HHS Public Access

Author manuscript

Diabetes Res Clin Pract. Author manuscript; available in PMC 2023 December 07.

Published in final edited form as:

Diabetes Res Clin Pract. 2023 June ; 200: 110695. doi:10.1016/j.diabres.2023.110695.

Prevalence of Anemia and Associated All-Cause Mortality Among Adults With Diabetes: The Role of Chronic Kidney Disease

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Abstract

Aims—Among adults with diabetes in the United States, we evaluated anemia prevalence by CKD status as well as the role of CKD and anemia, as potential risk factors for all-cause mortality.

Methods—In a retrospective cohort study, we included 6,718 adult participants with prevalent diabetes from the 2003-March 2020 National Health and Nutrition Examination Survey (NHANES), a nationally representative sample of the non-institutionalized civilian population in the United States. Cox regression models evaluated the role of anemia and CKD, alone or combined, as predictors of all-cause mortality.

Results—Anemia prevalence among adults with diabetes and CKD was 20%. Having anemia or CKD alone, compared with having neither condition, was significantly associated with all-cause mortality (anemia: HR=2.10 [1.49–2.96], CKD: HR=2.24 [1.90–2.64]). Having both conditions conferred a greater potential risk (HR=3.41 [2.75–4.23]).

Conclusions—Approximately one-quarter of the adult US population with diabetes and CKD also has anemia. The presence of anemia, with or without CKD, is associated with a two- to threefold increased risk of death by compared with adults who have neither condition, suggesting that anemia may be a strong predictor of death among adults with diabetes.

Keywords

anemia; diabetes; kidney disease; CKD; mortality

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Author Contributions

AKK was responsible for data curation, formal analysis, methodology, project administration, visualization, writing – original draft, writing – review & editing. EL was responsible for conceptualization, methodology, and writing – review & editing. KMB was responsible for methodology and writing – review & editing. MEP was responsible for methodology and writing – review & editing.

Declarations of interest: none

Disclosures: All authors have approved the final article. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

1. Introduction

Prevalence of diabetes in the United States remains high, affecting approximately 11% of the adult population[1] and costing around $327 billion annually in direct and indirect costs[2]. While much focus is placed on end-organ damage and major cardiovascular disease (CVD) events as complications of diabetes, it is also important to understand comorbid conditions such as anemia and the role they may play in long-term prognosis. Anemia, which affects between 8% and 18% of adults with diabetes[3, 4], has been shown to increase the risk of complications such as diabetic retinopathy[5–7], heart failure[8, 9], and diabetic foot ulcers [10]. The hyperglycemic state can lead to anemia through increased levels of circulating inflammatory cytokines, which in turn contribute to deficiencies in erythropoietin secretion and promotion of apoptosis in immature erythrocytes[6]. Hyperglycemia, through multiple pathophysiological mechanisms[11], is a major contributor to onset and progression of chronic kidney disease (CKD), itself a known risk factor for anemia, CVD comorbidity, and increased mortality [8, 9, 12, 13]. Therefore, anemia and CKD, due to their unique etiologies among adults with diabetes, may be particularly important markers of diabetes outcomes.

To assess the public health impact of the combined effects of anemia and CKD on long-term outcomes, it is important to evaluate the prevalence of anemia among adults with diabetes by CKD status. To date, studies evaluating anemia prevalence in adults with diabetes included patients in clinical settings or populations with diabetes-related CKD [14–18], with estimates ranging from 29% to 66% [5–7]. One community-based study conducted from 1987 to 1993 found that anemia was present in 8.8% of adults with diabetes aged 45 to 64 years and increased the risk of cardiovascular outcomes and early death only among those with both diabetes and CKD [4].

To provide more recent evidence in a representative sample of adults with diabetes in the United States, we aimed to do the following: 1) in a cross-sectional descriptive analysis, evaluate the prevalence of anemia by CKD status, as well as the characteristics associated with prevalent anemia; 2) in a longitudinal analysis, assess the role of CKD and anemia as potential risk factors for all-cause mortality.

2. Subjects

Data were from the National Health and Nutrition Examination Survey (NHANES), a cross-sectional survey of the health and nutritional status of the civilian, noninstitutionalized population of the United States, conducted every two years by the National Center for Health Statistics (NCHS)[19]. Participants are selected through a complex multistage sampling design. Interviews are conducted in participants' homes followed by examinations and laboratory measurements performed in mobile examination centers. For the current study, non-pregnant participants 18 years and older with prevalent diabetes from the 2003–2004 through the 2017-March 2020 survey cycles were included (sample n=7,584). Response rates ranged from 46.9% to 77.4%. Study participants were excluded if they were missing measurements to estimate CKD status (n=853 [11.2%]) or hemoglobin (n=563 [7.4%]), resulting in an analytic sample of 6,718 participants. Differences in characteristics between participants excluded for missing data and the 6,718 participants

without missing data are shown in Supplemental Table 1. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The NHANES survey protocol was approved by the Centers for Disease Control and Prevention's NCHS Ethics Review Board and written informed consent was obtained from all adult participants. Data are publicly available on the web site for the National Center for Health Statistics (https://www.cdc.gov/nchs/nhanes/index.htm).

3. Materials and Methods

3.1 Mortality Data

Public-use linked mortality files from NCHS were available to determine mortality status for participants from the 2003–2004 through 2017–2018 survey cycles[20]. Mortality status was ascertained through probabilistic record matching with data from the National Death Index[20]. Participants were eligible to be linked to the mortality data if there was sufficient identifying information (e.g. Social Security number, name, date of birth)[20]. Linked files included time-to-event data in person-months from examination date until either death or December 31, 2019. Of the 6,718 participants from the cross-sectional analysis, 6,193 participants were available for the mortality analysis.

3.2 Measurements

Demographic variables measured using the self-reported questionnaire included age, sex (male, female), and race and ethnicity (Hispanic, non-Hispanic Black, non-Hispanic Other, non-Hispanic White). The non-Hispanic Other group comprised participants who reported non-Hispanic Asian or Other race, and was combined due to sample size. Socioeconomic factors included education (less than high school, high school or equivalent, some college/associate's degree, college degree), employment (reported having a job in the last week), and health insurance coverage (yes, no). Smoking status was measured through self-report. If a participant reported not smoking at least 100 cigarettes in their lifetime, they were considered a never smoker. Participants who reported smoking at least 100 cigarettes were considered a former smoker if they further reported smoking "not at all" in response to the question "Do you now smoke cigarettes?" Those who responded "some days" or "every day" to this question were considered current smokers. CVD diseases (angina, congestive heart failure, coronary heart disease, myocardial infarction, stroke) were identified through self-reported diagnosis by a health care professional. Examination and laboratory measurements included body mass index (BMI, kg/m^2), calculated from measured height and weight, glycated hemoglobin (HbA1c, %), systolic blood pressure (SBP, mmHg), and total cholesterol (mg/dL).

A participant was considered to have prevalent diabetes through either self-reported diagnosis by a health care professional or from an HbA1c measurement ≥6.5% as part of the NHANES examination. Thresholds to define anemia were based on World Health Organization criteria, and individual measurements included adjustments to hemoglobin levels based on current smoking frequency (0.5–1 pack/day: −0.3 g/L; 1–2 packs/day:

−0.5 g/L; ≥2 packs/day: −0.7 g/L)[21]. Ranges of hemoglobin levels (g/L) for no anemia, mild, moderate, and severe anemia were as follows: ≥120.0, 110.0–119.9, 80.0–109.9, and <80.0, respectively, for women and ≥130.0, 110.0–129.9, 80.0–109.9, and <80.0 for men[21]. CKD was defined by a random urinary ACR ≥30 mg/g or estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2. eGFR was calculated using the 2012 CKD Epidemiology Collaboration (CKD-EPI) equation based on serum creatinine measurements using standardized isotope dilution mass spectrometry[22] and categorized into the following CKD stages: stages 1–2 (eGFR ≥60 mL/min/1.73 m^2 and ACR ≥30 mg/g) and stages 3–5 (eGFR <60 mL/min/1.73 m^2)[23]. Stages 3 to 5 were combined due to the small number of participants with stage 4 or 5 CKD. All serum measurements were based on a single blood draw during the NHANES examination visit. As a sensitivity analysis, all findings were also reported using the CKD-EPI 2021 equation[24], which omits the race variable in eGFR calculation.

3.3 Statistical Analysis

To describe the study sample, proportions and corresponding 95% confidence intervals (CI) were used for categorical variables and means and 95% confidence intervals were used for continuous variables. Percentages (and corresponding 95% confidence intervals) and weighted counts for age-adjusted prevalence of anemia among adults with diabetes by CKD status were estimated. Age adjustment was performed by adjusting to age distributions from the 2000 United States Census Bureau standard population[25]. To evaluate cross-sectional associations with prevalent anemia, logistic regression models were used. In a longitudinal analysis, Cox regression models were used to assess the risk of all-cause mortality attributed to anemia and CKD by creating a categorical variable with four levels: anemia and CKD, anemia alone, CKD alone, and no anemia or CKD (reference). Age was used as the time scale to nonparametrically model its potential effects. Follow-up time accrued from the NHANES examination date, until death or the end of the study period (December 31, 2019). To adjust for both potential calendar effects and introduction of left censoring from using age as the time scale, a stratified model was used to allow different baseline hazards by birth cohort[26]. For both logistic and Cox regression analyses, Model 1 was adjusted for sex, race, and ethnicity, and Model 2 was further adjusted for education, smoking status, BMI, HbA1c, and total cholesterol. The proportionality assumption was verified by visual inspection of Schoenfeld residuals. In all Cox regression models, mild, moderate, and severe anemia were combined into a dichotomous variable (any anemia, no anemia) due to small cell sizes. Variables with missing values used in regression models (BMI [n=145], HbA1c [n=13], education [n=31], smoking [n=21], total cholesterol [n=1]) were set to the median value for continuous variables and the largest category for categorical variables. Sensitivity analyses included use of the 2021 CKD-EPI equation, a complete case analysis, and additional adjustment for CVD conditions at baseline (myocardial infarction/angina, coronary heart disease, coronary heart failure). Population attributable risk and corresponding 95% confidence intervals were estimated for the potential effect of CKD on all-cause mortality, stratified by anemia status, using the adjusted hazard ratios from Model 2[27]. SAS 9.4 (SAS Institute Inc., Cary, NC) was used for data management and SUDAAN 11 software (Research Triangle Institute, Research Triangle Park, NC) for statistical analysis. Statistical significance was determined based on a two-sided p-value (α

= 0.05). Sample design variables and weights for the examination visit were used to produce nationally representative estimates that accounted for the complex survey design, including the stratified multistage cluster sampling. For the cross-sectional analysis that included the 2017-March 2020 survey cycle, weights were adjusted to account for the partial year 2020 survey cycle[28].

4. Results

Characteristics of the 6,718 adults with diabetes, by anemia and CKD status are displayed in Table 1. Overall, mean age was 59.2 years, 48% were women, nearly 60% were non-Hispanic White, 19% had higher education, and 88% had health insurance. Among adults with CKD, 20.3% had anemia. Participants with both anemia and CKD were generally older, more likely to be non-Hispanic White or non-Hispanic Black, and had a higher prevalence of CVD comorbidity than those without CKD. Using eGFR calculated by the 2021 CKD-EPI equation (Supplemental Table 2) shows a similar distribution of adult characteristics, with a slightly higher prevalence of CKD among non-Hispanic Black adults. Figure 1 describes the population-level prevalence of mild and moderate/severe anemia, age-adjusted to the 2000 US Census Bureau population, overall and by CKD status. The distribution of anemia by CKD status did not change when defining CKD using eGFR calculated by the 2021 CKD-EPI equation (Supplemental Figure 1).

The odds ratios for anemia were highest among adults with CKD stages 3–5 compared to those without CKD and in non-Hispanic Black compared to non-Hispanic White participants (Table 2). Current smoking (OR=0.49 [95% CI: 0.35–0.68]) was inversely associated with anemia. Anemia prevalence (adjusted for all covariates in Model 2) for adults without CKD, stages 1–2 CKD, and stages 3–5 CKD were 9.6% (8.4–10.9%), 12.5% (10.3–15.0%), and 25.2% (21.9–28.9%), respectively. Using the 2021 CKD-EPI equation (Supplemental Table 3), results were similar, with a slight attenuation of the odds ratios for non-Hispanic Black adults compared to non-Hispanic White adults.

In the longitudinal analysis on all-cause mortality, median (interquartile range) follow-up time was 6.3 (3.2–10.4) years. Compared with participants with diabetes only, the adjusted risk of death was twice as high among participants who also had anemia or CKD and 3.4 times higher among those with both anemia and CKD (Figure 2). Additional adjustment for baseline angina, congestive heart failure, coronary heart disease, myocardial infarction, and stroke did not appreciably change results (not shown). Results remained similar when using the 2021 CKD-EPI equation (Supplemental Figure 2) or when conducting a complete case analysis instead of missing indicator variables (Supplemental Figure 3). Population attributable risk for the potential effect of CKD on death was 37.5% (16.0–55.1%) and 33.8% (25.6–41.7%) for participants with and without anemia, respectively (data not shown in Tables/Figures).

5. Discussion

Among adults with diabetes in the United States, 13.5% have anemia. The odds of anemia are 3.5 times higher among non-Hispanic Black than non-Hispanic White adults. Regardless

of race/ethnicity, the odds for anemia are similarly higher with advanced stages of CKD than without CKD. Among participants without CKD, those with diabetes and anemia have twice the risk of death from any cause than those without anemia. In contrast, having both anemia and CKD was associated with a 3.4 times higher adjusted risk for all-cause mortality relative to having neither of the two comorbidities.

Prior studies have found wide variation in the prevalence of anemia among adults with diabetes or CKD. In the current sample, 13.5% of adults with diabetes had anemia, similar to a study in Australia that reported a prevalence of 10% and 18% in an urban and rural populations with diabetes, respectively [3]. Three additional studies in Brazil, South Korea, and Kuwait have reported a higher prevalence of between 28% and 66% [5–7], though these studies comprised patients in a clinical setting. Of studies describing anemia prevalence among adults with CKD, recent studies in Japan and Saudi Arabia reported a prevalence of 6% to 47% for patients with stage 3 CKD, 37–71% for stage 4, and 53–82% for stage 5[16, 17]. These studies assessed patients from nephrology clinics and hospitals from regions outside the United States, used different thresholds for hemoglobin levels to define anemia such as non-sex-specific thresholds or age-specific thresholds, and have not simultaneously assessed the role of both diabetes and CKD in estimating anemia prevalence, making valid comparisons difficult. Regardless, a common finding in both prior evidence and the current study is the progressive and substantial increase in anemia prevalence in later stages of CKD.

The higher odds of anemia experienced by non-Hispanic Black than non-Hispanic White participants was comparable to that of all individuals with stage 3–5 CKD (compared to those without CKD), and similar to associations previously observed in other studies in the United States[29, 30]. It is not entirely clear what determines the higher prevalence of anemia in non-Hispanic Black adults compared to non-Hispanic White adults, as clinical and sociodemographic factors only partly account for the difference[29]. Hispanic ethnicity was also significantly associated with an increased odds of anemia. These associations were not attenuated after adjustment for socioeconomic and clinical factors, suggesting the possible contribution of other unmeasured factors. Factors associated with lower odds of anemia included current smoking, an established factor that can increase hemoglobin levels as a compensatory mechanism from hypoxic conditions induced by carbon monoxide[31, 32], higher HbA1c level, and higher total cholesterol. While the latter two factors were unexpected as potentially protective factors, the magnitude of the associations was small and may have been due to the use of medications such as metformin, thiazolidinediones, and statins, which may lead to anemia[33, 34].

There are few comparable recent studies evaluating the risk of mortality from anemia among adults with diabetes. One study of 8,536 patients with diabetes (mean age: 57.3 years) in China found a significant twofold increased risk of all-cause mortality in patients with anemia compared to those without anemia, and a nearly fourfold higher risk among those with both anemia and CKD, compared to those having neither condition[35]. Among 307 hospitalized patients (mean age: 64.3 years) with type 2 diabetes and stage 1 or 2 CKD in Israel, mild anemia was significantly associated with one-year all-cause mortality after adjusting for age, HbA1c level, and length of hospital stay[36]. Despite differences in

study populations, the increased risk of mortality associated with anemia among adults with diabetes was very similar to the current study. The consistency in findings may be attributed to anemia being a particularly strong predictor of mortality among adults with diabetes. In the current study, the magnitude of the association was large relative to other potential risk factors and similar to the risk of mortality from CKD. While the risk of cardiovascular mortality from CKD is well-documented[37], fewer studies have explored possible mechanisms of the association between anemia and cardiovascular or all-cause mortality among adults with diabetes. Alternative mechanisms may also explain the observed associations. It is possible that the anemia in our cohort is a proxy measure of underlying risk factors of mortality that include cardiometabolic, inflammatory, nutritional, environmental and psychosocial factors, as well as CKD severity[38, 39]. Furthermore, prior evidence from a randomized trial did not show any reduction in mortality risk among adults with diabetic kidney disease when administered erythropoietin-stimulating agents to treat anemia[40], further highlighting the possible role of anemia as a predictive but not a causative factor for mortality.

A particular strength of the current study is the representativeness of the sample to the general population, as participants were not recruited from a patient population. Limitations include the potential role of residual confounding due to the observational design of the study, and the inability to ascertain causality in the cross-sectional analysis. Selection bias may arise from healthier adults who agree to participate in the survey, which may result in fewer adults with more severe CKD and/or anemia. Accordingly, precise estimates for later stages of CKD and different levels of severity of anemia were not evaluated. However, as the aim was not to evaluate anemia in a patient population, the low prevalence of more severe cases may be more representative of the general population. Additionally, diabetes status was not differentiated between type 1 and type 2 diabetes. Lastly, anemia and CKD status were based on a single serum measurement, which may be less sensitive and/or specific than using multiple measurements.

We observed non-Hispanic Black race and the presence and severity of CKD to have the strongest associations with prevalent anemia among adults with diabetes. Among adults with diabetes, anemia and CKD, particularly when occurring together, were significant predictors of all-cause mortality. While underlying biologic mechanisms of anemia and CKD in adults with diabetes may explain the observed associations, future studies may shed further light on the mechanisms underlying the associations between race/ethnicity and prevalent anemia.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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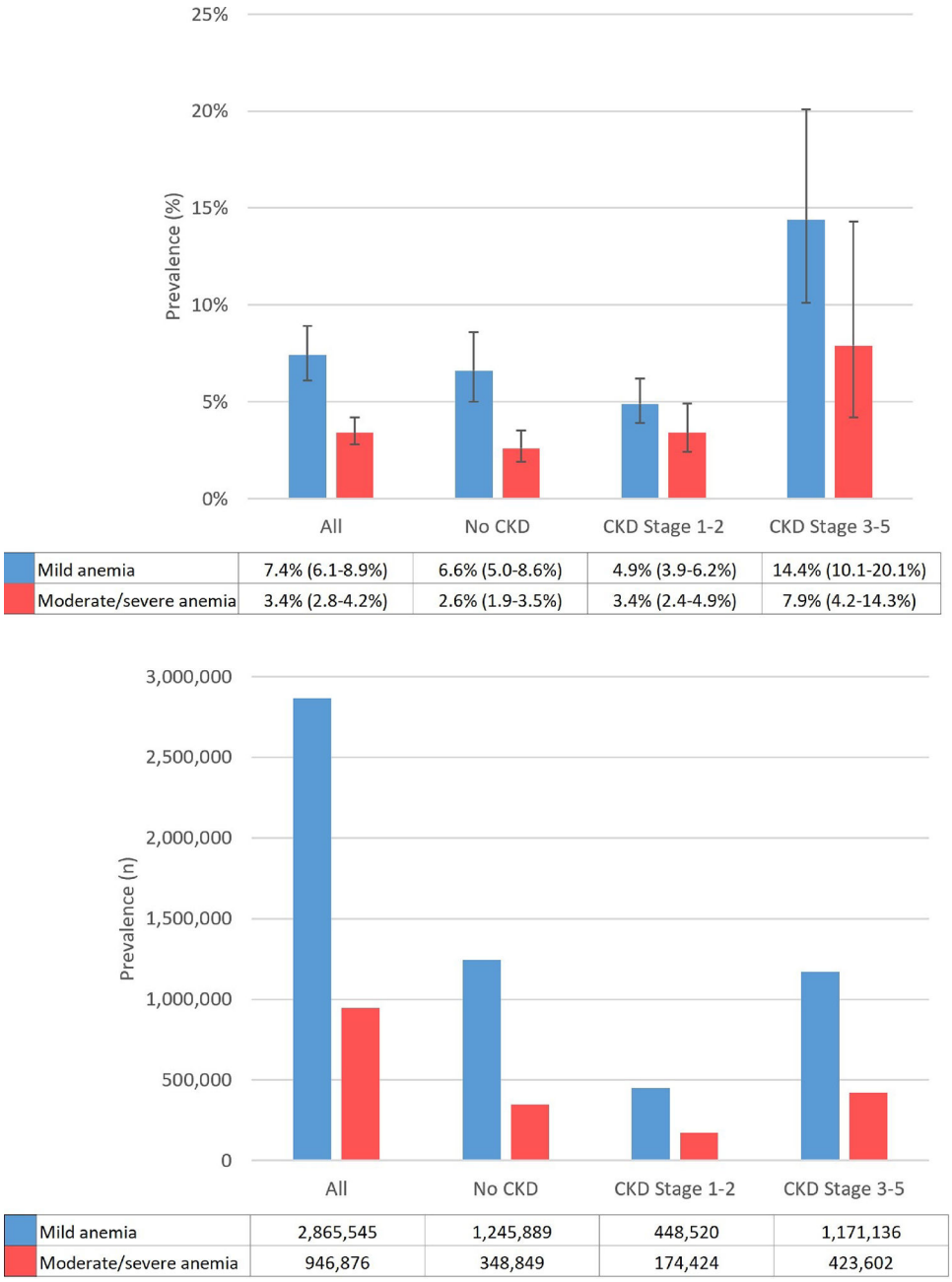

Mild anemia	7.4% (6.1-8.9%)	6.6% (5.0-8.6%)	4.9% (3.9-6.2%)	14.4% (10.1-20.1%)
Moderate/severe anemia	3.4% (2.8-4.2%)	2.6% (1.9-3.5%)	3.4% (2.4-4.9%)	7.9% (4.2-14.3%)

Mild anemia	2,865,545	1,245,889	448,520	1,171,136
Moderate/severe anemia	946,876	348,849	174,424	423,602

Figure 1 - Age-adjusted prevalence of anemia among adults with diabetes by CKD status, National Health and Nutrition Examination Survey (NHANES) 2003-March 2020.

The top figure shows percentages and corresponding 95% confidence intervals. Prevalence is adjusted to age distributions from 2000 United States Census Bureau data. The bottom figure shows weighted counts based on U.S. population totals for NHANES 2017-March 2020. Variance estimates account for the complex survey design.

Abbreviations: CKD = chronic kidney disease.

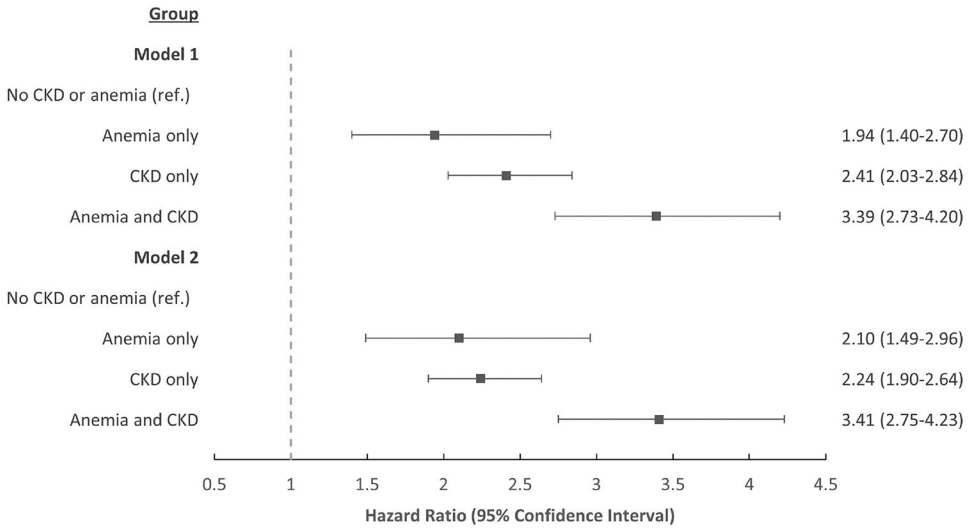

Figure 2 - Adjusted hazard ratios for all-cause mortality by the presence of anemia and CKD in participants with diabetes, National Health and Nutrition Examination Survey 2003–2018 (n=6,193).

Variance estimates account for the complex survey design. Age is adjusted for as the time scale in all models. Model 1 is adjusted for sex and race/ethnicity. Model 2 is further adjusted for education, smoking status, body mass index, hemoglobin A1c, total cholesterol. Abbreviations: CKD = chronic kidney disease.

Table 1 –

Characteristics of adults with diabetes by anemia and CKD status, NHANES 2003-March 2020.

		No Anemia (n=5,527 [86.5%])		Anemia (n=1,191 [13.5%])	
	All (n=6,718)	No CKD (n=3,400 [55.5%])	CKD (n=2,127 [31.0%])	No CKD (n=447 [5.7%])	CKD (n=744 [7.9%])
Demographic Factors					
Age in years	59.2 (58.7–59.7)	56.1 (55.5–56.7)	62.7 (61.9–63.6)	57.8 (56.2–59.4)	68.2 (67.2–69.1)
Female	47.9% (46.3–49.5%)	47.9% (45.4–50.3%)	45.6% (42.6–48.7%)	56.0% (48.4–63.4%)	51.5% (47.0–55.9%)
Race/ethnicity					
Hispanic	16.2% (14.1–18.7%)	16.7% (14.4–19.3%)	16.2% (13.6–19.2%)	18.0% (13.7–23.3%)	11.9% (9.1–15.4%)
Non-Hispanic Black	15.0% (13.2–17.0%)	13.2% (11.5–15.2%)	12.4% (10.4–14.6%)	28.1% (22.9–34.1%)	28.9% (24.9–33.3%)
Non-Hispanic Other	9.1% (8.0–10.4%)	9.0% (7.5–10.7%)	9.7% (8.2–11.5%)	8.4% (5.9–11.8%)	7.7% (5.9–10.1%)
Non-Hispanic White	59.6% (56.3–62.9%)	61.1% (57.5–64.5%)	61.7% (57.8–65.4%)	45.5% (37.5–53.7%)	51.5% (46.1–56.9%)
Socioeconomic Factors					
Education					
Less than high school	23.9% (22.5–25.5%)	21.3% (19.4–23.3%)	26.8% (24.8–28.8%)	21.9% (17.5–27.0%)	33.5% (28.7–38.6%)
High school or equivalent	26.0% (24.3–27.8%)	24.9% (22.6–27.4%)	27.2% (24.5–30.1%)	26.0% (20.7–32.0%)	28.5% (24.5–32.9%)
Some college/associate's degree	30.8% (29.1–32.6%)	32.0% (29.5–34.7%)	30.9% (28.2–33.7%)	30.0% (24.5–36.2%)	22.8% (19.3–26.7%)
College degree	19.3% (17.6–21.0%)	21.8% (19.5–24.2%)	15.2% (13.3–17.3%)	22.1% (15.6–30.3%)	15.2% (11.5–19.8%)
Employed	44.5% (42.5–46.5%)	52.5% (49.9–55.1%)	37.6% (34.2–41.0%)	41.9% (34.8–49.4%)	16.0% (12.3–20.5%)
Insurance coverage	88.0% (86.9–89.1%)	86.9% (85.4–88.2%)	88.7% (87.0–90.2%)	87.2% (82.0–91.1%)	94.5% (92.3–96.1%)
Lifestyle Factors					
Smoking status					
Never	49.4% (47.5–51.2%)	50.0% (47.1–52.9%)	45.3% (42.3–48.4%)	60.9% (54.7–66.7%)	52.5% (47.8–57.2%)
Former	34.1% (32.4–35.9%)	32.2% (29.5–35.0%)	37.2% (34.5–40.1%)	29.4% (24.0–35.4%)	39.1% (34.6–43.8%)
Current	16.5% (15.4–17.7%)	17.8% (16.1–19.7%)	17.5% (15.7–19.4%)	9.7% (6.8–13.8%)	8.4% (6.0–11.6%)
Anthropometrics/Laboratory					
BMI, kg/m^2	33.1 (32.8–33.4)	33.1 (32.7–33.4)	33.1 (32.6–33.6)	33.2 (32.0–34.3)	32.8 (31.9–33.6)
HbA1c, %	7.4 (7.3–7.4)	7.2 (7.2–7.3)	7.7 (7.6–7.8)	7.0 (6.8–7.1)	7.2 (7.1–7.4)
SBP, mmHg	129.9 (129.1–130.6)	126.5 (125.6–127.4)	134.9 (133.4–136.3)	127.3 (125.2–129.4)	136.3 (134.2–138.3)
Total cholesterol, mg/dL	185.1 (183.3–186.9)	187.4 (185.1–189.6)	187.4 (184.6–190.2)	171.2 (166.5–175.8)	170.0 (165.3–174.6)
Comorbidities					

		No Anemia (n=5,527 [86.5%])		Anemia (n=1,191 [13.5%])	
	All (n=6,718)	**No CKD (n=3,400 [55.5%])**	**CKD (n=2,127 [31.0%])**	**No CKD (n=447 [5.7%])**	**CKD (n=744 [7.9%])**
Angina	7.4% (6.5–8.5%)	6.1% (4.9–7.6%)	9.3% (7.5–11.4%)	7.8% (3.9–14.8%)	9.4% (7.0–12.6%)
Congestive heart failure	8.8% (8.0–9.8%)	4.4% (3.5–5.5%)	13.7% (11.7–16.0%)	8.6% (6.2–11.8%)	21.4% (18.1–25.0%)
Coronary heart disease	11.2% (9.9–12.6%)	8.2% (6.6–10.0%)	15.0% (12.9–17.3%)	10.1% (6.2–16.2%)	18.7% (14.9–23.3%)
Myocardial infarction	10.5% (9.5–11.6%)	8.2% (6.8–9.8%)	13.3% (11.4–15.4%)	6.9% (4.5–10.3%)	19.0% (15.6–22.9%)
Stroke	8.2% (7.3–9.2%)	5.2% (4.3–6.3%)	10.9% (9.2–13.0%)	6.9% (4.6–10.4%)	20.3% (16.6–24.7%)
CKD Stage					
No CKD	61.4% (59.8–63.0%)	100%	0%	100%	0%
Stage 1–2	19.8% (18.4–21.3%)	-	57.0% (53.8–60.1%)	-	28.6% (24.4–33.1%)
Stage 3–5	18.8% (17.7–20.0%)	-	43.0% (39.9–46.2%)	-	71.4% (66.9–75.6%)

Means and 95% confidence intervals are shown for continuous variables; proportions and 95% confidence intervals are shown for categorical variables. Proportions in column headers are weighted percentages of row totals. Variance estimates are adjusted for the complex survey design. Abbreviations: BMI = body mass index, CKD = chronic kidney disease, NHANES = National Health and Nutrition Examination Survey, SBP = systolic blood pressure.

Table 2 –

Adjusted odds ratios for anemia among adults with diabetes, NHANES 2003-March 2020 (n=6,718).

	Model 1	Model 2
	Odds Ratio (95% CI)	**Odds Ratio (95% CI)**
No CKD (ref.)	-	-
CKD stages 1–2	1.17 (0.92–1.49)	1.37 (1.07–1.76)
CKD stages 3–5	3.43 (2.70–4.36)	3.44 (2.67–4.43)
Age, per 5-year increase	1.10 (1.06–1.14)	1.05 (1.01–1.10)
Female vs. male	1.12 (0.94–1.34)	1.20 (1.00–1.45)
Race/ethnicity		
Hispanic	1.50 (1.14–1.96)	1.49 (1.14–1.95)
Non-Hispanic Black	3.28 (2.63–4.10)	3.48 (2.78–4.34)
Non-Hispanic Other	1.24 (0.90–1.70)	1.22 (0.88–1.70)
Non-Hispanic White (ref.)	-	-
Education		
Less than high school (ref.)		-
High school or equivalent		0.94 (0.73–1.22)
Some college/associate's degree		0.79 (0.62–1.00)
College degree		0.87 (0.63–1.19)
Smoking status		
Never (ref.)		-
Former		0.84 (0.67–1.05)
Current		0.49 (0.35–0.68)
BMI, per 5 kg/m^2 increase		0.98 (0.92–1.06)
HbA1c, per 1% increase		0.91 (0.86–0.97)
Total cholesterol, per 10 mg/dL increase		0.92 (0.90–0.95)

Variance estimates account for the complex survey design.

Abbreviations: BMI = body mass index, CI = confidence interval, CKD = chronic kidney disease, NHANES = National Health and Nutrition Examination Survey.