

Supplemental Online Content

Chu CD, Xia F, Du Y, et al. Estimated prevalence and testing for albuminuria in US adults at risk for chronic kidney disease. *JAMA Netw Open*. 2023;6(7):e2326230. doi:10.1001/jamanetworkopen.2023.26230

eTable 1. Diagnosis Code List for Variable Definition

eTable 2. Characteristics of Included and Excluded Optum® EHR Study Population

eTable 3. Study Population Characteristics of Optum® EHR Patients by Diabetes Status

eTable 4. Population Characteristics of NHANES Participants with Hypertension or Diabetes, 2007-2018

eTable 5. Albuminuria Prevalence, Testing Rates, and Detection Rates

eTable 6. Albuminuria Prevalence, Testing, and Detection by Diabetes Status

eTable 7. Baseline Characteristics for Secondary Analysis Including Optum® EHR Patients Having ≥ 1 Year Follow-Up

eTable 8. Albuminuria Prevalence, Testing, and Detection, Using Optum® EHR-Derived Prediction Model

eFigure 1. Consort Diagram – Optum® EHR Study Population

eFigure 2. Consort Diagram – NHANES Study Population

eFigure 3. Calibration Plots for Albuminuria Prediction Model

eFigure 4. Estimated Albuminuria Prevalence and Proportion Detected by Diabetes Status (Optum® EHR; N = 192,108)

eFigure 5. Calibration Plot for Optum® Electronic Health Record Derived Albuminuria Prediction Model

This supplemental material has been provided by the authors to give readers additional information about their work.

eTable 1. Diagnosis Code List for Variable Definition

Condition	Codes
End-Stage Kidney Disease (includes dialysis and kidney transplant)	CPT-4: 90935, 90937, 90945, 90947, 99512 ICD-10: I12.0, I13.11, I13.2, N18.5, N18.6, Z49x, Z91.15, Z94.0, Z99.2, T86.1x ICD-10-PCS: 0TYx, 3E1M39Z, 5A1D60Z, 5A1D70Z, 5A1D80Z, 5A1D90Z
Diabetes Type 1	ICD-10: E10x
Diabetes Type 2	ICD-10: E11x
Diabetes (unspecified type)	ICD-10: E08x, E09x, E13x
Hypertension	ICD-10: I10.x, I11.x, I12.x, I13.x, I15.x, I16.x
Coronary Heart Disease	ICD-10: I21.x, I22.x, I23.x, I25.x
Heart Failure	ICD-10: I09.81, I11.0, I13.0, I13.2, I50
Cerebrovascular Disease	ICD-10: I60.x, I61.x, I62.x, I63.x

Abbreviations: CPT = Current Procedural Terminology, ICD = International Classification of Disease.

eTable 2. Characteristics of Included and Excluded Optum® EHR Study Population

Characteristic	Included	Excluded
N	192,108	103,089
Age, years	60.3 ±15.1	58.3 ± 16.5
Sex		
Female	105,591 (55.0)	56,676 (55.0)
Male	86,517 (45.0)	46,299 (44.9)
Race and Ethnicity		
Black	21,001 (10.9)	10,375 (10.1)
Hispanic	8,153 (4.2)	4,636 (4.5)
White	152,655 (79.5)	80,511 (78.1)
Other ¹	10,299 (5.4)	7,567 (7.3)
Insurance		
Commercial	112,370 (58.5)	63,312 (61.4)
Medicaid	12,925 (6.7)	6,972 (6.8)
Medicare	58,307 (30.4)	24,126 (23.4)
Uninsured	3,856 (2.0)	2,675 (2.6)
Other/Unknown	4,650 (2.4)	6,004 (5.8)
Current smoker	22,443 (11.7)	9,410 (9.1)
Systolic BP, mm Hg	131 ± 13	131 ± 15
Diastolic BP, mm Hg	77 ± 8	78 ± 10
Heart failure	13,307 (6.9)	5,303 (5.1)
Coronary artery disease	28,010 (14.6)	12,730 (12.3)
Hypertension only	141,601 (73.7)	88,723 (86.1)
Diabetes only	6,519 (3.4)	3,057 (3.0)
Hypertension and diabetes	43,988 (22.9)	11,309 (11.0)

Note: Results presented as mean ± standard deviation or n (%). All comparisons are statistically significant to p <0.01 except sex (p=0.70).

¹Other includes American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander.

Abbreviations: BP = diastolic blood pressure; DM = diabetes mellitus; eGFR = estimated glomerular filtration rate; EHR = electronic health record; HTN = hypertension.

eTable 3. Study Population Characteristics of Optum® EHR Patients by Diabetes Status

Characteristic	Diabetes	No Diabetes
N	50,507	141,601
Age, years	61.3 ± 13.7	59.9 ± 15.5
Sex		
Female	25,166 (49.8)	80,425 (56.8)
Male	25,341 (50.2)	61,176 (43.2)
Race and Ethnicity		
Black	6,767 (13.4)	14,234 (10.1)
Hispanic	3,257 (6.5)	4,896 (3.5)
White	37,346 (73.9)	115,309 (81.4)
Other ¹	3,137 (6.2)	7,162 (5.1)
Insurance		
Commercial	27,764 (55.0)	84,606 (59.8)
Medicaid	3,835 (7.6)	9,090 (6.4)
Medicare	16,669 (33.0)	41,368 (29.4)
Uninsured	1,347 (2.7)	2,509 (1.8)
Other/Unknown	892 (1.8)	3,758 (2.7)
Current smoker	5,868 (11.6)	16,575 (11.7)
eGFR, ml/min/1.73m ²	82 ± 23	84 ± 21
eGFR Category, ml/min/1.73m ²		
≥60	40,745 (80.1)	122,861 (86.8)
45-59	5,893 (11.7)	12,816 (9.1)
30-44	3,141 (6.2)	4,851 (3.4)
<30	728 (1.4)	1,073 (0.8)
Systolic BP, mm Hg	131 ± 13	131 ± 13
Diastolic BP, mm Hg	75 ± 8	77 ± 9
Heart failure	4,814 (9.5)	8,493 (6.0)
Coronary artery disease	9,585 (19.0)	18,425 (13.0)
Albuminuria testing	26,410 (52.3)	7,219 (5.1)

Data are presented as mean ± standard deviation or n (%).

¹Other includes American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander.

Abbreviations: BP = blood pressure; eGFR = estimated glomerular filtration rate; EHR = electronic health record; NHANES = National Health And Nutrition Examination Survey

eTable 4. Population Characteristics of NHANES Participants with Hypertension or Diabetes, 2007-2018

Characteristic	Unweighted	Weighted
N	13,410	82,239,546
Age, years	60.0 ± 14.9	57.9 ± 14.9
Female	6,836 (51.0)	42,158,912 (51.3)
Race/Ethnicity		
Black	3,248 (24.2)	10,135,824 (12.3)
Hispanic	2,932 (21.9)	8,604,052 (10.5)
White	5,878 (43.8)	57,585,531 (70.0)
Other ¹	1,352 (10.1)	5,914,049 (7.2)
Insurance		
Commercial	4,355 (32.5)	35,287,814 (43.0)
Medicaid	1,068 (8.0)	4,970,063 (6.1)
Medicare	5,511 (41.1)	29,233,870 (35.6)
Uninsured	1,532 (11.4)	7,349,484 (9.0)
Other/Unknown	944 (7.0)	5,321,324 (6.5)
eGFR, ml/min/1.73m ²	85 ± 23	87 ± 22
Systolic BP, mm Hg	133 ± 20	131 ± 19
Diastolic BP, mm Hg	71 ± 15	72 ± 14
Heart failure	854 (6.4)	4,295,330 (5.2)
Coronary artery disease	1,104 (8.2)	6,351,763 (7.7)
Hypertension only	8,725 (65.1)	58,146,831 (70.7)
Diabetes only	841 (6.3)	4,751,037 (5.8)
Hypertension and diabetes	3,844 (28.7)	19,341,588 (23.5)

¹Other includes American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander.

Data are presented as mean ± standard deviation or n (%). Weighted figures are accounting for complex survey design used by NHANES to obtain nationally representative estimates.

Abbreviations: BP = blood pressure; eGFR = estimated glomerular filtration rate; NHANES = National Health And Nutrition Examination Survey.

eTable 5. Albuminuria Prevalence, Testing Rates, and Detection Rates

Stratum	N	N tested (%)	Tested, observed albuminuria	Untested, predicted albuminuria	Albuminuria prevalence in stratum (%)	Albuminuria detection rate (%)
Overall	192,108	33,629 (17.5)	11,525	21,231	17.1	35.2
Sex						
Male	86,517	16,683 (19.3)	6,045	10,039	18.6	37.6
Female	105,591	16,946 (16.0)	5,480	11,192	15.8	32.9
Age (years)						
18-49	43,583	6,042 (13.9)	1,780	3,368	11.8	34.6
50-64	69,262	12,700 (18.3)	3,843	6,063	14.3	38.8
65-74	42,941	8,659 (20.2)	3,054	4,903	18.5	38.4
75+	36,322	6,228 (17.1)	2,848	6,895	26.8	29.2
Race and Ethnicity						
Black	21,001	4,644 (22.1)	1,573	2,607	19.9	37.6
Hispanic	8,153	2,100 (25.8)	765	951	21.0	44.6
White	152,655	24,801 (16.2)	8,407	16,373	16.2	33.9
Other	10,299	2,084 (20.2)	780	1,299	20.2	37.5
DM only	6,519	3,070 (47.1)	562	655	18.7	46.2
HTN only	141,601	7,219 (5.1)	1,742	14,939	11.8	10.4
DM + HTN	43,988	23,340 (53.1)	9,221	5,637	33.8	62.1
All DM	50,507	26,410 (52.3)	9,783	6,292	31.8	60.9
All HTN	185,589	30,559 (16.5)	10,963	20,576	17.0	34.8
eGFR (ml/min/1.73m²)						
eGFR 60+	163,606	27,283 (16.7)	8,143	14,604	13.9	35.8
eGFR 45-59	18,709	3,982 (21.3)	1,844	3,527	28.7	34.3
eGFR 30-44	7,992	1,939 (24.3)	1,192	2,363	44.5	33.5
eGFR <30	1,801	425 (23.6)	346	733	59.9	32.1

Albuminuria prevalence within each stratum was computed as $([n \text{ tested, observed albuminuria}] + [n \text{ untested, predicted albuminuria}]) / (N \text{ within stratum})$. Albuminuria detection rate is the percent of all albuminuria within a stratum that has detected by UACR testing. Abbreviations: DM = diabetes mellitus; eGFR = estimated glomerular filtration rate; HTN = hypertension; UACR = urine albumin/creatinine ratio.

eTable 6. Albuminuria Prevalence, Testing, and Detection by Diabetes Status

Stratum	N	N tested (%)	Tested, observed albuminuria	Untested, predicted albuminuria	Albuminuria prevalence in stratum (%)	Albuminuria detection rate (%)
Diabetes						
Male	25,341	13,453 (53.1)	5,230	3,206	33.3	62.0
Female	25,166	12,957 (51.5)	4,553	3,086	30.4	59.6
Age 18-49	9,471	4,796 (50.6)	1,556	874	25.7	64.0
Age 50-64	19,279	10,231 (53.1)	3,376	1,935	27.5	63.6
Age 65-74	12,726	6,833 (53.7)	2,629	1,651	33.6	61.4
Age 75+	9,031	4,550 (50.4)	2,222	1,831	44.9	54.8
Black	6,767	3,553 (52.5)	1,281	941	32.8	57.7
Hispanic	3,257	1,779 (54.6)	690	406	33.7	63.0
Other	3,137	1,656 (52.8)	662	425	34.7	60.9
White	37,346	19,422 (52.0)	7,150	4,519	31.2	61.3
eGFR 60+	40,745	21,583 (53)	7,064	3,981	27.1	64.0
eGFR 45-59	5,893	3,055 (51.8)	1,526	1,104	44.6	58.0
eGFR 30-44	3,141	1,484 (47.2)	955	904	59.2	51.4
eGFR <30	728	288 (39.6)	238	301	74.0	44.2
No Diabetes						
Male	61,176	3,230 (5.3)	815	6,832	12.5	10.7
Female	80,425	3,989 (5)	927	8,106	11.2	10.3
Age 18-49	34,112	1,246 (3.7)	224	2,494	8.0	8.2
Age 50-64	49,983	2,469 (4.9)	467	4,128	9.2	10.2
Age 65-74	30,215	1,826 (6)	425	3,252	12.2	11.6
Age 75+	27,291	1,678 (6.1)	626	5,064	20.8	11.0
Black	14,234	1,091 (7.7)	292	1,665	13.7	14.9
Hispanic	4,896	321 (6.6)	75	545	12.7	12.1
Other	7,162	428 (6.0)	118	873	13.8	11.9
White	115,309	5,379 (4.7)	1,257	11,854	11.4	9.6
eGFR 60+	122,861	5,700 (4.6)	1,079	10,623	9.5	9.2
eGFR 45-59	12,816	927 (7.2)	318	2,423	21.4	11.6
eGFR 30-44	4,851	455 (9.4)	237	1,459	35.0	14.0
eGFR <30	1,073	137 (12.8)	108	432	50.3	20.0

Albuminuria prevalence within each stratum was computed as $([n \text{ tested, observed albuminuria}] + [n \text{ untested, predicted albuminuria}]) / (N \text{ within stratum})$. Albuminuria detection rate is the percent of all albuminuria within a stratum that has detected by UACR testing.

Abbreviations: eGFR = estimated glomerular filtration rate; UACR = urine albumin/creatinine ratio.

eTable 7. Baseline Characteristics for Secondary Analysis including Optum® EHR Patients having ≥1 Year Follow Up

Characteristic	Overall	UACR tested	UACR untested
N	149,554	27,548	122,006
Female	83,403 (55.8)	13,982 (50.8)	69,421 (56.9)
Age, years	59.9 ± 14.9	61.7 ± 13.4	59.5 ± 15.2
Race and Ethnicity			
Black	16,314 (10.9)	3,905 (14.2)	12,409 (10.2)
Hispanic	6,123 (4.1)	1,616 (5.9)	4,507 (3.7)
White	119,608 (80.0)	20,399 (74.1)	99,209 (81.3)
Other ¹	7,509 (5.0)	1,628 (5.9)	5,881 (4.8)
Insurance,			
Commercial	90,732 (60.7)	15,610 (56.7)	75,122 (61.6)
Medicaid	10,090 (6.8)	1,736 (6.3)	8,354 (6.9)
Medicare	42,457 (28.4)	9,081 (33.0)	33,376 (27.4)
Other	1,856 (1.2)	259 (0.9)	1,597 (1.3)
Uninsured	2,573 (1.7)	527 (1.9)	2,046 (1.7)
Unknown	1,846 (1.2)	355 (1.2)	1,511 (1.2)
eGFR, ml/min/1.73m ²	84 ± 21	82 ± 22	85 ± 21
Systolic BP, mm Hg	131 ± 13	130 ± 16	130 ± 13
Diastolic BP, mm Hg	77 ± 8	76 ± 10	77 ± 8
Heart failure	5,194 (3.5)	1,092 (4.0)	4,102 (3.4)
Coronary artery disease	13,327 (8.9)	2,991 (10.9)	10,336 (8.5)
HTN only	110,891 (74.1)	6,031 (21.9)	104,860 (85.9)
DM only	4,385 (2.9)	2,238 (8.1)	2,147 (1.8)
HTN + DM	34,278 (22.9)	19,279 (70.0)	14,999 (12.3)

Note: Results presented as mean ± standard deviation or n (%)

¹Other includes American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander.

Abbreviations: BP = diastolic blood pressure; DM = diabetes mellitus; eGFR = estimated glomerular filtration rate; EHR = electronic health record; HTN = hypertension; NHANES = National Health And Nutrition Examination Survey.

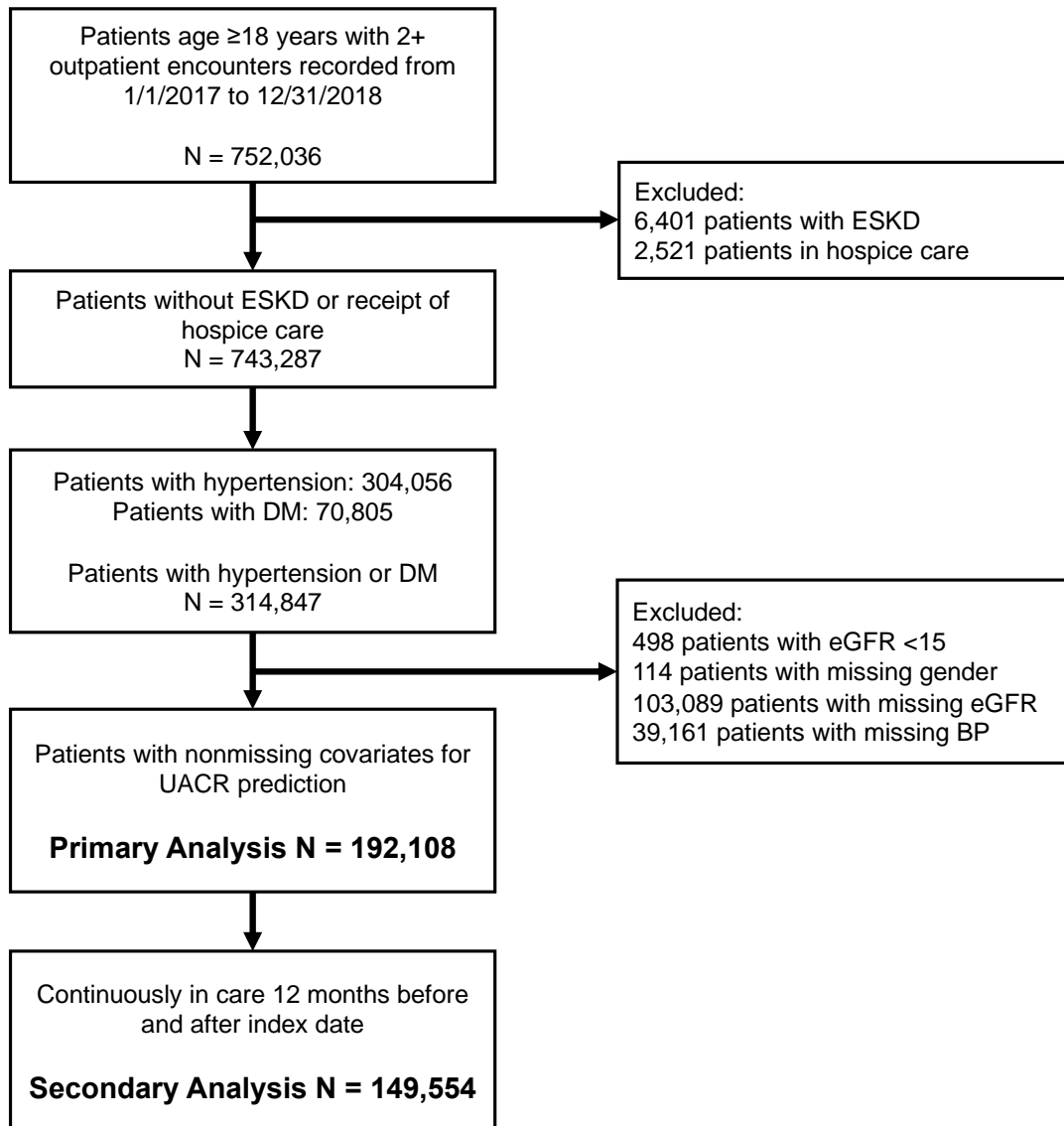
eTable 8. Albuminuria Prevalence, Testing, and Detection, using Optum® EHR-derived Prediction Model

Stratum	N	N tested (%)	Tested, observed albuminuria	Untested, predicted albuminuria	Albuminuria prevalence in stratum (%)	Albuminuria detection rate (%)
Overall	192,108	33,629 (17.5)	11,525	38,109	25.8	23.2
Male	86,517	16,683 (19.3)	6,045	18,352	28.2	24.8
Female	105,591	16,946 (16)	5,480	19,756	23.9	21.7
Age 18-49	43,583	6,042 (13.9)	1,780	7,227	20.7	19.8
Age 50-64	69,262	12,700 (18.3)	3,843	11,782	22.6	24.6
Age 65-74	42,941	8,659 (20.2)	3,054	8,450	26.8	26.5
Age 75+	36,322	6,228 (17.1)	2,848	10,648	37.2	21.1
Black	21,001	4,644 (22.1)	1,573	4,030	26.7	28.1
Hispanic	8,153	2,100 (25.8)	765	1,630	29.4	31.9
Other	10,299	2,084 (20.2)	780	2,256	29.5	25.7
White	152,655	24,801 (16.2)	8,407	30,191	25.3	21.8
DM only	6,519	3,070 (47.1)	562	1,033	24.5	35.2
HTN only	141,601	7,219 (5.1)	1,742	28,780	21.6	5.7
DM + HTN	43,988	23,340 (53.1)	9,221	8,296	39.8	52.6
eGFR 60+	163,606	27,283 (16.7)	8,143	28,234	22.2	22.4
eGFR 45-59	18,709	3,982 (21.3)	1,844	5,594	39.8	24.8
eGFR 30-44	7,992	1,939 (24.3)	1,192	3,334	56.6	26.3
eGFR <30	1,801	425 (23.6)	346	945	71.7	26.8

Albuminuria prevalence within each stratum was computed as $([n \text{ tested, observed albuminuria}] + [n \text{ untested, predicted albuminuria}]) / (N \text{ within stratum})$. Albuminuria detection rate is the percent of all albuminuria within a stratum that has detected by UACR testing.

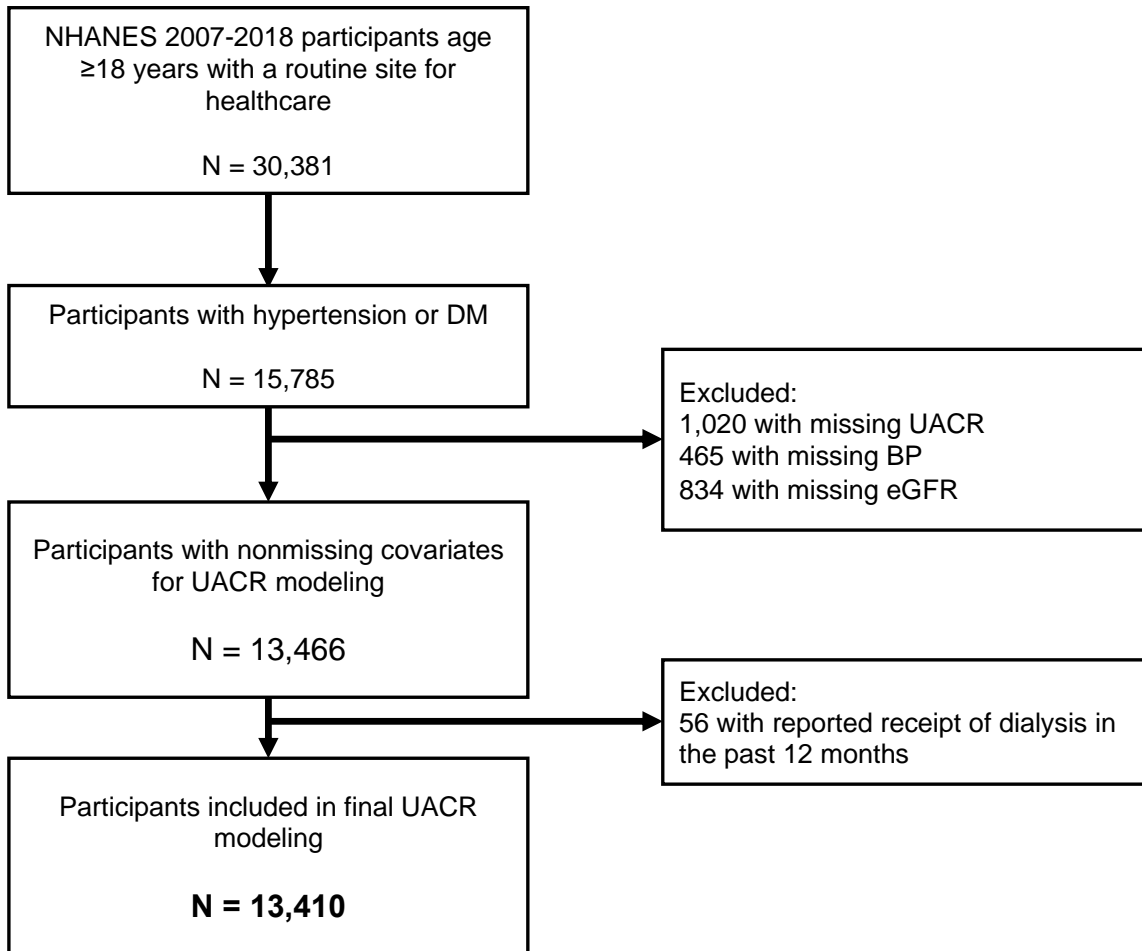
Abbreviations: DM = diabetes mellitus; eGFR = estimated glomerular filtration rate; EHR = electronic health record; HTN = hypertension; UACR = urine albumin/creatinine ratio.

eFigure 1. Consort Diagram – Optum® EHR Study Population



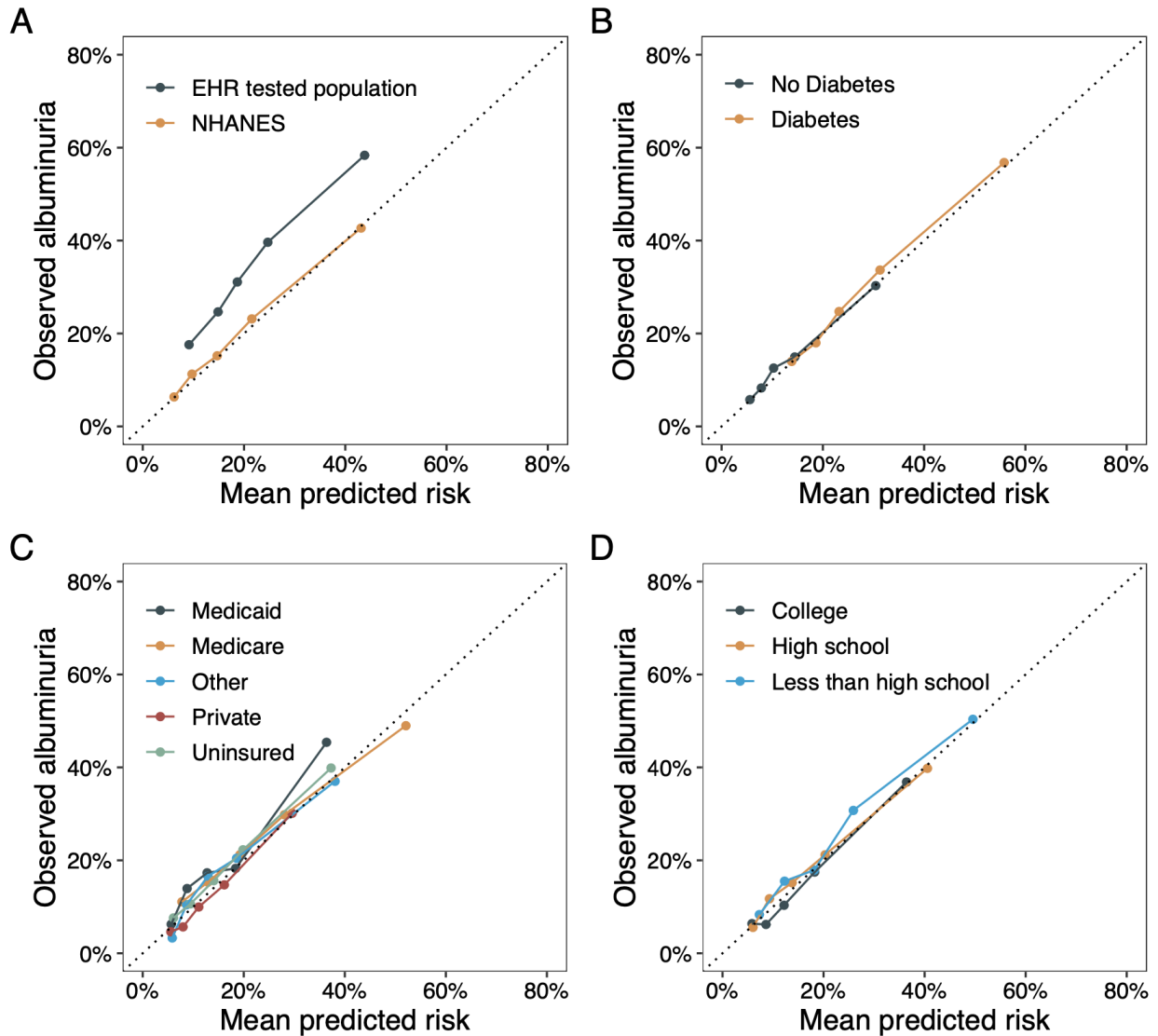
Abbreviations: BP = blood pressure; DM = diabetes mellitus; eGFR = estimated glomerular filtration rate; EHR = electronic health record; ESKD = end-stage kidney disease; UACR = urine albumin/creatinine ratio.

eFigure 2. Consort Diagram – NHANES Study Population



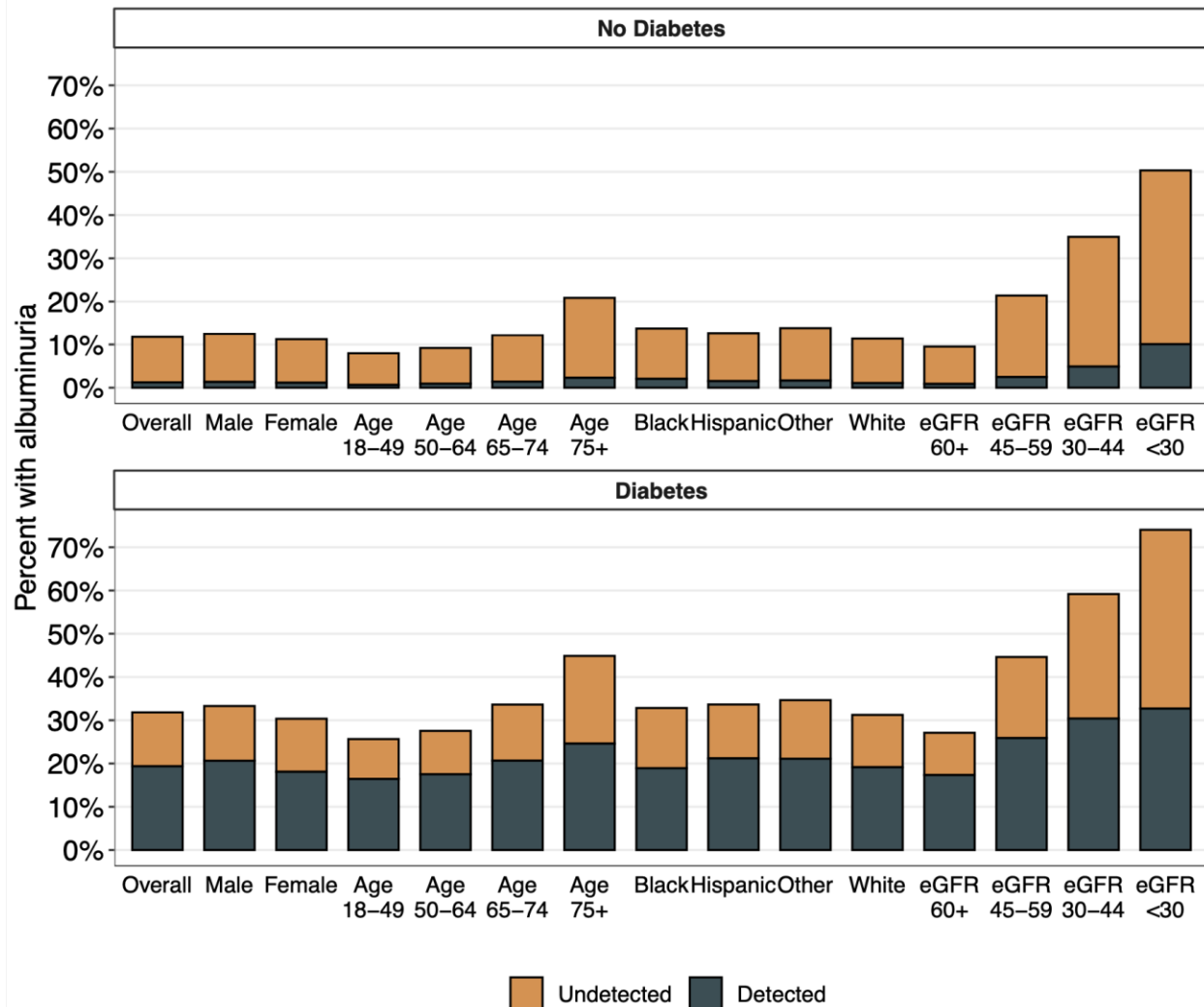
Abbreviations: BP = blood pressure; DM = diabetes mellitus; eGFR = estimated glomerular filtration rate; NHANES = National Health And Nutrition Examination Survey; UACR = urine albumin/creatinine ratio.

eFigure 3. Calibration Plots for Albuminuria Prediction Model



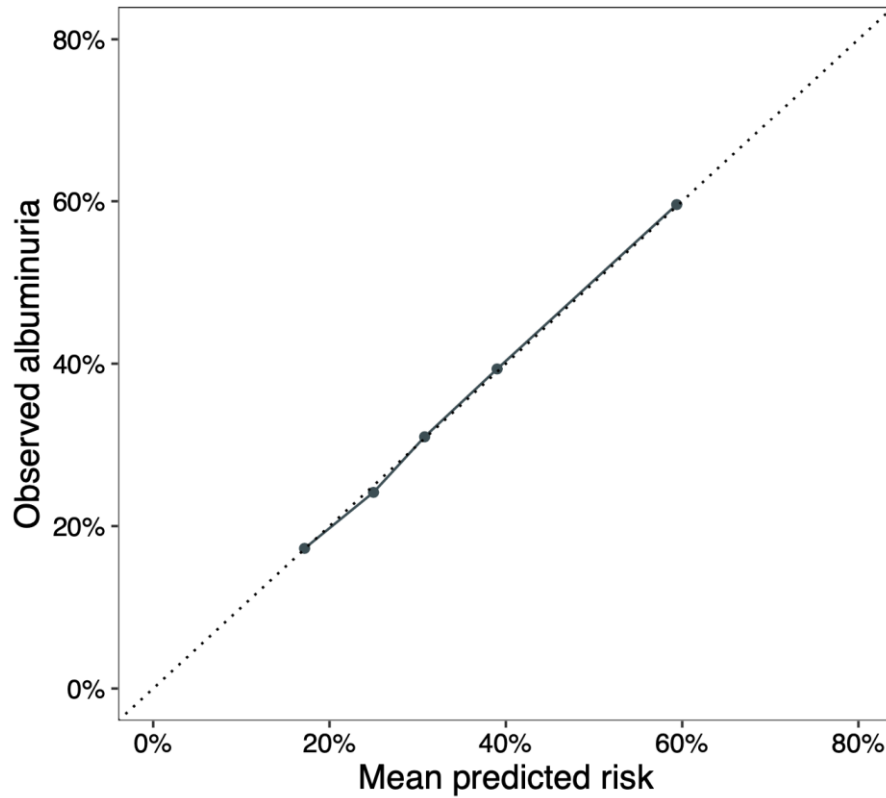
Panel A shows calibration of the albuminuria risk model internally in NHANES and externally in Optum EHR data. Panels B-D: Model calibration in NHANES was assessed stratified by diabetes status, insurance type, and education level respectively, as these subpopulations may potentially have different albuminuria testing rates. The diagonal line denotes perfect agreement between predicted and observed risk. Abbreviations: EHR = electronic health record; NHANES = National Health And Nutrition Examination Survey.

eFigure 4. Estimated Albuminuria Prevalence and Proportion Detected by Diabetes Status (Optum® EHR; N = 192,108)



Detected albuminuria prevalence refers to tested patients having albuminuria ≥ 30 mg/g. Undetected albuminuria prevalence is the estimated prevalence of albuminuria ≥ 30 mg/g based on patient characteristics among the untested population. Abbreviations: eGFR = estimated glomerular filtration rate; EHR = electronic health record.

eFigure 5. Calibration Plot for Optum[®] Electronic Health Record Derived Albuminuria Prediction Model



The diagonal line denotes perfect agreement between predicted and observed risk. The c-statistic for this model was 0.687 (95% confidence interval; 0.681, 0.693).