Supplementary material for:

Diabetes and chronic kidney disease in the US population, 2009-2014

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Supplemental Figure 1. Flow diagram of selection of final analytic population
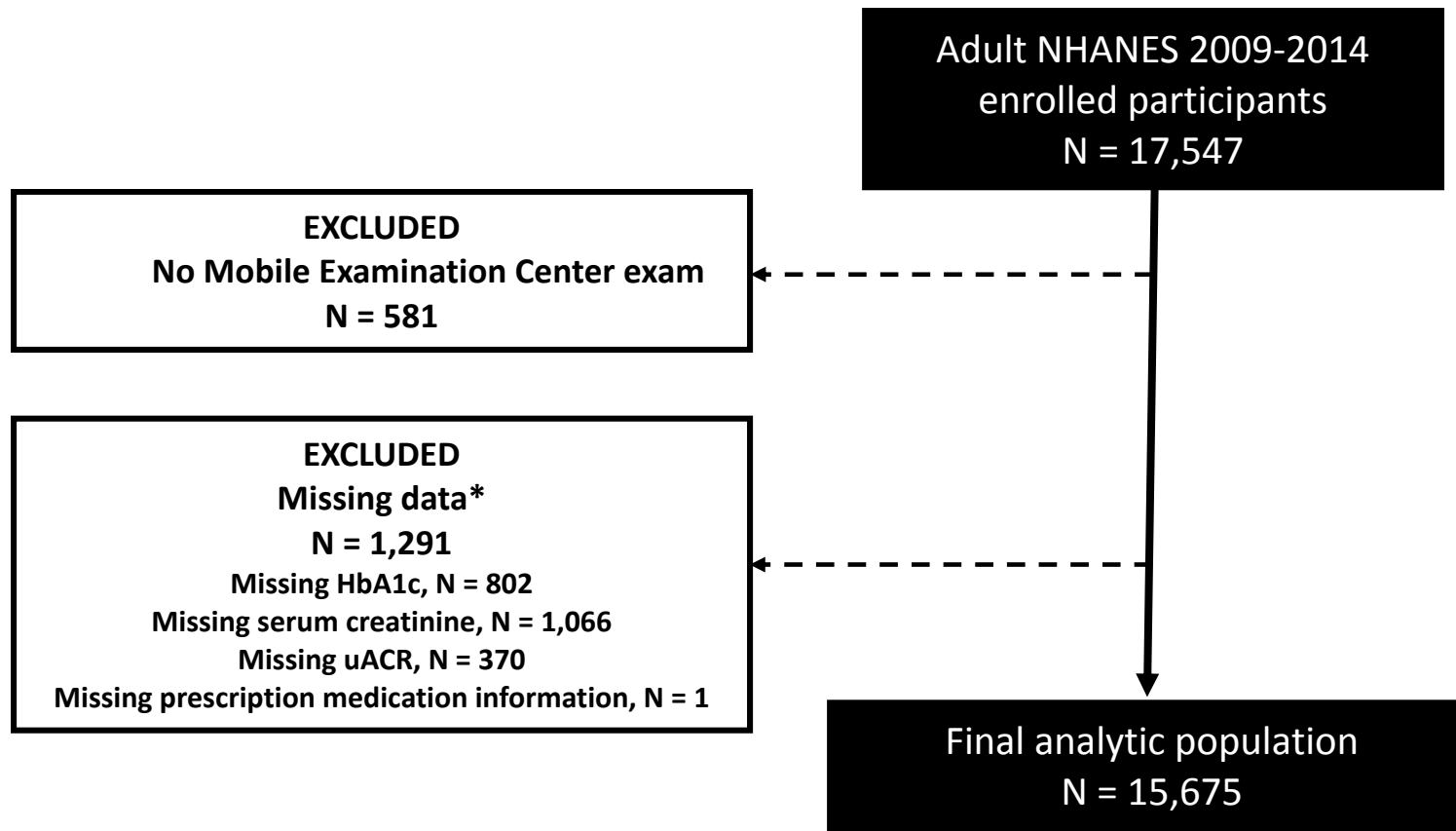
ACR = albumin-creatinine ratio
*Participants were required to have complete information for listed data elements in order to be included in final analytic population; some participants had multiple missing measurements.

Supplemental Table 1. Characteristics of adult 2009-2014 NHANES participants included and excluded from analysis population

	All adult 2009-2014 NHANES participants (N = 17,547)		Excluded from analysis population (N = 1,872)		Included in analytic population (N = 15,675)	
	N	Weighted proportion (95% CI) or mean (95% CI)	N	Weighted proportion (95% CI) or mean (95% CI)	N	Weighted proportion (95% CI) or mean (95% CI)
Demographic variables						
Age, weighted mean, y		47.3 (46.6, 48.0)		48.8 (46.9, 50.6)		47.2 (46.5, 47.9)
Female sex, %	9,043	52 (51, 53)	999	57 (53, 61)	8,044	52 (51, 52)
Race/ethnicity, %						
White (non-Hispanic)	7,489	67 (63, 71)	665	55 (49, 61)	6,824	68 (63, 72)
Black (non-Hispanic)	3,754	11 (10, 13)	554	22 (18, 26)	3,200	11 (9, 13)
Mexican-American	2,447	9 (6, 11)	210	8 (5, 10)	2,237	9 (6, 11)
Medical history						
History of hypertension	6,340	32 (31, 33)	765	39 (35, 43)	5,575	32 (30, 33)
Duration of hypertension, y		11.1 (10.6, 11.5)		12.9 (11.5, 14.3)		10.9 (10.5, 11.4)
Medication use						
Antihypertensive medications, %	5,622	28 (27, 30)	708	35 (32, 39)	4,914	28 (26, 29)
RAS inhibitors, %	3,693	19 (17, 20)	417	20 (17, 23)	3,276	18 (17, 20)
ACE inhibitors	2,374	12 (11, 13)	246	11 (9, 14)	2,128	12 (11, 13)
Angiotensin receptor blockers	1,266	6.2 (5.5, 6.9)	165	8.9 (6.5, 11.3)	1,101	6.0 (5.4, 6.7)
Blood pressure						
Systolic blood pressure, mmHg		121.5 (120.9, 122.1)		125.3 (123.2, 127.4)		121.3 (120.7, 121.9)
Diastolic blood pressure, mmHg		70.2 (69.6, 70.8)		69.6 (68.7, 70.5)		70.2 (69.6, 70.9)

Diabetes is defined to be use of antidiabetic medications or a HbA1c ≥ 6.5%.

Cell contents are raw numbers of participants, or weighted proportion or mean (95% CI) of US adults included or excluded from analytic population with the indicated characteristic, as appropriate.

Abbreviations: RAS = renin angiotensin system; ACE = angiotensin-converting-enzyme.

Supplemental Table 2. Persistence of clinical manifestations of chronic kidney disease, by diabetes status.

	Number with abnormality during main NHANES examination*	Number with persistent abnormality during repeat testing	Proportion with persistent abnormality
Albuminuria (ACR≥ 30 mg/g)			
No diabetes	320	134	0.42
Diabetes	205	121	0.59
Macroalbuminuria (ACR ≥ 300 mg/g)			
No diabetes	40	20	0.50
Diabetes	47	34	0.72
Estimated GFR < 60 mL/min/1.73 m^2			
No diabetes	136	63	0.46
Diabetes	42	25	0.60
Estimated GFR < 30 mL/min/1.73 m^2			
No diabetes	6	6	1.00
Diabetes	3	3	1.00
Any chronic kidney disease			
No diabetes	N/A	N/A	0.47
Diabetes	N/A	N/A	0.65

*Only participants who underwent two measurements of urine ACR (or eGFR) were included in this analysis; no participants had two measurements of both urine ACR and serum. 4,268 non-diabetic and 727 diabetics NHANES 2009-2010 participants were used for evaluation of urine albumin-creatinine ratio (ACR); 2,483 non-diabetic and 304 diabetic NHANES III (1988-1994) participants were used for evaluation of estimated glomerular filtration rate (eGFR). Proportion with persistent abnormality is defined as the proportion of participants in each category with abnormal values whose values were also abnormal on repeat testing.

Supplemental Figure 2. Persistence of albuminuria and low GFR, by diabetes status.
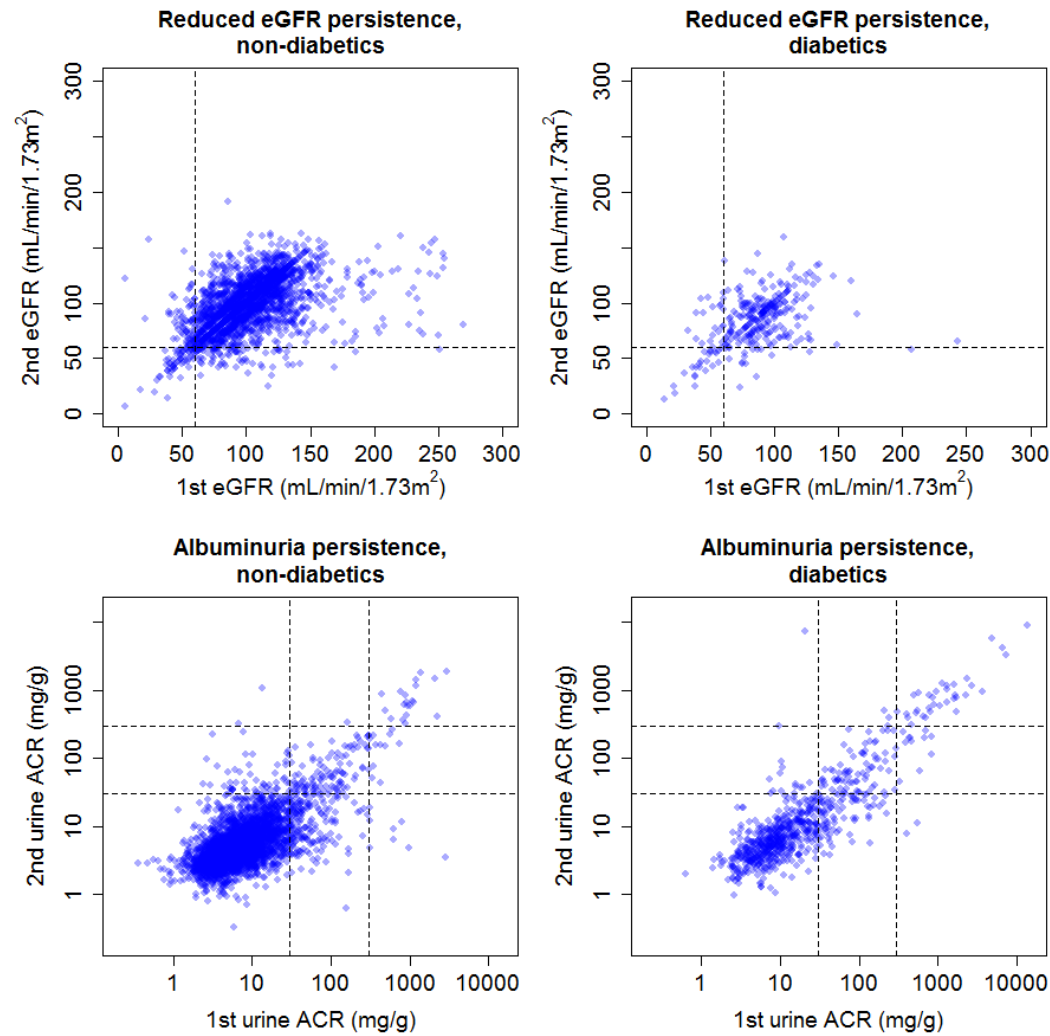
For estimated glomerular filtration rate (GFR) plots, dashed lines indicate the threshold for low eGFR (<60 mL/min/1.73m^2). In albuminuria plots, dashed lines indicate thresholds for microalbuminuria (ACR ≥30 mg/g) and macroalbuminuria (ACR ≥300 mg/g), and units are mg albumin per gram creatinine. The first urine albumin-creatinine ratio (ACR) measurement was made from spot urine samples collected during the Mobile Examination Center examination at any time of day, while the second urine ACR measurement was made from spot urine samples collected at home as a first-morning void.

Supplemental Table 3. Associations of diabetes mellitus with chronic kidney disease among adults in the United States, by age, sex, and race/ethnicity strata.

	N with abnormality		Unadjusted prevalence (%) (95% CI)		Adjusted prevalence ratio (95% CI)	Adjusted difference in prevalence (%) (95% CI)	Adjusted attributable risk (%) (95% CI)
	No diabetes	Diabetes	No diabetes	Diabetes	Model 1	Model 1	Model 1
Albuminuria (ACR≥ 30 mg/g)							
Age							
< 65 years	683	339	2.1 (1.8, 2.4)	13 (11, 15)	5.32 (4.47, 6.33)	11 (9, 12)	81 (78, 84)
≥ 65 years	456	339	6.2 (5.2, 7.3)	17 (14, 20)	2.96 (2.46, 3.56)	11 (9, 13)	66 (60, 72)
Sex							
Female	647	299	3.2 (2.7, 3.7)	14 (12, 17)	3.38 (2.80, 4.07)	10 (8, 12)	70 (65, 76)
Male	492	379	2.2 (1.8, 2.6)	15 (13, 18)	5.13 (4.25, 6.19)	12 (10, 14)	80 (77, 84)
Race/ethnicity							
White	507	233	2.6 (2.1, 3.0)	14 (11, 16)	4.23 (3.52, 5.09)	10 (9, 12)	76 (72, 81)
Black	241	181	3.4 (2.8, 4.0)	17 (14, 19)	3.62 (3.00, 4.36)	12 (10, 14)	72 (67, 77)
Mexican-American	147	137	3.0 (2.3, 3.6)	18 (14, 22)	4.59 (3.80, 5.55)	14 (12, 16)	78 (74, 82)
Estimated GFR < 60 mL/min/1.73 m²							
Age							
< 65 years	170	117	0.7 (0.5, 0.9)	5.4 (3.5, 7.3)	3.62 (2.74, 4.78)	3.8 (2.5, 5.1)	72 (64, 80)
≥ 65 years	695	378	11 (9, 14)	23 (18, 29)	2.14 (1.58, 2.88)	12 (6, 17)	53 (38, 68)
Sex							
Female	469	243	2.7 (2.2, 3.3)	13 (9, 16)	2.35 (1.75, 3.17)	6.8 (4.0, 9.7)	57 (44, 70)
Male	396	252	2.0 (1.6, 2.5)	12 (9, 15)	2.42 (1.79, 3.26)	6.3 (3.6, 8.9)	58 (45, 71)
Race/ethnicity							
White	605	209	3.0 (2.4, 3.6)	14 (10, 18)	2.28 (1.69, 3.08)	7.3 (4.2, 10.3)	56 (42, 70)
Black	114	134	1.4 (1.0, 1.7)	12 (9, 16)	2.99 (2.20, 4.06)	7.6 (4.9, 10.4)	66 (55, 77)
Mexican-American	51	58	0.8 (0.5, 1.1)	6.4 (4.1, 8.7)	2.33 (1.70, 3.18)	2.8 (1.4, 4.3)	57 (42, 71)
Any chronic kidney disease							
Age							
< 65 years	808	398	2.8 (2.4, 3.1)	17 (15, 20)	4.35 (3.81, 4.97)	13 (11, 15)	77 (74, 80)
≥ 65 years	972	546	16 (14, 18)	35 (31, 40)	2.19 (1.84, 2.61)	19 (14, 23)	54 (46, 62)
Sex							

Female	1,002	448	5.7 (5.0, 6.4)	24 (21, 28)	2.53 (2.15, 2.98)	14 (12, 17)	60 (54, 67)
Male	778	496	4.1 (3.5, 4.6)	24 (21, 27)	3.14 (2.66, 3.70)	16 (13, 18)	68 (63, 73)
Race/ethnicity							
White	970	347	5.3 (4.6, 5.9)	24 (21, 28)	2.76 (2.33, 3.28)	15 (12, 18)	64 (58, 70)
Black	324	259	4.6 (3.9, 5.3)	26 (22, 30)	2.79 (2.39, 3.26)	17 (15, 20)	64 (58, 70)
Mexican-American	174	160	3.6 (2.9, 4.3)	22 (18, 26)	2.99 (2.57, 3.47)	15 (13, 17)	67 (61, 72)

Cell contents are raw numbers of participants, weighted proportion (95% CI) of US adults with and without diabetes who have the indicated clinical manifestation, adjusted prevalence ratios, adjusted differences in prevalence, and risk of CKD attributable to diabetes. All estimates of prevalence take into account information on the persistence of albuminuria, reduced eGFR, or both. Any chronic kidney disease was defined as a urine albumin to creatinine ratio (ACR) ≥30 mg/g or estimated glomerular filtration rate (GFR) <60 mL/min/1.73m^2. Model 1 was adjusted for demographics and included adjustment for age, age^2, sex, race/ethnicity, and an interaction between the clinical manifestation and the stratum of interest.

Supplemental Table 4. Extent to which chronic kidney disease can be attributed to diabetes among adults in the United States, by age, sex, and race/ethnicity strata.

	Prevalence among all US adults	Prevalence among US adults without diabetes	Prevalence attributable to diabetes	Proportion attributable to diabetes
Albuminuria (ACR ≥ 30 mg/g)				
Age				
< 65 years	3.3 (2.9, 3.7)	2.4 (2.0, 2.8)	0.9 (0.7, 1.1)	27 (22, 33)
≥ 65 years	9.2 (8.2, 10.3)	6.4 (5.4, 7.5)	2.8 (2.0, 3.5)	30 (23, 38)
Sex				
Female	4.6 (4.0, 5.1)	3.6 (3.1, 4.2)	0.9 (0.7, 1.2)	21 (15, 26)
Male	4.1 (3.6, 4.7)	2.6 (2.1, 3.0)	1.6 (1.2, 1.9)	38 (31, 45)
Race/ethnicity				
White	3.9 (3.4, 4.4)	3.0 (2.5, 3.5)	0.9 (0.7, 1.2)	24 (18, 30)
Black	6.0 (5.2, 6.7)	4.0 (3.3, 4.6)	2.0 (1.5, 2.5)	34 (26, 41)
Mexican-American	5.3 (4.5, 6.1)	3.3 (2.6, 4.0)	2.0 (1.4, 2.5)	38 (29, 47)
Macroalbuminuria (ACR ≥ 300 mg/g)				
Age				
< 65 years	0.6 (0.4, 0.7)	0.3 (0.2, 0.4)	0.3 (0.2, 0.4)	55 (42, 69)
≥ 65 years	1.8 (1.4, 2.3)	0.8 (0.5, 1.2)	1.0 (0.6, 1.4)	55 (39, 71)
Sex				
Female	0.7 (0.5, 0.8)	0.4 (0.2, 0.5)	0.3 (0.2, 0.4)	43 (27, 59)
Male	0.9 (0.7, 1.2)	0.3 (0.2, 0.5)	0.6 (0.4, 0.8)	64 (51, 77)
Race/ethnicity				
White	0.6 (0.4, 0.8)	0.3 (0.1, 0.4)	0.3 (0.2, 0.5)	57 (41, 73)
Black	1.5 (1.0, 2.0)	0.6 (0.3, 0.9)	0.9 (0.5, 1.2)	57 (41, 74)
Mexican-American	1.2 (0.8, 1.6)	0.5 (0.2, 0.9)	0.7 (0.3, 1.0)	55 (35, 76)
Estimated GFR < 60 mL/min/1.73 m^2				
Age				
< 65 years	1.1 (0.9, 1.4)	0.8 (0.6, 1.0)	0.3 (0.2, 0.4)	27 (16, 38)
≥ 65 years	15 (12, 17)	12 (9, 14)	3.0 (1.4, 4.6)	21 (10, 31)
Sex				
Female	3.9 (3.2, 4.5)	3.0 (2.4, 3.7)	0.8 (0.4, 1.2)	21 (12, 31)
Male	3.1 (2.5, 3.7)	2.4 (1.8, 2.9)	0.7 (0.3, 1.1)	23 (12, 35)
Race/ethnicity				

White	4.1 (3.4, 4.7)	3.3 (2.6, 4.0)	0.8 (0.4, 1.2)	19 (9, 28)
Black	3.1 (2.5, 3.8)	2.0 (1.5, 2.5)	1.1 (0.6, 1.7)	35 (21, 49)
Mexican-American	1.3 (1.0, 1.7)	0.8 (0.5, 1.1)	0.6 (0.3, 0.9)	42 (24, 59)
Any chronic kidney disease				
Age				
< 65 years	4.3 (3.8, 4.7)	3.3 (2.9, 3.8)	0.9 (0.7, 1.2)	22 (16, 28)
≥ 65 years	22 (19, 24)	16 (14, 18)	5.7 (4.2, 7.1)	26 (20, 32)
Sex				
Female	7.9 (7.1, 8.7)	6.4 (5.6, 7.2)	1.5 (1.1, 1.9)	19 (14, 24)
Male	6.7 (6.0, 7.4)	4.6 (4.0, 5.3)	2.0 (1.6, 2.5)	31 (25, 37)
Race/ethnicity				
White	7.5 (6.7, 8.3)	5.9 (5.2, 6.7)	1.6 (1.2, 2.0)	21 (16, 26)
Black	8.4 (7.5, 9.4)	5.8 (5.0, 6.7)	2.6 (1.9, 3.3)	31 (24, 38)
Mexican-American	6.3 (5.4, 7.2)	4.2 (3.4, 4.9)	2.1 (1.4, 2.8)	34 (25, 43)

Estimates and confidence intervals are based on 500 bootstrap samples, and incorporate bootstrap estimates of persistence. Estimates for prevalence among US adults without diabetes are standardized for age, sex, and race/ethnicity to US population, as appropriate, within each stratum. Prevalence attributable to diabetes is defined as the difference in prevalence among all US adults and US adults without diabetes; proportion attributable to diabetes is defined as the ratio of the prevalence attributable to diabetes to the prevalence among all US adults. Abbreviations: ACR = albumin-creatinine ratio; GFR = glomerular filtration rate.