4% of women of child-bearing age for hyperlipidemia and 11.2% for parity

¶ mm Hg

Table 2: Mean daily intake and DASH scores by blood pressure status*

	DASH Diet (ref)^	Normal BP	Elevated BP	Undiagnosed Hypertension	Self-reported Hypertension
Total Energy (kcal)	§	1875 (9.6)	1950 (32) †	1905 (28)	1901 (30)
DASH diet score	9	2.40 (0.03)	2.29 (0.07)	2.21 (0.06) †	2.11 (0.06) ‡
Total Fat (% of energy)	27%	33.44 (0.15)	34.0 (0.40)	34.32 (0.30)	34.36 (0.38)
Total Fat DASH score		0.37 (0.01)	0.35 (0.02)	0.32 (0.01) †	0.34 (0.02) †
Saturated Fat (% of energy)	6%	10.90 (0.06)	11.20 (0.18)	11.33 (0.14) †	11.26 (0.15) †
Saturated Fat DASH score		0.37 (0.01)	0.33 (0.02)	0.32 (0.01) †	0.33 (0.02) †
Protein (% of energy)	18%	15.52 (0.07)	15.58 (0.20)	15.61 (0.21)	15.92 (0.22)
Protein DASH score		0.26 (0.01)	0.27 (0.02)	0.29 (0.02)	0.29 (0.02)
Cholesterol (mg/1000 kcal)	71.4	129 (1)	131 (4)	139 (4) †	143 (3) ‡
Cholesterol DASH score		0.41 (0.01)	0.39 (0.02)	0.36 (0.01)	0.33 (0.01) ‡
Fiber (g/1000 kcal)	14.8	8.2 (0.1)	7.8 (0.1) †	7.9 (0.2)	7.3 (0.2) ‡
Fiber DASH score		0.16 (0.01)	0.14 (0.01)	0.13 (0.01) †	0.11 (0.01) ‡
Magnesium (mg/1000 kcal)	238	144 (1)	142 (2) †	139 (2) †	134 (2) ‡
Magnesium DASH score		0.16 (0.005)	0.15 (0.01)	0.15 (0.01)	0.13 (0.01) †
Calcium (mg/1000 kcal)	590	468 (4)	482 (11)	457 (9) †	442 (8) †
Calcium DASH score		0.37 (0.01)	0.37 (0.02)	0.34 (0.02) †	0.31 (0.01) ‡
Sodium (mg/1000 kcal)	1095 ‖	1676 (9)	1657 (27)	1660 (21)	1700 (22) †
Sodium DASH score		0.18 (0.01)	0.18 (0.02)	0.20 (0.02)	0.19 (0.01)
Potassium (mg/1000 kcal)	2238	1274 (7)	1246 (19)	1251 (20)	1210 (18) ‡

Potassium DASH score		0.11 (0.004)	0.10 (0.01)	0.11 (0.01)	0.09 (0.01) ‡
DASH Adherence (%) ¶		10.1	7.4	6.3†	6.5†

Abbreviations: DASH, Dietary Approaches to Stop Hypertension

* Data are reported as mean (SE) percentage of total energy or mean (SE) number of indicated units

^ Published Dietary Approaches to Stop Hypertension (DASH) diet nutrients[20]

† $P < 0.05$, reference group Normal BP

‡ $P < 0.001$, reference group Normal BP

§ DASH diet was designed with four calorie levels (1600, 2100, 2600, and 3100 kcal). Specific nutrient levels listed based on 2100 kcal diet

|| Sodium target of 2300 mg/day based on 2013 AHA/ACC Lifestyle management Guideline and intermediate target of 2300 mg/day in the DASH-Sodium trial[19,40]

¶ DASH Adherence defined as DASH score ≥4.5, which represents half of the maximum score of 9

Table 3. Hypertension medication use and daily energy and sodium intake among women of child-bearing age by degree of blood pressure control*

	Self-reported Hypertension		
	All (N = 824)	**Controlled Hypertension†** (N = 616)	**Uncontrolled Hypertension†** (N = 208)
U.S. population	4,456,603	3,450,250	1,006,353
Age (y)	37.9 (0.3)	37.5 (0.36)	39.6 (0.52) ‡
Taking prescription for hypertension	84.8	87.2	77.8 ‡
Beta blocker	14.4	14.5	14.4
Atenolol ||	4.85	4.87	4.80
Labetalol	0.85	0.97	0.48 ‡
Diuretic	25.0	25.6	23.1
ACE inhibitor/ARB ||	33.6	35.5	27.9 ‡
Calcium channel blockers	11.3	10.9	12.5
Nifedipine	1.45	1.62	0.96
Methyldopa	0.48	0.49	0.48
Mineralocorticoid receptor antagonists ||	1.09	1.29	0.48 ‡
Multidrug (≥ 2 drug classes)	24.5	25.0	23.1
Energy intake (kcal)	1916 (29)	1931 (35)	1862 (46)
Sodium intake (mg/1000 kcal)	1692 (22)	1704 (26)	1653 (39)

Abbreviations: ACE: angiotensin converting enzyme; ARB: angiotensin receptor blocker; Beta-blocker: beta-adrenergic blocking agents

* Data are reported as mean percentage of subjects or mean (SE) number of indicated units

† Controlled Hypertension defined by SBP < 140 mm Hg and DBP < 90 mm Hg. Uncontrolled Hypertension defined by SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg

‡ P < 0.05

||Medications not recommended in pregnancy

Table 4: Trends in energy intake, DASH adherence, and risk factors for hypertension in women of child-bearing age from 2001-2016*

	2001-2004 (N = 1788)	**2005-2008** (N = 1928)	**2009-2012** (N = 2081)	**2013-2016** (N = 1985)	***P-value*** †
HTN prevalence	22.5	20.3	18.1	18.4	<0.001
Self-reported HTN	10.0	10.9	7.9	10.7	0.01
Undiagnosed HTN	12.5	9.4	10.2	7.7	<0.001
On prescription for HTN	7.9	9.4	6.9	8.9	0.05
Uncontrolled HTN ‡	2.29	2.74	1.80	2.07	0.32
Energy intake	1978 (17)	1862 (14)	1867 (15)	1895 (21)	<0.001
DASH Score	2.1 (0.05)	2.2 (0.04)	2.3 (0.04)	2.2 (0.03)	0.06
Sodium intake (mg/1000 kcal)	1601 (16)	1679 (15)	1710 (11)	1709 (11)	<0.001
Potassium intake (mg/1000 kcal)	1238 (14)	1257 (11)	1282 (9)	1261 (11)	0.05
BMI (kg/m^2)	27.6 (0.2)	28.0 (0.3)	28.1 (0.2)	29.0 (0.2)	0.01
Current smoking	26.1	23.4	20.7	19.5	<0.001
Hyperlipidemia	22.2	24.6	15.5	12.1	<0.001
Diabetes	2.67	3.04	2.40	3.22	0.50
Never been pregnant	26.9	27.9	34.7	34.9	<0.001
Gravidity	2.9 (0.07)	2.9 (0.06)	2.7 (0.05)	2.8 (0.07)	0.74
Parity	2.1 (0.03)	2.1 (0.04)	2.1 (0.04)	2.2 (0.04)	0.20
Systolic blood pressure §	112.3 (0.4)	112.2 (0.3)	110.8 (0.5)	112.5 (0.4)	0.05
Diastolic blood pressure §	70.0 (0.4)	68.7 (0.3)	68.3 (0.5)	68.4 (0.3)	0.08

Abbreviations: DASH, Dietary Approaches to Stop Hypertension; HTN, hypertension; BMI, body mass index

* Data are reported as mean percentage of subjects or mean (SE) number of indicated units;

† Trends compared across 4-year intervals from 2001-16, adjusted for age and race

‡ Uncontrolled HTN defined by SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg

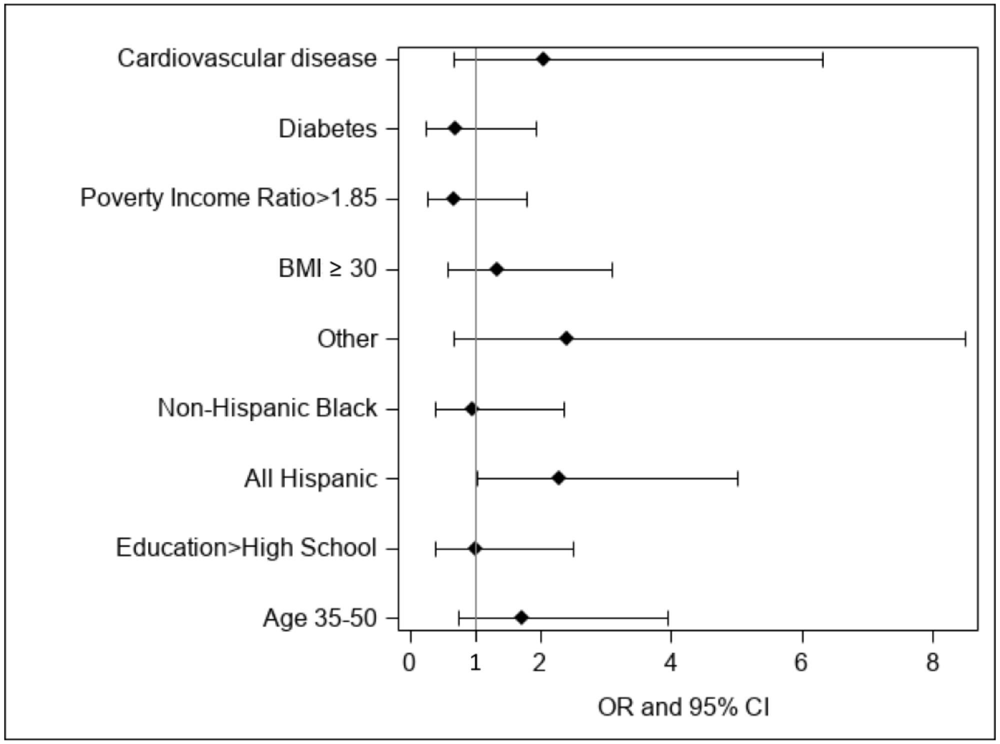
§ mm Hg

Table 5: Trends in energy intake, DASH adherence, and risk factors of women with self-reported hypertension from 2001-2016*

	2001-2004 (N = 189)	**2005-2008** (N = 219)	**2009-2012** (N = 181)	**2013-2016** (N = 235)	***P-value*†**
Energy intake (kcal)	1991 (63)	1767 (43)	1985 (69)	1949 (58)	0.006
DASH Score	1.7 (0.12)	2.2 (0.11)	1.9 (0.14)	2.0 (0.11)	0.073
Sodium intake (mg/1000 kcal)	1645 (45)	1700 (43)	1654 (31)	1738 (44)	0.36
Potassium intake (mg/1000 kcal)	1204 (36)	1239 (34)	1197 (31)	1189 (30)	0.73
BMI	33.6 (0.7)	33.5 (0.7)	35.0 (0.7)	34.8 (0.6)	0.31
BMI ≥30.0	61.4	62.5	72.4	71.9	0.18
Current smoking	28.0	30.1	32.6	25.5	0.51
Hyperlipidemia	28.0	28.7	27.1	23.4	0.02
Diabetes	12.7	14.6	12.1	13.6	0.22
Stroke	4.2	4.6	3.3	2.2	0.56
Coronary heart disease	3.2	1.3	1.1	2.1	0.49
Congestive heart failure	2.1	3.2	2.7	3.8	0.26
Never been pregnant	8.4	16.4	13.2	15.7	0.28
Gravidity	2.9 (0.15)	3.3 (0.18)	2.8 (0.19)	3.6 (0.19)	0.02
Parity	2.1 (0.10)	2.3 (0.10)	2.1 (0.14)	2.5 (0.11)	0.08
Systolic blood pressure (mm Hg)	128.8 (1.3)	125.6 (1.2)	126.2 (1.3)	126.7 (1.2)	0.88
Diastolic blood pressure (mm Hg)	79.3 (0.9)	76.8 (0.8)	78.1 (1.1)	77.1 (0.9)	0.22

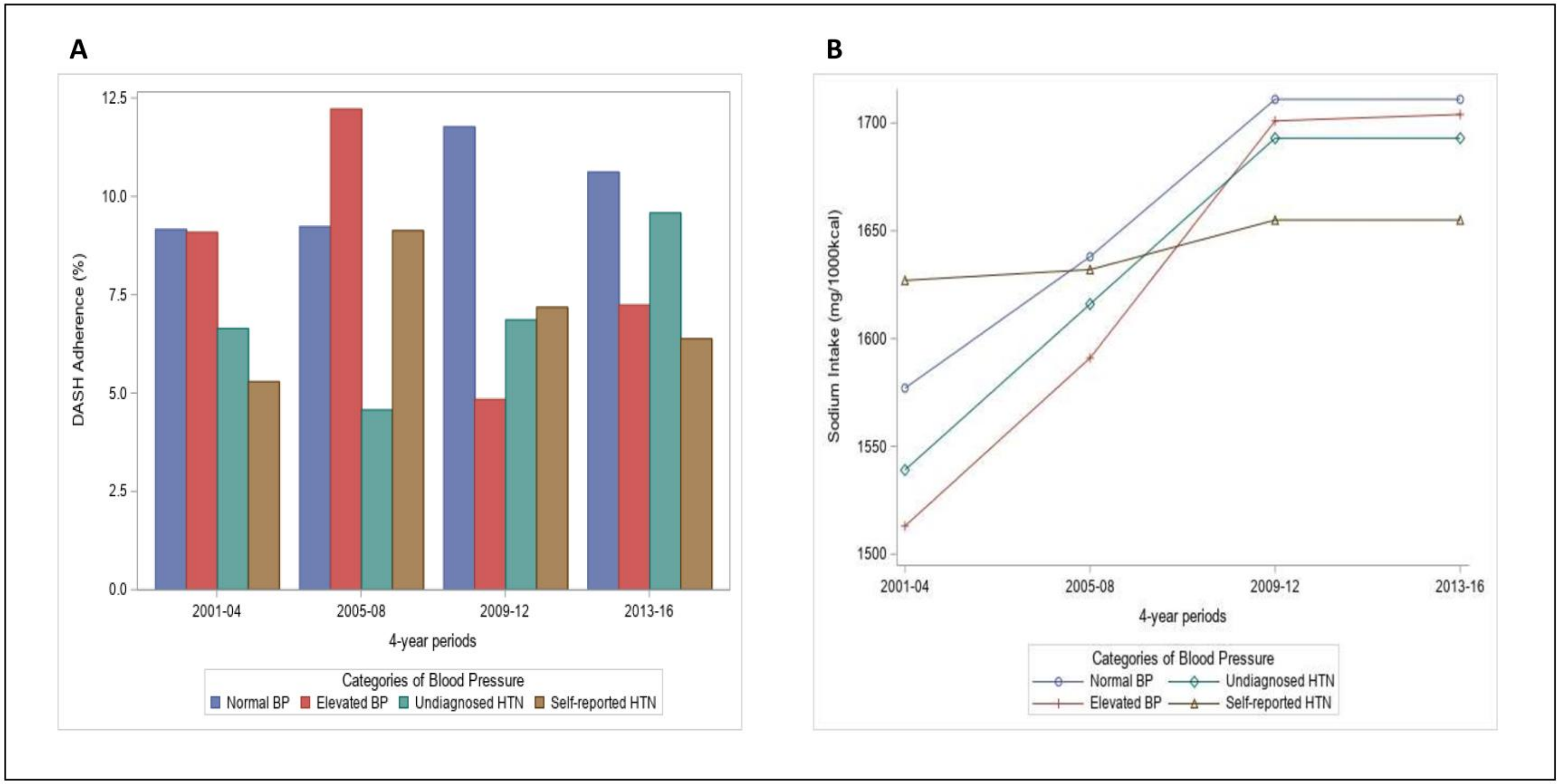
Abbreviations: DASH, Dietary Approaches to Stop Hypertension; BMI, body mass index
* Data are reported as percentage of subjects or mean (SE) number of indicated units
† Trends compared across 4-year intervals from 2001-16, adjusted for age and race

Figure 1



Cardiovascular disease
Diabetes
Poverty Income Ratio>1.85
BMI ≥ 30
Other
Non-Hispanic Black
All Hispanic
Education>High School
Age 35-50
0
1
2
4
6
8
OR and 95% CI

Figure 2



A
B
12.5
10.0
7.5
5.0
2.5
0.0
DASH Adherence (%)
2001-04
2005-08
2009-12
2013-16
4-year periods
Categories of Blood Pressure
Normal BP
Elevated BP
Undiagnosed HTN
Self-reported HTN
1700
1650
1600
1550
1500
Sodium Intake (mg/1000kcal)
2001-04
2005-08
2009-12
2013-16
4-year periods
Categories of Blood Pressure
Normal BP
Undiagnosed HTN
Elevated BP
Self-reported HTN