Predicted cardiovascular risk for US adults with diabetes, chronic kidney disease, and ≥ 65 years of age

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1

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ABSTRACT

Background: The 2017 American College of Cardiology/American Heart Association blood pressure (BP) guideline recommends using 10-year predicted atherosclerotic cardiovascular disease (ASCVD) risk to guide decisions to initiate antihypertensive medication.

Objectives: Determine if the majority of US adults in subgroups defined by diabetes, chronic kidney disease (CKD), and age ≥65 years have high ASCVD risk (i.e., 10-year predicted ASCVD risk ≥10% or clinical CVD), and estimate the age-adjusted probability of having high ASCVD risk.

Methods: Adults aged 40-79 years from the National Health and Nutrition Examination Survey 2013-2018 were included (n=8,803). We predicted 10-year ASCVD risk using the Pooled Cohort risk equations and clinical CVD was self-reported. Analyses were conducted overall and among those with stage 1 hypertension, defined by systolic BP of 130-139 mm Hg or diastolic BP of 80-89 mm Hg.

Results: Among US adults, an estimated 72.3%, 64.5%, and 83.9% of those with diabetes, CKD, and age ≥65 years had high ASCVD risk, respectively. Among US adults with stage 1 hypertension, an estimated 55.0%, 36.7%, and 72.6% of those with diabetes, CKD, and age ≥65 years had high ASCVD risk, respectively. The probability of having high ASCVD risk increased with age and exceeded 50% for US adults with diabetes and CKD at ages 52 and 57 years, respectively. For those with stage 1 hypertension, these ages were 55 and 64, respectively.

Conclusions: Most US adults with diabetes, CKD, or age ≥65 years had high ASCVD risk. However, many with stage 1 hypertension did not.

3

ABBREVIATIONS

CVD = cardiovascular disease

ASCVD = atherosclerotic cardiovascular disease

ACC/AHA = American College of Cardiology and the American Heart Association

BP = blood pressure

SBP = systolic blood pressure

DBP = diastolic blood pressure

CKD = chronic kidney disease

NHANES = National Health and Nutrition Examination Survey

CI = confidence interval

CONDENSED ABSTRACT

The 2017 American College of Cardiology/American Heart Association blood pressure (BP) guideline recommends using atherosclerotic cardiovascular disease (ASCVD) risk to guide decisions to initiate antihypertensive medication. Using National Health and Nutrition Examination Survey 2013-2018 data, it was estimated that 55.0%, 36.7%, and 72.6% of US adults with stage 1 hypertension and diabetes, chronic kidney disease and age ≥65 years had high ASCVD risk defined by 10-year predicted ASCVD risk ≥10% or clinical CVD. Predicted 10-year ASCVD risk should be calculated for all adults with stage 1 hypertension and without clinical CVD as many are not at high risk for ASCVD.

Central Illustration

Distribution of US adults by blood pressure and antihypertensive medication use categories. In pie charts, the proportion of adults with stage 1 hypertension at high atherosclerotic cardiovascular disease risk in subgroups defined by diabetes, chronic kidney disease and age ≥ 65 years.
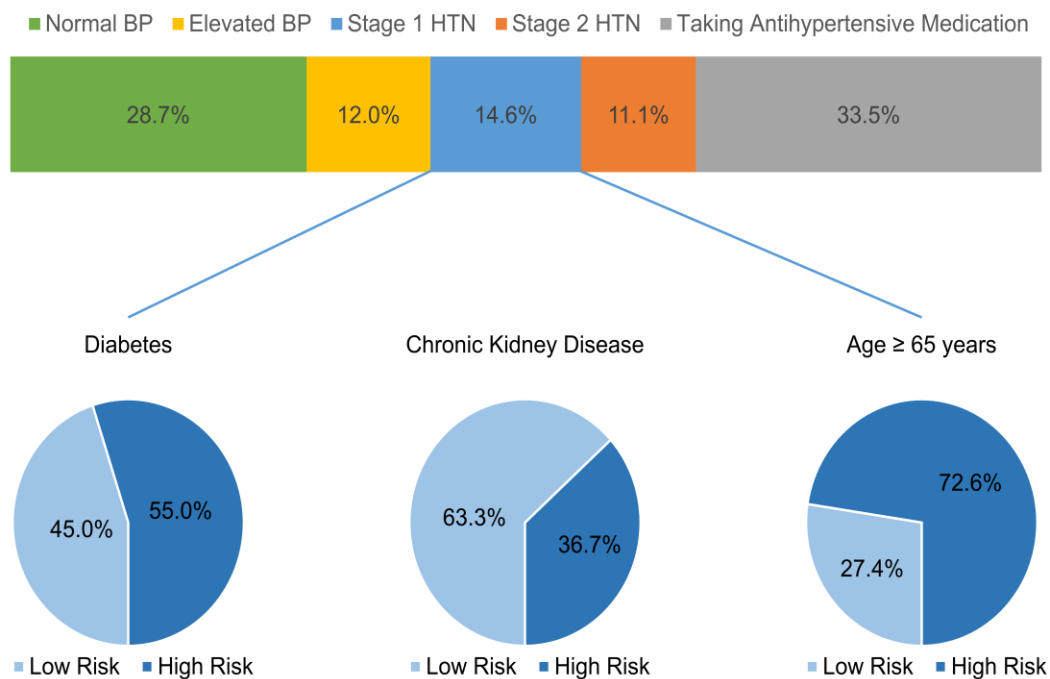
High atherosclerotic cardiovascular disease risk was defined by a 10-year predicted risk for atherosclerotic cardiovascular disease ≥ 10% or clinical cardiovascular disease.

Data are from the National Health and Nutrition Examination Survey, 2013-2018.

BP = blood pressure; HTN = hypertension

Clinical Perspectives:

Competency in Medical Knowledge: The 2017 American College of Cardiology/American Heart Association blood pressure guideline recommends using both blood pressure and atherosclerotic cardiovascular disease (ASCVD) risk to guide decisions to initiate antihypertensive medication.

Competency in Patient Care: The guideline recommends computing 10-year predicted ASCVD risk for all adults with hypertension who do not have clinical CVD.

Translational Outlook: Predicted 10-year ASCVD risk should be computed for all adults with stage 1 hypertension and without clinical CVD, as many are not at high risk for ASCVD.

INTRODUCTION

In November 2017, the American College of Cardiology and the American Heart Association (ACC/AHA) published a guideline for the prevention, detection, evaluation, and management of high blood pressure (BP) in adults (1). This guideline recommends using both BP levels and predicted risk for cardiovascular disease (CVD) to guide the initiation of antihypertensive medication in addition to nonpharmacological therapy. Initiation of antihypertensive medication is recommended for all adults with a confirmed average systolic BP (SBP) ≥ 140 mm Hg or diastolic BP (DBP) ≥ 90 mm Hg, stage 2 hypertension in the guideline. Initiation of antihypertensive medication is also recommended for adults with clinical CVD or a 10-year risk of atherosclerotic CVD (ASCVD) events ≥ 10% who have a confirmed average SBP between 130 and 139 mm Hg and/or DBP between 80 and 89 mm Hg, stage 1 hypertension in the guideline (2). Additionally, as a matter of practical convenience, adults with stage 1 hypertension and diabetes mellitus, chronic kidney disease (CKD), or ≥ 65 years of age are considered to have high CVD risk by the guideline and initiation of antihypertensive medication is recommended. This recommendation, written in Sections 9.3, 9.6, and 10.3 of the guideline, was based on the assumption that the vast majority of adults with diabetes, CKD, or ≥ 65 years of age are likely to have a 10-year predicted ASCVD risk ≥ 10% and the knowledge that surveys suggest most clinicians, including cardiologists, do not assess CVD risk using recommended risk prediction tools (1, 3).

The goal of the current analysis was to estimate the proportion of US adults with diabetes, CKD, or ≥ 65 years of age that have high ASCVD risk (defined by 10-year predicted risk for ASCVD ≥ 10% or clinical CVD). This analysis was conducted for all US adults and among those with stage

9

1 hypertension. To accomplish this goal, we analyzed data from 3 cycles of the US National

Health and Nutrition Examination Survey (NHANES).

METHODS

NHANES was designed to assess the health and nutritional status of the non-institutionalized US

population and was conducted by the National Center for Health Statistics of the Centers for

Disease Control and Prevention (4). Since 1999-2000, NHANES has been conducted in two-year

cycles using a multistage probability sampling design to select participants. Each cycle is

independent with different participants recruited. For the current analysis, the 3 cycles conducted

in 2013-2014, 2015-2016, and 2017-2018 were combined (5). Written informed consent was

obtained from each participant. The University of Alabama at Birmingham Institutional Review

Board considered the analysis of NHANES data to be exempt research.

The current analysis was restricted to adults aged 40 to 79 years of age who completed the

NHANES interview and examination (n = 9,937). Participants < 40 or > 79 years of age were not

included because use of the Pooled Cohort risk equations is not recommended in these age

ranges (2). Participants who did not have three SBP and DBP measurements (n = 565) and those

who were missing information on age, race, sex, total and high-density lipoprotein cholesterol,

smoking status, diabetes, or CKD status (n = 569) were excluded. After these exclusions, a total

of 8,803 participants were included in the analysis (Figure S1).

10

Data collection

Data were collected during an in-home interview and a study visit completed at a mobile examination center. Standardized questionnaires were used to assess participants' age, sex, race/ethnicity, smoking habits, medical history, use of antihypertensive medication, oral glucose lowering medication, and insulin. The medical history assessment included questions about whether the participant had been told by a doctor or other health professional that they had a heart attack, coronary heart disease, stroke, or heart failure. Clinical CVD was defined as answering yes to at least one of these questions.

Blood and urine samples were collected during the medical examination. Serum creatinine, serum glucose and glycated hemoglobin were measured using standard methods. Diabetes was defined by fasting plasma glucose ≥ 126 mg/dL (≥ 200 mg/dL for those who were not fasting), glycated hemoglobin ≥ 6.5%, or self-reported use of insulin or oral glucose lowering medication. Estimated glomerular filtration rate was calculated using the CKD Epidemiology Collaboration equation (6, 7). Urinary albumin and creatinine levels were measured and used to calculate the albumin-to-creatinine ratio. CKD was defined by an estimated glomerular filtration rate < 60 ml/min/1.73m^2 or an albumin-to-creatinine ratio ≥ 30 mg/g. Ten-year predicted ASCVD risk was calculated using the Pooled Cohort risk equations for participants without clinical CVD (2, 8). High ASCVD risk was defined as having a 10-year predicted ASCVD risk ≥ 10% or clinical CVD.

11

Blood pressure measurements

The same protocol was followed to measure SBP and DBP in each NHANES cycle. After survey participants had rested 5 minutes, their BP was measured by a trained physician using a mercury sphygmomanometer and an appropriately sized cuff. Three BP measurements were obtained at 30 second intervals. The mean of all three measurements was used to define SBP and DBP. Quality control included re-certification of physicians every quarter with retraining if needed. All physicians participated in annual retraining.

Blood pressure and antihypertensive medication use categories

Participants not taking antihypertensive medication were grouped into four non-overlapping categories based on the 2017 ACC/AHA BP guideline: normal BP (SBP < 120 mm Hg and DBP < 80 mm Hg), elevated BP (SBP between 120 and 129 mm Hg and DBP < 80 mm Hg), stage 1 hypertension (SBP between 130 and 139 mm Hg or DBP between 80 and 89 mm Hg with SBP < 140 mm Hg and DBP < 90 mm Hg), stage 2 hypertension (SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg). Participants taking antihypertensive medication were placed in a fifth category.

Statistical analysis

Analyses were conducted for the overall population and among participants with diabetes, CKD, ≥ 65 years of age, and for those with any of these three characteristics. Participant characteristics were summarized as mean with its standard error for continuous variables and percentage for categorical variables. The percentage of US adults in each of the five categories based on BP and antihypertensive medication use was computed. The 25th, 50th, and 75th percentile of 10-year

12

predicted ASCVD risk and the proportion of participants with high ASCVD risk were estimated

for the overall population and within each of the five categories based on BP and

antihypertensive medication use. To assess the extent to which participants with a 10-year

predicted ASCVD risk < 10% were close to the 10% threshold, we estimated the distribution of

10-year predicted ASCVD risk. The probability of having high ASCVD risk was estimated for

each year of age from 40 to 79 years using logistic regression. Analyses of participant

characteristics, the distribution of 10-year predicted ASCVD risk, and the probability of having

high ASCVD risk were repeated among participants with stage 1 hypertension.

NHANES sampling weights, which were calculated as the inverse probability of being selected

for the survey, were used in all calculations to obtain nationally representative estimates of the

non-institutionalized US population. P-values were two-sided. Data analysis was conducted

using R version 4.0.2 (released June 22, 2020) along with a collection of open-source software

packages (9–12). The first author's GitHub repository (https://github.com/bcjaeger/ACC-AHA-

BP-guideline-groups) provides code to reproduce the current study.

RESULTS

Among US adults aged 40 to 79 years in 2013-2018, the estimated prevalence (95% confidence

interval [CI]) of diabetes and CKD was 17.2% (16.0%, 18.5%) and 17.2% (15.9%, 18.5%),

respectively, 25.4% (23.7%, 27.2%) were estimated to be ≥ 65 years of age, and 42.1% (40.2%,

43.9%) had diabetes, CKD, or ≥ 65 years of age (Table 1). The estimated prevalence (95% CI) of

13

stage 1 hypertension was 14.6% (13.3%, 16.1%) overall and 10.5% (8.5%, 12.8%), 8.9% (7.3%, 10.8%), 9.1% (7.5%, 10.9%), and 10.2% (8.9%, 11.8%) among those with diabetes, CKD, age ≥ 65 years, and at least one of these conditions, respectively (Table 2). Characteristics of US adults 40 to 79 years of age with stage 1 hypertension, overall and for subgroups defined by diabetes, CKD and age ≥ 65 years, are presented in Table S1.

Predicted 10-year atherosclerotic cardiovascular disease risk

Among US adults aged 40 to 79 years without clinical CVD, the estimated median (25th, 75th percentiles) 10-year predicted ASCVD risk was 5.1% (1.9%, 11.4%) in the overall population and 14.4% (7.0%, 27.3%), 11.4% (4.8%, 22.3%), 17.9% (11.2%, 27.3%), and 13.3% (6.9%, 22.0%) among those with diabetes, CKD, age ≥ 65 years, and any of these conditions, respectively (Table 3; top panel). Among those with stage 1 hypertension, the estimated median (25th, 75th percentiles) 10-year predicted ASCVD risk was 4.3% (1.9%, 8.5%) in the overall population and 8.9% (4.5%, 19.3%), 7.4% (2.8%, 12.2%), 13.7% (8.6%, 22.3%), and 9.8% (5.3%, 16.5%) for those with diabetes, CKD, age ≥ 65 years, and any of these conditions, respectively.

Among US adults aged 40 to 79 years, the estimated percentage (95% CI) with high ASCVD risk was 36.5% (34.7%, 38.5%) (Table 3; bottom panel). Among sub-groups with diabetes, CKD, age ≥ 65 years, or any of these conditions, 72.3% (69.3%, 75.4%), 64.5% (61.4%, 67.7%), 83.9% (81.7%, 86.1%), and 69.0% (66.9%, 71.2%) had high ASCVD risk, respectively. Among those with stage 1 hypertension, the estimated percentage (95% CI) with high ASCVD risk was

24.3% (20.7%, 27.9%) in the overall population and 55.0% (43.7%, 66.4%), 36.7% (26.2%, 47.2%), 72.6% (63.2%, 81.9%), and 54.4% (46.7%, 62.1%) for those with diabetes, CKD, age ≥ 65 years, or any of these conditions, respectively.

Among US adults aged 40 to 79 years without high ASCVD risk, an estimated 43.6% (95% CI: 41.4%, 45.8%) had 10-year predicted ASCVD risk < 2.5% (Figure 1). Among subgroups with diabetes, CKD, age ≥ 65 years, and any of these conditions, an estimated 19.0% (95% CI: 13.9%, 25.4%), 32.7% (95% CI: 27.2%, 38.7%), 0.0% (95% CI: 0.0%, 0.0%), and 21.2% (95% CI: 17.5%, 25.6%) had a 10-year predicted ASCVD risk < 2.5%, respectively. Among those with stage 1 hypertension, an estimated 37.7% (95% CI: 33.0%, 42.7%) had a 10-year predicted ASCVD risk < 2.5% (Figure S2). Also, 19.6% (95% CI: 9.5%, 36.0%), 30.5% (95% CI: 21.0%, 42.0%), and 0.0% (95% CI: 0.0%, 0.0%) of those with diabetes, CKD, and ≥ 65 years of age had a 10-year predicted ASCVD risk < 2.5%, respectively.

Age-specific probability of having high ASCVD risk

The estimated probability of having high ASCVD risk increased with older age and exceeded 50% at 64 years for US adults without diabetes or CKD, compared with 52 years for US adults with diabetes and 57 years for US adults with CKD (Figure 2). Among US adults with stage 1 hypertension, the age at which the estimated probability of having high ASCVD risk exceeded 50% was 65, 55, and 64 years for US adults without diabetes or CKD, with diabetes, and with CKD, respectively (Figure S3). The minimum age where the probability of high ASCVD risk

exceeded 50% was not estimated for adults ≥ 65 years of age as the probability exceeded 50% at all ages above 65 years.

DISCUSSION

In the current study, the majority of US adults aged 40 to 79 years with diabetes, CKD, age ≥ 65 years, and any of these conditions had high ASCVD risk, defined by a 10-year predicted ASCVD risk ≥ 10% or clinical CVD. Also, the majority of US adults with stage 1 hypertension who were ≥ 65 years of age had high ASCVD risk. However, a substantial proportion of US adults with stage 1 hypertension and diabetes or CKD did not have high ASCVD risk. Among US adults with CKD and without high ASCVD risk, approximately one-third had a 10-year predicted ASCVD risk < 2.5%. In contrast, over 80% of US adults aged ≥ 65 years without high ASCVD risk had a 10-year predicted ASCVD risk between 5% and 10%. The probability of having high ASCVD risk was age-dependent with over 50% of US adults with diabetes and CKD having high ASCVD risk at ages above 52 and 57 years, respectively.

The current study estimates that about 15% of US adults aged 40 to 79 years have stage 1 hypertension. The 2017 ACC/AHA BP guideline recommends computing 10-year predicted ASCVD risk for all adults with hypertension who do not have clinical CVD (1). As many adults with stage 1 hypertension and diabetes or CKD do not have 10-year predicted ASCVD risk ≥ 10%, computing 10-year predicted ASCVD risk for adults with stage 1 hypertension can inform

16

recommendations to initiate antihypertensive medication and inform patient-provider discussions on the potential benefits of treatment.

Previous studies have shown that the use of predicted ASCVD risk in addition to BP can direct antihypertensive medication to adults likely to receive the largest risk reduction benefit (13, 14). For example, in an analysis of the Reasons for Geographic and Racial Differences in Stroke study, those with stage 1 hypertension for whom initiation of antihypertensive medication was recommended versus not recommended by the 2017 ACC/AHA BP guideline were roughly 6 times more likely to experience a CVD event over 8 years of follow-up (13). Although a substantial proportion of US adults with stage 1 hypertension and diabetes or CKD did not have a high ASCVD risk in the current study, these subgroups were more likely to have high ASCVD risk compared to the overall US population with stage 1 hypertension, and may therefore still benefit from initiating antihypertensive medication.

Previous randomized trials and meta-analyses have investigated whether lower BP goals reduce incident CVD risk in patients with diabetes, CKD, or older age. A randomized trial of patients with diabetes and baseline SBP < 140 mm Hg and DBP < 90 mm Hg found lower risk of stroke among participants with more intense BP treatment goals (16). The Systolic Blood Pressure Intervention Trial compared an SBP treatment target of < 120 mm Hg to < 140 mm Hg among older adults (mean age of 68 years) without diabetes. Among participants with CKD, randomization to the lower SBP target reduced rates of major CVD events and all-cause death without evidence of effect modifications by CKD or deleterious effect on estimated glomerular

17

filtration rate or end stage renal disease (17). In the overall population, those randomized to the lower SBP target experienced lower rates of incident fatal and nonfatal major CVD events as well as all-cause mortality (18). A systematic review and meta-analysis of 123 studies with 613,815 participants found strong support for lowering SBP to < 130 mm Hg and providing antihypertensive medication to adults with diabetes, CKD, and various other comorbidities (19). Benefits associated with a SBP treatment goal of < 130 mm Hg have also been identified in several other meta-analyses (20, 21). Collectively, evidence from previous studies suggests that adults with hypertension and diabetes, CKD or ≥ 65 years of age may experience lower rates of CVD events by initiating antihypertensive medication with an SBP treatment goal of < 130 mm Hg versus < 140 mm Hg.

It has been suggested that most adults with diabetes, CKD, or ≥ 65 years of age have a 10-year predicted ASCVD risk ≥ 10% (1). Previous research has shown that diabetes, CKD, and older age are each associated with an increased risk for ASCVD events (22–25). Although the current study suggests that a high proportion of US adults with stage 1 hypertension and diabetes or CKD do not have a 10-year predicted ASCVD risk ≥ 10%, diabetes and CKD are associated with a high lifetime CVD risk (26, 27). Age-specific estimates in the current study suggest that US adults with diabetes or CKD develop high ASCVD risk at a younger age than their counterparts without these conditions. Prior studies have also found that cumulative exposure to high BP is associated with increased CVD risk (28). Therefore, for younger adults with diabetes or CKD, early initiation of antihypertensive medication may be an important step towards lowering lifetime CVD risk. Estimating lifetime CVD risk may be useful when discussing the initiation of antihypertensive medication among young and middle-aged adults with diabetes or CKD.

18

The current study has a number of strengths. The design of NHANES allows its results to be

weighted to provide results that are representative of the US population. Additionally, NHANES

data are collected following a rigorous protocol by trained study staff. BP was measured three

times following a standardized protocol. However, the results of this study should be considered

in the context of known and potential limitations. NHANES participants completed only one

visit and guidelines recommend using the mean BP averaged over 2 or more visits. In addition,

the ACC/AHA BP guideline recommends confirmation of office hypertension by measurement

of out-of-office BPs. Additionally, since only one measurement of serum creatinine and urine

albuminuria were available, CKD status may have been mis-classified in some adults. A total of

1,271 participants had stage 1 hypertension, and some subgroups of this population based on

diabetes, CKD, and ≥ 65 years of age were small.

CONCLUSIONS

While the majority of US adults with diabetes, CKD, or age ≥ 65 years had high ASCVD risk,

many with stage 1 hypertension and diabetes or CKD did not. Results from the current study

support computing 10-year predicted ASCVD risk for all adults with hypertension, as

recommended by the 2017 ACC/AHA BP guideline.

Table 1: Characteristics of US adults 40-79 years of age overall and in subgroups defined by diabetes, chronic kidney disease, and ≥ 65 years of age

Characteristic[*]	Overall N = 8,803	Sub-groups			
		Diabetes N = 2,000[†]	CKD N = 1,790[‡]	Age 65+ years N = 2,506	Diabetes, CKD, or age 65+ years N = 4,252
Age, years	56.7 (0.2)	60.3 (0.4)	62.4 (0.4)	70.6 (0.1)	64.0 (0.2)
Male	48.2	55.7	45.8	46.7	48.1
Race / ethnicity					
Non-Hispanic White	68.6	60.1	68.0	76.8	69.4
Non-Hispanic Black	10.1	13.6	12.2	7.8	10.6
Hispanic	12.6	15.9	11.8	8.3	11.6
Non-Hispanic Asian	5.2	7.0	4.6	4.5	5.1
Other Race/ethnicity - Including Multi-Racial	3.5	3.5	3.4	2.7	3.3
Current smoker	17.3	14.5	16.7	10.0	14.3
Total cholesterol, mg/dl	197.0 (0.9)	183.1 (1.8)	193.4 (1.7)	188.8 (1.3)	191.4 (1.2)
HDL-cholesterol, mg/dl	54.9 (0.4)	46.6 (0.5)	53.2 (0.7)	56.6 (0.7)	53.8 (0.5)
Systolic blood pressure, mm Hg	126.0 (0.3)	130.6 (0.6)	132.7 (0.7)	131.8 (0.6)	130.7 (0.5)
Diastolic blood pressure, mm Hg	72.8 (0.3)	71.6 (0.4)	71.8 (0.4)	68.2 (0.4)	71.0 (0.3)
Antihypertensive medication use	33.5	60.1	55.6	53.3	51.8
Diabetes	17.2	100.0	35.8	24.7	40.9
CKD	17.2	35.7	100.0	32.3	40.8
Aged 65+ years	25.4	36.5	47.9	100.0	60.4
Diabetes, chronic kidney disease, or age 65+ years	42.1	100.0	100.0	100.0	100.0
Clinical CVD[§]	10.5	22.5	22.3	21.4	18.9

[*]Table values are mean (standard error) or proportion.
[†]Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, glycated hemoglobin (HbA1c) ≥ 6.5%, or self-reported use of insulin or oral glucose lowering medication.
[‡]Chronic kidney disease is defined by an albumin-to-creatinine ratio ≥ 30 mg/g or an estimated glomerular filtration rate < 60 ml/min/1.73m²

20

		Sub-groups			
Characteristic[*]	**Overall** **N = 8,803**	**Diabetes** **N = 2,000**[†]	**CKD** **N = 1,790**[‡]	**Age 65+** **years** **N = 2,506**	**Diabetes,** **CKD, or age** **65+ years** **N = 4,252**

[§]Clinical cardiovascular disease was defined by self-report of previous heart failure, coronary heart disease, stroke, or myocardial infarction

CKD = chronic kidney disease; CVD = cardiovascular disease; HDL = high density lipoprotein

Table 2: Distribution of blood pressure categories among US adults, overall and for subgroups defined by diabetes, chronic kidney disease, and aged ≥ 65 years.

Blood pressure category[*]	Overall N = 8,803	Sub-groups			
		Diabetes N = 2,000[†]	CKD N = 1,790[‡]	Age 65+ years N = 2,506	Diabetes, CKD, or age 65+ years N = 4,252
Normal blood pressure	28.7%	12.1%	14.2%	14.9%	15.8%
Elevated blood pressure	12.0%	7.9%	7.2%	11.1%	10.3%
Stage 1 hypertension	14.6%	10.5%	8.9%	9.1%	10.2%
Stage 2 hypertension	11.1%	9.5%	14.1%	11.6%	11.7%
Taking antihypertensive medication	33.5%	60.1%	55.6%	53.3%	51.8%

[*]Normal blood pressure: systolic blood pressure < 120 mm Hg and diastolic blood pressure < 80 mm Hg;
Elevated blood pressure: systolic blood pressure from 120 to 129 mm Hg and diastolic blood pressure < 80 mm Hg;
Stage 1 hypertension: systolic blood pressure between 130 and 139 mm Hg or diastolic blood pressure between 80 and 89 mm Hg;
Stage 2 hypertension: systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg.
[†]Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, glycated hemoglobin (HbA1c) ≥ 6.5%, or self-reported use of insulin or oral glucose lowering medication.
[‡]Chronic kidney disease is defined by an albumin-to-creatinine ratio ≥ 30 mg/g or an estimated glomerular filtration rate < 60 ml/min/1.73m²
CKD = chronic kidney disease

Table 3: Median 10-year predicted risk for atherosclerotic cardiovascular disease and proportion of US adults with high atherosclerotic cardiovascular disease risk overall and for subgroups defined by diabetes, chronic kidney disease, and ≥ 65 years of age, stratified by blood pressure categories based on the 2017 American College of Cardiology / American Heart Association blood pressure guideline.

| Blood pressure category[*] | Overall N = 8,803 | Sub-groups | | | |
		Diabetes N = 2,000[†]	CKD N = 1,790[‡]	Age 65+ years N = 2,506	Diabetes, CKD, or age 65+ years N = 4,252
Median (25th - 75th percentile) 10-year predicted risk for ASCVD among those without clinical CVD[∥§]					
Overall	5.1 (1.9, 11.4)	14.4 (7.0, 27.3)	11.4 (4.8, 22.3)	17.9 (11.2, 27.3)	13.3 (6.9, 22.0)
Normal blood pressure	2.0 (0.8, 4.8)	6.8 (2.9, 15.7)	3.3 (1.1, 8.9)	10.5 (6.7, 15.9)	6.8 (3.2, 12.4)
Elevated blood pressure	4.3 (1.9, 9.3)	11.4 (4.2, 17.3)	6.2 (1.6, 16.7)	14.6 (7.5, 20.0)	11.3 (5.7, 17.4)
Stage 1 hypertension	4.3 (1.9, 8.5)	8.9 (4.5, 19.3)	7.4 (2.8, 12.2)	13.7 (8.6, 22.3)	9.8 (5.3, 16.5)
Stage 2 hypertension	8.1 (4.2, 16.0)	18.8 (10.1, 30.2)	13.2 (6.6, 21.8)	20.3 (16.0, 29.6)	16.8 (8.6, 24.6)
Taking antihypertensive medication	10.5 (5.2, 19.8)	17.3 (9.9, 31.6)	16.8 (8.4, 28.6)	21.4 (13.9, 31.6)	16.9 (9.8, 27.1)
Proportion (95% confidence interval) with high ASCVD risk[¶]					
Overall	36.5 (34.7, 38.5)	72.3 (69.3, 75.4)	64.5 (61.4, 67.7)	83.9 (81.7, 86.1)	69.0 (66.9, 71.2)
Normal blood pressure	13.4 (11.1, 15.8)	46.8 (39.0, 54.6)	34.7 (26.2, 43.1)	64.4 (57.7, 71.2)	44.9 (39.1, 50.7)
Elevated blood pressure	27.4 (23.3, 31.5)	57.7 (49.6, 65.8)	48.9 (39.0, 58.7)	69.8 (59.6, 79.9)	57.0 (49.8, 64.3)
Stage 1 hypertension	24.3 (20.7, 27.9)	55.0 (43.7, 66.4)	36.7 (26.2, 47.2)	72.6 (63.2, 81.9)	54.4 (46.7, 62.1)
Stage 2 hypertension	45.7 (40.4, 51.0)	79.0 (69.3, 88.7)	63.2 (53.5, 72.9)	90.2 (83.9, 96.6)	74.3 (67.4, 81.2)
Taking antihypertensive medication	61.9 (59.5, 64.3)	81.3 (77.8, 84.9)	79.0 (75.3, 82.7)	92.8 (91.0, 94.5)	80.5 (78.2, 82.9)

[*]Normal blood pressure: systolic blood pressure < 120 mm Hg and diastolic blood pressure < 80 mm Hg;
Elevated blood pressure: systolic blood pressure from 120 to 129 mm Hg and diastolic blood pressure < 80 mm Hg;
Stage 1 hypertension: systolic blood pressure between 130 and 139 mm Hg or diastolic blood pressure between 80 and 89 mm Hg;
Stage 2 hypertension: systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg.

		Sub-groups			
Blood pressure category[*]	**Overall** **N = 8,803**	**Diabetes** **N = 2,000**[†]	**CKD** **N = 1,790**[‡]	**Age 65+** **years** **N = 2,506**	**Diabetes,** **CKD, or age** **65+ years** **N = 4,252**

[†]Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, glycated hemoglobin (HbA1c) ≥ 6.5%, or self-reported use of insulin or oral glucose lowering medication.

[‡]Chronic kidney disease is defined by an albumin-to-creatinine ratio ≥ 30 mg/g or an estimated glomerular filtration rate < 60 ml/min/1.73m²
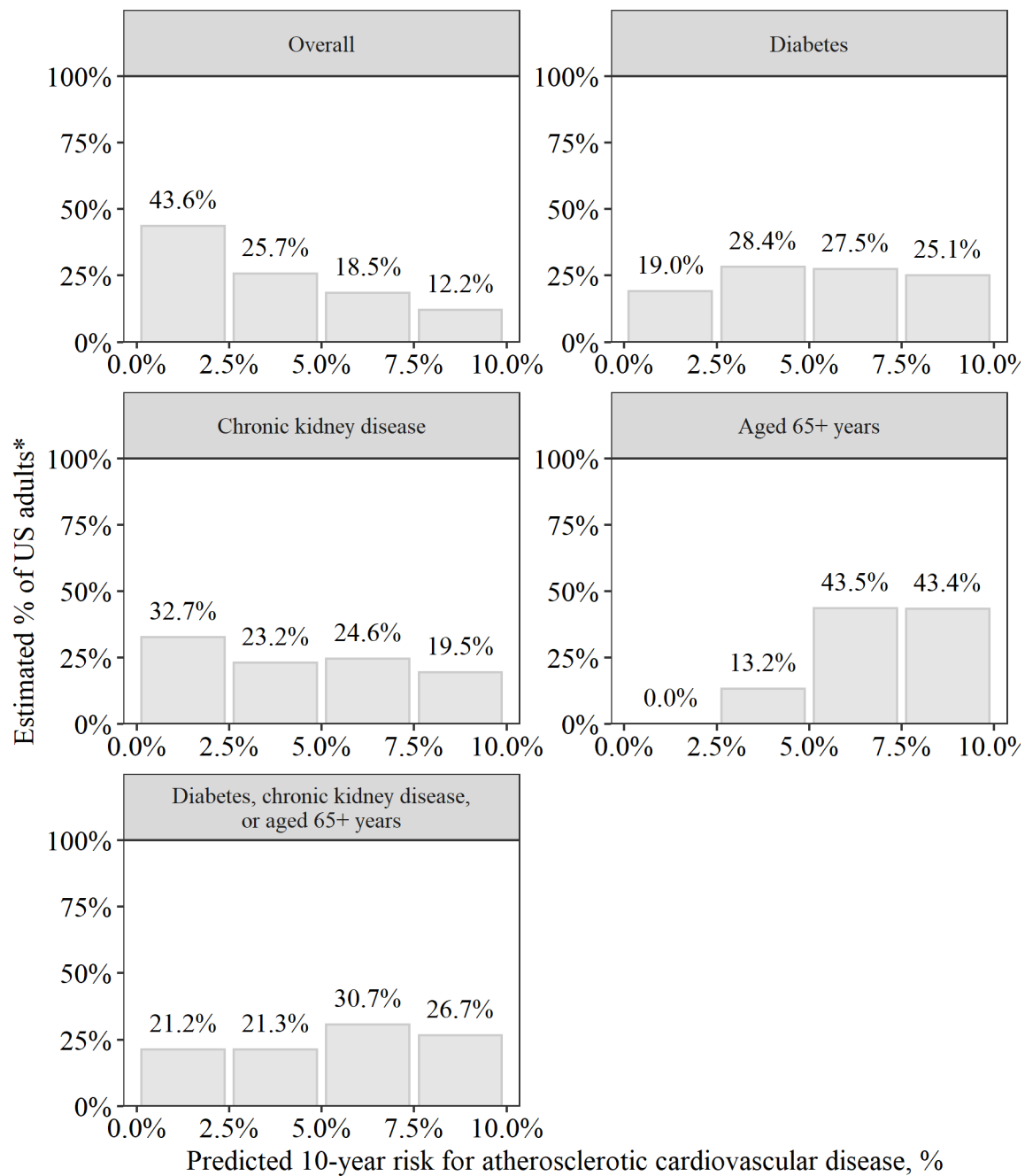
[ǁ]Predicted risk for atherosclerotic cardiovascular disease was computed using the Pooled Cohort risk equations, based on the guideline by American College of Cardiology / American Heart Association, 2013

[§]Clinical cardiovascular disease was defined by self-report of previous heart failure, coronary heart disease, stroke, or myocardial infarction

[¶]High atherosclerotic cardiovascular disease risk was defined by a 10-year predicted risk for atherosclerotic cardiovascular disease ≥ 10% or clinical cardiovascular disease
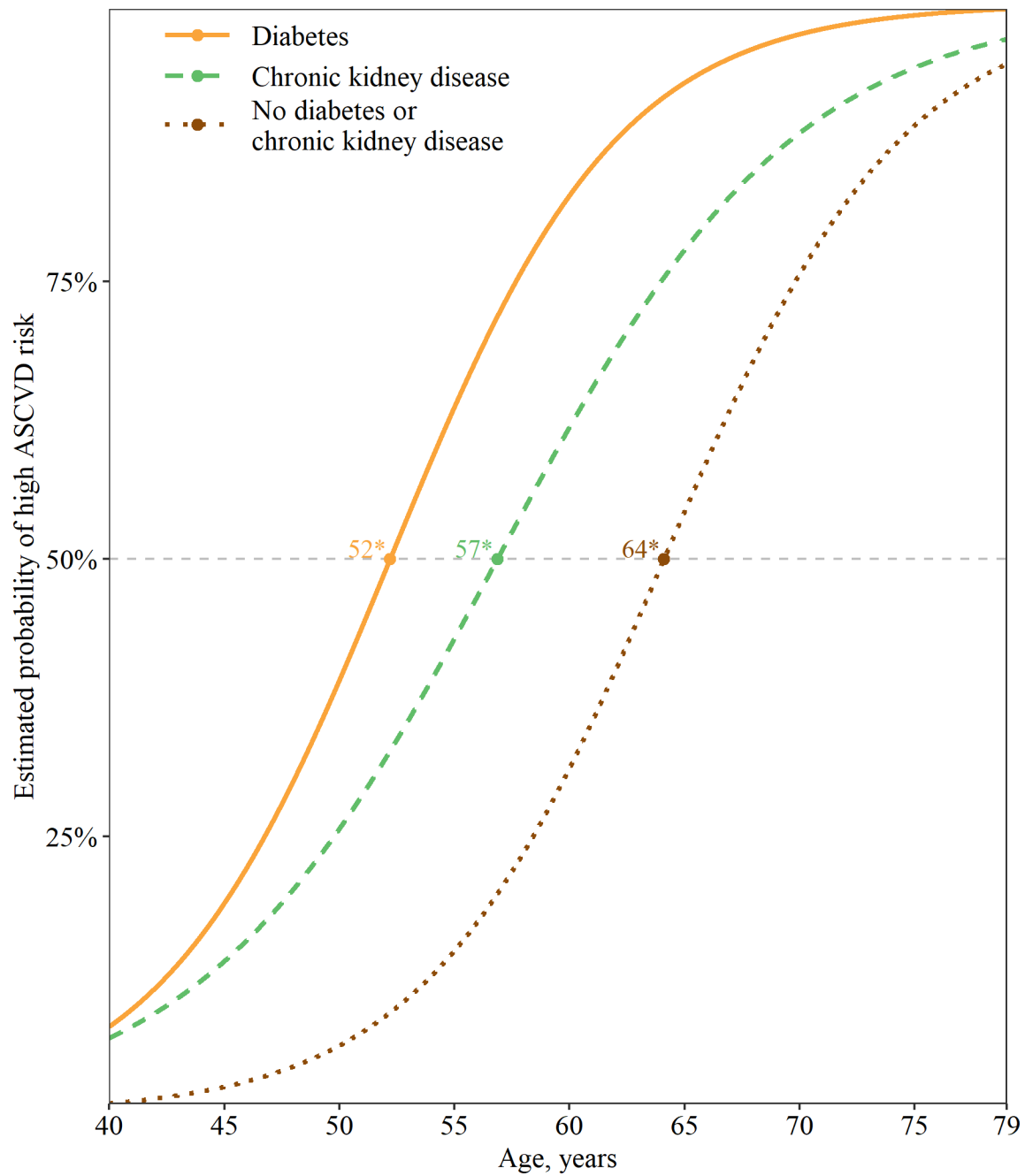
ASCVD = atherosclerotic cardiovascular disease; CKD = chronic kidney disease; CVD = cardiovascular disease

Figure 1: Distribution of 10-year predicted risk for atherosclerotic cardiovascular disease among US adults with predicted risk < 10%, overall and for subgroups defined by diabetes, chronic kidney disease, and ≥ 65 years of age.

* The distributions are restricted to US adults without clinical cardiovascular disease and 10-year predicted atherosclerotic cardiovascular disease risk < 10%.

Figure 2: Estimated probability of high atherosclerotic cardiovascular disease risk for US adults with diabetes, with chronic kidney disease, and without diabetes or chronic kidney disease.

* Age at which 50% of the subgroup is estimated to have high atherosclerotic cardiovascular disease risk, defined as a predicted 10-year atherosclerotic cardiovascular disease risk ≥ 10% or clinical cardiovascular disease.

SUPPLEMENT

Table S1: Median 10-year predicted risk for atherosclerotic cardiovascular disease using an updated Pooled Cohort risk prediction equation and proportion of US adults with high atherosclerotic cardiovascular disease risk overall and for subgroups defined by diabetes, chronic kidney disease, and ≥ 65 years of age, stratified by blood pressure categories based on the 2017 American College of Cardiology / American Heart Association blood pressure guideline.

| Blood pressure category[*] | Overall N = 8,803 | Sub-groups | | | |
		Diabetes N = 2,000[†]	CKD N = 1,790[‡]	Age 65+ years N = 2,506	Diabetes, CKD, or age 65+ years N = 4,252
Median (25th - 75th percentile) 10-year predicted risk for ASCVD among those without clinical CVD[∥§]					
Overall	5.1 (1.9, 11.4)	14.4 (7.0, 27.3)	11.4 (4.8, 22.3)	17.9 (11.2, 27.3)	13.3 (6.9, 22.0)
Normal blood pressure	2.0 (0.8, 4.8)	6.8 (2.9, 15.7)	3.3 (1.1, 8.9)	10.5 (6.7, 15.9)	6.8 (3.2, 12.4)
Elevated blood pressure	4.3 (1.9, 9.3)	11.4 (4.2, 17.3)	6.2 (1.6, 16.7)	14.6 (7.5, 20.0)	11.3 (5.7, 17.4)
Stage 1 hypertension	4.3 (1.9, 8.5)	8.9 (4.5, 19.3)	7.4 (2.8, 12.2)	13.7 (8.6, 22.3)	9.8 (5.3, 16.5)
Stage 2 hypertension	8.1 (4.2, 16.0)	18.8 (10.1, 30.2)	13.2 (6.6, 21.8)	20.3 (16.0, 29.6)	16.8 (8.6, 24.6)
Taking antihypertensive medication	10.5 (5.2, 19.8)	17.3 (9.9, 31.6)	16.8 (8.4, 28.6)	21.4 (13.9, 31.6)	16.9 (9.8, 27.1)
Proportion (95% confidence interval) with high ASCVD risk[¶]					
Overall	27.0 (25.2, 28.8)	65.4 (62.3, 68.5)	54.6 (51.3, 57.9)	60.4 (57.3, 63.5)	52.4 (49.8, 54.9)
Normal blood pressure	8.6 (6.7, 10.6)	35.5 (27.7, 43.4)	24.9 (17.7, 32.0)	39.0 (32.0, 45.9)	27.6 (22.5, 32.6)
Elevated blood pressure	16.1 (12.6, 19.6)	47.9 (40.1, 55.8)	34.2 (22.0, 46.4)	38.1 (29.7, 46.5)	34.3 (28.2, 40.3)
Stage 1 hypertension	14.6 (12.1, 17.1)	45.2 (34.0, 56.4)	27.5 (19.5, 35.5)	42.3 (32.5, 52.0)	34.6 (27.7, 41.4)
Stage 2 hypertension	37.4 (32.7, 42.0)	76.8 (67.0, 86.5)	58.9 (50.4, 67.5)	73.5 (66.6, 80.4)	62.5 (56.0, 69.1)
Taking antihypertensive medication	48.5 (46.1, 50.9)	75.4 (71.5, 79.4)	68.1 (64.5, 71.7)	71.3 (67.7, 75.0)	64.8 (61.7, 67.8)

[*]Normal blood pressure: systolic blood pressure < 120 mm Hg and diastolic blood pressure < 80 mm Hg;
Elevated blood pressure: systolic blood pressure from 120 to 129 mm Hg and diastolic blood pressure < 80 mm Hg;
Stage 1 hypertension: systolic blood pressure between 130 and 139 mm Hg or diastolic blood pressure between 80 and 89 mm Hg;
Stage 2 hypertension: systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg.

		Sub-groups			
Blood pressure category[*]	**Overall N = 8,803**	**Diabetes N = 2,000**[†]	**CKD N = 1,790**[‡]	**Age 65+ years N = 2,506**	**Diabetes, CKD, or age 65+ years N = 4,252**

[†]Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, glycated hemoglobin (HbA1c) ≥ 6.5%, or self-reported use of insulin or oral glucose lowering medication.

[‡]Chronic kidney disease is defined by an albumin-to-creatinine ratio ≥ 30 mg/g or an estimated glomerular filtration rate < 60 ml/min/1.73m²

[ǁ]Predicted risk for atherosclerotic cardiovascular disease was computed using an updated version of the Pooled Cohort risk equations from Yadlowsky et al., 2018

[§]Clinical cardiovascular disease was defined by self-report of previous heart failure, coronary heart disease, stroke, or myocardial infarction

[¶]High atherosclerotic cardiovascular disease risk was defined by a 10-year predicted risk for atherosclerotic cardiovascular disease ≥ 10% or clinical cardiovascular disease
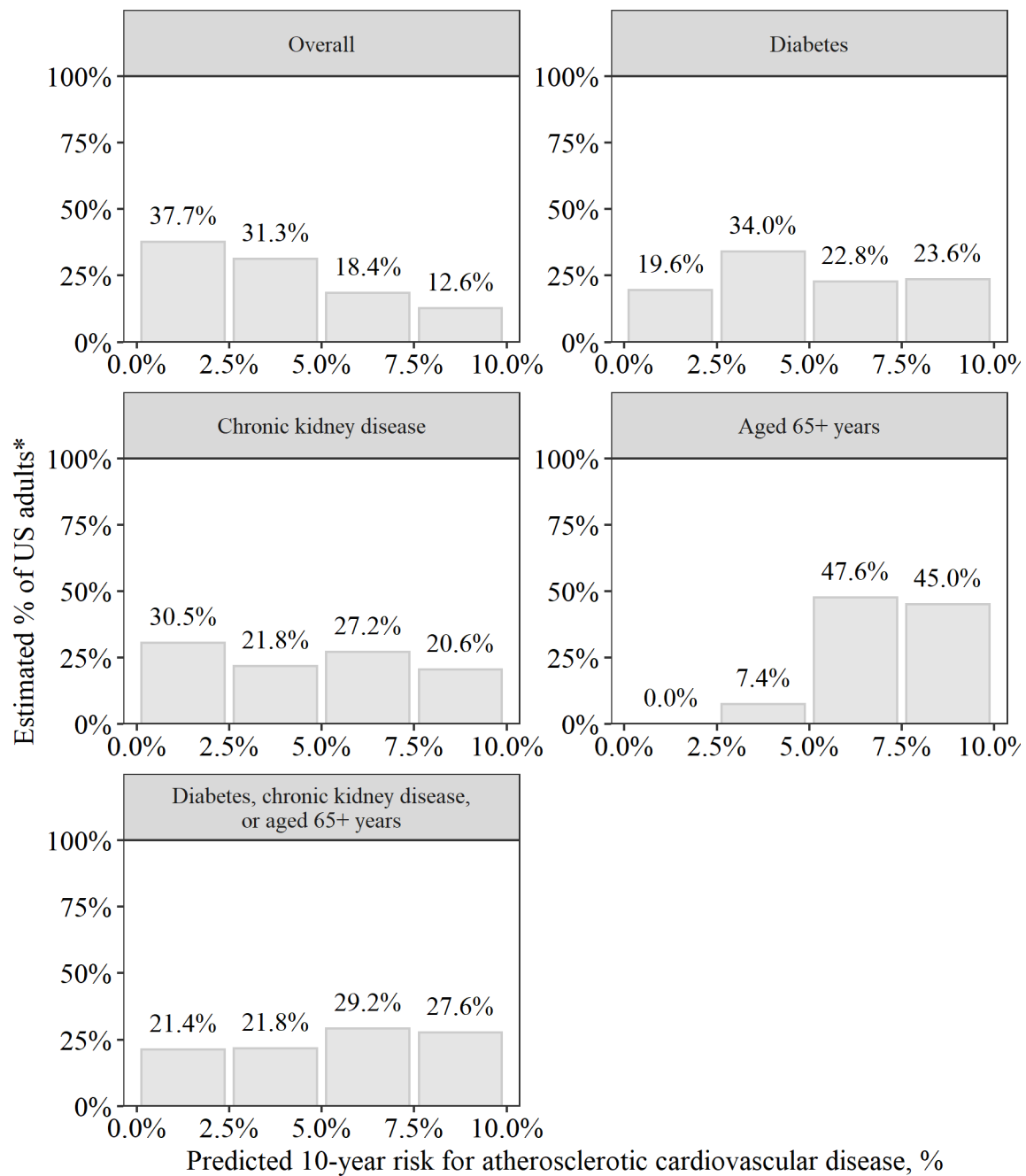
ASCVD = atherosclerotic cardiovascular disease; CKD = chronic kidney disease; CVD = cardiovascular disease

Figure S1: Flowchart showing the application of the inclusion criteria to National Health and Nutrition Examination Survey 2013-2018 participants

|	NHANES Cycle			
	Overall	2013-2014	2015-2016	2017-2018
	Number of survey participants			
Approached to participate	48,419	14,332	16,253	17,834
Completed NHANES interview and exam*	28,061	9,813 (69%)	9,544 (59%)	8,704 (49%)
Aged 40 to 79 years	9,937	3,376	3,267	3,294
Had 3 valid systolic and diastolic BP measures	9,372	3,164	3,147	3,061
With complete data for variables in the Pooled Cohort risk equations and CKD status	8,803	2,991	2,964	2,848

* The completed National Health and Nutrition Examination Survey interview and exam cells include number with the response rate in parentheses. BP = blood pressure; CKD = chronic kidney disease; NHANES = National Health and Nutrition Examination Survey.

Figure S2: Distribution of 10-year predicted risk for atherosclerotic cardiovascular disease among US adults with stage 1 hypertension and predicted risk < 10%, overall and for subgroups defined by diabetes, chronic kidney disease, and ≥ 65 years of age.

* The distributions are restricted to US adults without clinical cardiovascular disease and 10-year predicted atherosclerotic cardiovascular disease risk < 10%.

Figure S3: Estimated Probability of high atherosclerotic cardiovascular disease risk for US adults with stage 1 hypertension and with diabetes, with chronic kidney disease, and without diabetes or chronic kidney disease.
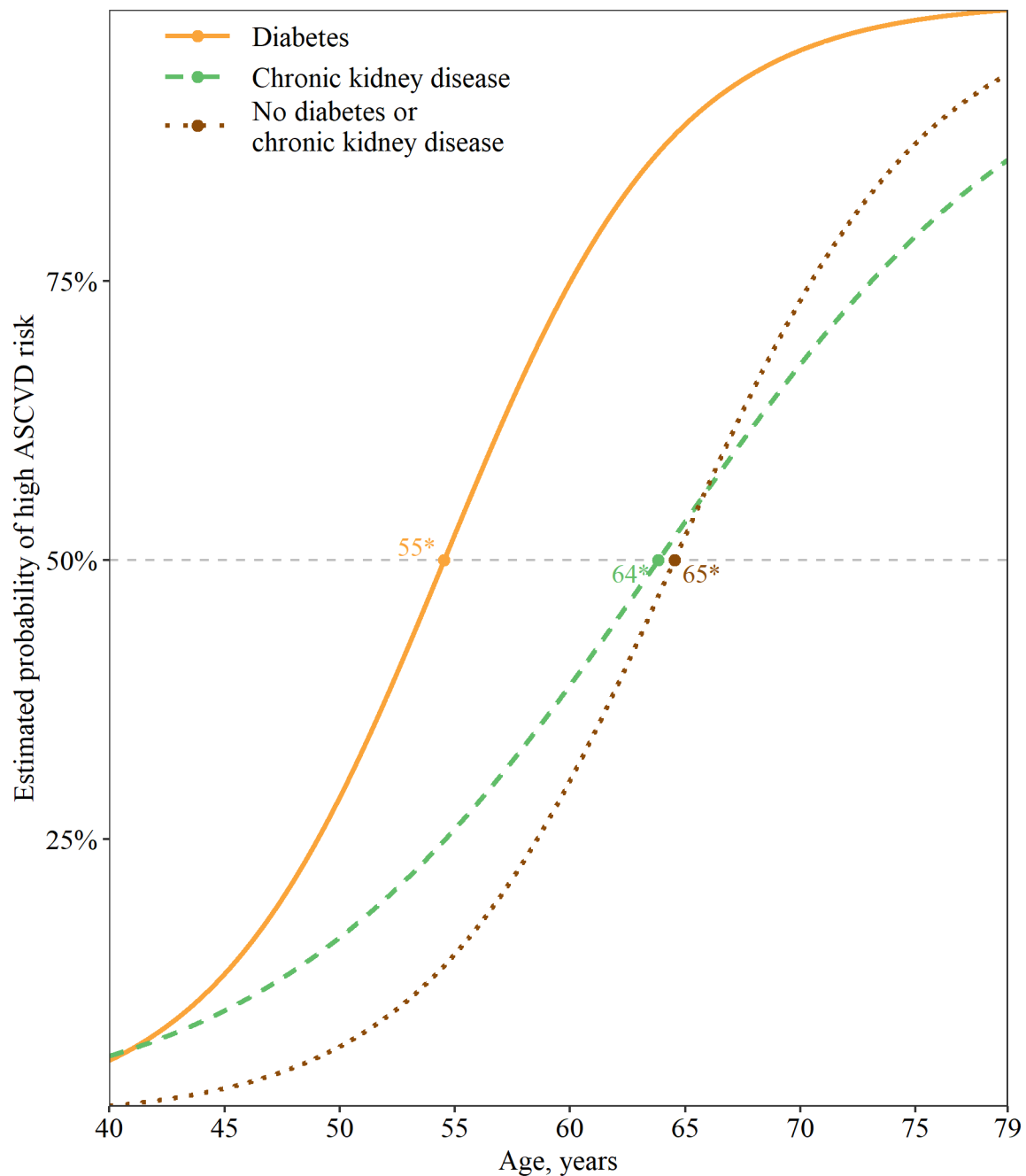
* Age at which 50% of the subgroup is estimated to have high atherosclerotic cardiovascular disease risk, defined as a predicted 10-year atherosclerotic cardiovascular disease risk ≥ 10% or clinical cardiovascular disease.

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