**Predicted cardiovascular risk and blood pressure for Americans with diabetes, chronic kidney disease, and ≥65 years of age**

**Byron C. Jaeger, Shakia T. Hardy, Paul Muntner, Paul Whelton**

**Main idea:**

The 2017 ACC/AHA BP guideline states that the absolute CVD risk reduction attributable to BP lowering is greater at greater absolute levels of CVD risk (see Section 8.1.1, first paragraph). The guideline also states that the vast majority of adults with diabetes, chronic kidney disease, or ≥65 years of age have a 10-year CVD risk ≥10%, placing them in the high risk category that requires initiation of antihypertensive drug therapy at BP ≥ 130/80\* mm Hg (see Section 9.3, 9.6, and 10.3.1 of ACC/AHA guidelines: treatment recommendations paragraph). However, data from NHANES show that US adults with stage 1 hypertension and diabetes or chronic kidney disease have heterogeneous predicted risk for CVD. While adults with diabetes and chronic kidney disease have higher risk on average compared to those with no diabetes or chronic kidney disease, nationally representative survey data do not indicate that the vast majority of adults with these conditions have a 10-year CVD risk ≥10%.

\* For adults aged ≥65 years DBP is not used.

Table 1: Characteristics of US adults overall and with diabetes, chronic kidney disease, ≥ 65 years of age, and any of the preceding conditions

|  | | **Sub-groups** | | | |
| --- | --- | --- | --- | --- | --- |
| **Characteristic\*** | **Overall  N = 8,797** | **Diabetes  N = 1,998†** | **Chronic kidney disease  N = 1,566‡** | **Any preceding condition  N = 2,501** | **Overall  N = 4,183** |
| Age, years | 56.7 (0.22) | 60.3 (0.35) | 61.8 (0.42) | 70.6 (0.14) | 64.2 (0.25) |
| Male | 48.2 | 55.8 | 44.8 | 46.7 | 48.0 |
| Race / ethnicity | | | | | |
| Hispanic | 12.6 | 15.9 | 13.1 | 8.3 | 11.7 |
| Non-Hispanic Asian | 5.2 | 7.0 | 4.9 | 4.5 | 5.2 |
| Non-Hispanic White | 68.6 | 60.0 | 63.4 | 76.7 | 68.8 |
| Non-Hispanic Black | 10.1 | 13.6 | 15.0 | 7.8 | 10.9 |
| Other Race - Including Multi-Racial | 3.5 | 3.5 | 3.7 | 2.7 | 3.3 |
| Total cholesterol, mg/dl | 197.0 (0.92) | 183.2 (1.8) | 194.6 (1.8) | 188.9 (1.3) | 191.1 (1.2) |
| HDL-cholesterol, mg/dl | 54.9 (0.36) | 46.6 (0.51) | 53.0 (0.85) | 56.6 (0.72) | 53.7 (0.48) |
| Systolic blood pressure, mm Hg | 126.0 (0.33) | 130.5 (0.65) | 134.2 (0.74) | 131.8 (0.60) | 131.0 (0.48) |
| Diastolic blood pressure, mm Hg | 72.8 (0.28) | 71.6 (0.39) | 72.4 (0.37) | 68.3 (0.40) | 70.9 (0.35) |
| Antihypertensive medication use | 33.5 | 60.0 | 55.9 | 53.2 | 52.1 |
| Diabetes | 17.2 | 100.0 | 38.3 | 24.7 | 41.9 |
| Chronic kidney disease | 14.1 | 31.3 | 100.0 | 25.3 | 34.3 |
| Aged 65+ years | 25.4 | 36.4 | 45.6 | 100.0 | 61.9 |
| Current smoker | 17.3 | 14.6 | 19.1 | 10.0 | 14.4 |
| Prevalent CVD§ | 10.5 | 22.6 | 23.3 | 21.4 | 19.3 |
| \*Table values are mean (standard error) or proportion. | | | | | |
| †Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, 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/dl or an estimated glomerular filtration rate <60 ml/min/1.73m² | | | | | |
| §Prevalent cardiovascular disease was defined by self-report of previous heart failure, coronary heart disease, stroke, or myocardial infarction | | | | | |
| CVD = cardiovascular disease; HDL = High density lipoprotein | | | | | |

Table 2: Estimated distribution of blood pressure categories among US adults, overall and for subgroups with diabetes, chronic kidney disease, ≥ 65 years of age, or any of the preceding three conditions.

|  | | **Sub-groups** | | | |
| --- | --- | --- | --- | --- | --- |
| **Blood pressure category\*** | **Overall  N = 8,797** | **Diabetes  N = 1,998†** | **Chronic kidney disease  N = 1,566‡** | **Any preceding condition  N = 2,501** | **Overall  N = 4,183** |
| Normal blood pressure | 28.8 | 12.1 | 13.5 | 15.0 | 15.5 |
| Elevated blood pressure | 12.0 | 7.9 | 6.7 | 11.2 | 10.4 |
| Stage 1 hypertension | 14.6 | 10.5 | 9.5 | 9.1 | 10.4 |
| Stage 2 hypertension | 11.1 | 9.5 | 14.5 | 11.6 | 11.7 |
| Taking antihypertensive medication | 33.5 | 60.0 | 55.9 | 53.2 | 52.1 |
| \*Normal blood pressure: systolic/diastolic blood pressure < 120/80 mm Hg; Elevated blood pressure: systolic/diastolic blood pressure 120-129/<80 mm Hg; Stage 1 hypertension: systolic/diastolic blood pressure 130-139/80-89 mm Hg; Stage 2 hypertension: systolic/diastolic blood pressure ≥ 140/90 mm Hg. | | | | | |
| †Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, 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/dl or an estimated glomerular filtration rate <60 ml/min/1.73m² | | | | | |

Table 3: Predicted atherosclerotic cardiovascular risk among US adults with diabetes, chronic kidney disease, ≥ 65 years of age, and any of the preceding conditions, overall and by BP category.

|  | | **Sub-groups** | | | |
| --- | --- | --- | --- | --- | --- |
| **Blood pressure category\*** | **Overall  N = 8,797** | **Diabetes  N = 1,998†** | **Chronic kidney disease  N = 1,566‡** | **Any preceding condition  N = 2,501** | **Overall  N = 4,183** |
| *Proportion (95% confidence interval) with predicted risk ≥ 10% or prevalent cardiovascular disease§‖* | | | | | |
| Overall | 36.6 (34.7, 38.6) | 72.5 (69.3, 75.6) | 65.4 (61.7, 69.0) | 83.8 (81.6, 86.0) | 70.3 (68.0, 72.7) |
| Normal blood pressure | 13.7 (11.4, 16.0) | 46.8 (39.0, 54.6) | 32.3 (21.6, 43.0) | 64.4 (57.7, 71.2) | 46.3 (40.5, 52.1) |
| Elevated blood pressure | 27.4 (23.3, 31.5) | 57.7 (49.6, 65.8) | 47.9 (36.9, 59.0) | 69.8 (59.6, 79.9) | 57.9 (50.5, 65.3) |
| Stage 1 hypertension | 24.3 (20.7, 27.9) | 55.0 (43.7, 66.4) | 38.5 (27.4, 49.6) | 72.6 (63.2, 81.9) | 55.2 (47.0, 63.3) |
| Stage 2 hypertension | 45.7 (40.4, 51.0) | 79.0 (69.3, 88.7) | 65.6 (54.7, 76.4) | 90.2 (83.8, 96.6) | 75.6 (69.5, 81.7) |
| Taking antihypertensive medication | 61.9 (59.4, 64.5) | 81.6 (78.0, 85.2) | 79.9 (75.9, 84.0) | 92.8 (91.0, 94.5) | 81.8 (79.4, 84.2) |
| *Median (25th - 75th percentile) predicted risk¶* | | | | | |
| Overall | 5.1 (1.9, 11.4) | 14.4 (7.0, 27.3) | 12.1 (4.8, 22.8) | 17.9 (11.2, 27.3) | 13.6 (7.0, 22.3) |
| Normal blood pressure | 2.0 (0.79, 4.8) | 6.8 (2.9, 15.8) | 3.0 (0.96, 8.1) | 10.6 (6.7, 16.0) | 7.0 (3.3, 12.9) |
| Elevated blood pressure | 4.3 (1.9, 9.3) | 11.4 (4.2, 17.3) | 6.2 (1.5, 13.8) | 14.6 (7.5, 19.9) | 11.8 (5.8, 17.4) |
| Stage 1 hypertension | 4.2 (1.9, 8.5) | 8.9 (4.5, 19.3) | 6.8 (2.6, 12.3) | 13.8 (8.6, 22.3) | 9.8 (5.3, 16.6) |
| Stage 2 hypertension | 8.1 (4.2, 16.0) | 18.8 (10.1, 30.2) | 13.9 (5.7, 21.3) | 20.4 (16.0, 29.6) | 17.3 (9.2, 25.4) |
| Taking antihypertensive medication | 10.5 (5.2, 19.8) | 17.2 (9.8, 31.6) | 17.0 (9.0, 29.0) | 21.2 (14.0, 31.6) | 17.2 (10.1, 27.3) |
| \*Normal blood pressure: systolic/diastolic blood pressure < 120/80 mm Hg; Elevated blood pressure: systolic/diastolic blood pressure 120-129/<80 mm Hg; Stage 1 hypertension: systolic/diastolic blood pressure 130-139/80-89 mm Hg; Stage 2 hypertension: systolic/diastolic blood pressure ≥ 140/90 mm Hg. | | | | | |
| †Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, 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/dl or an estimated glomerular filtration rate <60 ml/min/1.73m² | | | | | |
| §Prevalent cardiovascular disease was defined by self-report of previous heart failure, coronary heart disease, stroke, or myocardial infarction | | | | | |
| ‖Predicted risk for cardiovascular disease was computed using the Pooled Cohort Risk equations, based on the guideline by American College of Cardiology / American Heart Association, 2013 | | | | | |
| ¶Data from survey participants with prevalent cardiovascular disease were not included for these statistics | | | | | |

Figure 1: Distribution of 10-year predicted atherosclerotic cardiovascular risk among survey participants with predicted risk < 10% and diabetes, chronic kidney disease, ≥ 65 years of age, or any of the preceding conditions.



Results do not include data from survey participants with prevalent cardiovascular disease or 10-year predicted risk for atherosclerotic cardiovascular disease ≥ 10%.

Figure 2: Probability of ten-year predicted risk for atherosclerotic cardiovascular disease ≥ 10% as a function of age for survey participants overall and among those with diabetes, chronic kidney disease, or both diabetes and chronic kidney disease.



\* these values indicate the expected age where probability of having ≥10% predicted risk for atherosclerotic cardiovascular disease is ≥ 50%

SUPPLEMENT

Table S1: Participants included in the current analysis

| **Criteria** | **N included** | **N excluded** |
| --- | --- | --- |
| Participated in 2013-2014, 2015-2016, or 2017-2018 exam | 29,400 | 0 |
| Aged 40-79 years | 10,308 | 19,092 |
| Valid survey weight values | 9,937 | 371 |
| 3 or more systolic and diastolic blood pressure measurements | 9,372 | 565 |
| Complete data for variables used in the pooled cohort risk equations | 8,797 | 575 |

Table S2: Characteristics of US adults with stage 1 hypertension, overall and with diabetes, chronic kidney disease, ≥ 65 years of age, or any of the three preceding conditions

|  | | **Sub-groups** | | | |
| --- | --- | --- | --- | --- | --- |
| **Characteristic\*** | **Overall  N = 1,271** | **Diabetes  N = 204†** | **Chronic kidney disease  N = 155‡** | **Any preceding condition  N = 236** | **Overall  N = 453** |
| Age, years | 54.0 (0.41) | 56.8 (1.2) | 57.0 (1.2) | 69.7 (0.45) | 61.5 (0.78) |
| Male | 52.3 | 58.5 | 48.8 | 51.5 | 51.9 |
| Race / ethnicity | | | | | |
| Hispanic | 14.2 | 19.9 | 19.2 | 10.3 | 15.1 |
| Non-Hispanic Asian | 6.0 | 7.6 | 7.0 | 4.2 | 6.0 |
| Non-Hispanic White | 66.3 | 60.0 | 59.1 | 73.8 | 65.5 |
| Non-Hispanic Black | 9.8 | 11.4 | 12.7 | 7.4 | 10.3 |
| Other Race - Including Multi-Racial | 3.7 | 1.2 | 1.9 | 4.4 | 3.1 |
| Total cholesterol, mg/dl | 205.0 (2.4) | 188.8 (4.6) | 198.4 (5.0) | 195.4 (3.5) | 195.8 (2.9) |
| HDL-cholesterol, mg/dl | 54.0 (0.73) | 47.1 (1.5) | 53.2 (2.3) | 57.9 (1.4) | 53.8 (1.0) |
| Systolic blood pressure, mm Hg | 129.6 (0.31) | 131.1 (0.66) | 131.2 (0.68) | 132.5 (0.59) | 131.3 (0.43) |
| Diastolic blood pressure, mm Hg | 78.6 (0.39) | 76.7 (0.96) | 76.5 (0.81) | 72.2 (1.0) | 75.3 (0.64) |
| Antihypertensive medication use | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Diabetes | 12.3 | 100.0 | 30.7 | 21.0 | 42.4 |
| Chronic kidney disease | 9.1 | 22.6 | 100.0 | 16.1 | 31.3 |
| Aged 65+ years | 15.7 | 26.9 | 27.8 | 100.0 | 54.2 |
| Current smoker | 19.3 | 18.8 | 23.3 | 10.7 | 16.4 |
| Prevalent CVD§ | 5.8 | 15.2 | 12.8 | 13.2 | 11.4 |
| \*Table values are mean (standard error) or proportion. | | | | | |
| †Diabetes was defined by fasting serum glucose ≥ 126 mg/dL, non-fasting glucose ≥ 200 mg/dL, 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/dl or an estimated glomerular filtration rate <60 ml/min/1.73m² | | | | | |
| §Prevalent cardiovascular disease was defined by self-report of previous heart failure, coronary heart disease, stroke, or myocardial infarction | | | | | |
| CVD = cardiovascular disease; HDL = High density lipoprotein | | | | | |

Figure S1: Distribution of 10-year predicted atherosclerotic cardiovascular risk among survey participants with stage 1 hypertension, predicted risk < 10% and diabetes, chronic kidney disease, ≥ 65 years of age, or any of the preceding conditions.



Results do not include data from survey participants with prevalent cardiovascular disease or 10-year predicted risk for atherosclerotic cardiovascular disease ≥ 10%.

Figure S2: Probability of ten-year predicted risk for atherosclerotic cardiovascular disease ≥ 10% as a function of age for participants with stage 1 hypertension overall and among those with diabetes, chronic kidney disease, or both diabetes and chronic kidney disease.



\* these values indicate the expected age where probability of having ≥10% predicted risk for atherosclerotic cardiovascular disease is ≥ 50%