

Proposed Research Project

Title:

Racial Disparities in End-Stage Renal Disease

Introduction

Hypothesis Being Tested

Primary Hypothesis

This study hypothesizes that race is a significant predictor of the risk of developing End-Stage Renal Disease (ESRD).

Secondary Hypotheses

1. **APOL1 Risk Variants:** Apolipoprotein L1 (APOL1) risk variants, which are prevalent among individuals of African ancestry, are associated with an increased risk of ESRD[1]. This study will evaluate the role of comorbid conditions and exposures in the progression to ESRD among patients with high-risk APOL1 alleles.
2. **Proteinuria:** Recognizing proteinuria's established link to CKD progression, this study aims to investigate its specific role in racial disparities in ESRD incidence.
3. **Socioeconomic Factors:** This study will assess the impact of socioeconomic status on racial disparities in ESRD, examining how differences in socioeconomic variables influence ESRD risk and progression.

Background

Chronic kidney disease (CKD) is one of the fastest-growing chronic health conditions worldwide, particularly among minority populations, and is associated with substantially increased risks of end-stage renal disease (ESRD) and cardiovascular mortality [1]. Data from the United States Renal Data System (USRDS) show that the number of people living with end-stage kidney disease (ESKD) more than doubled between 2000 and 2019, increasing from 358,247 to 783,594. During the same period, new ESKD cases rose by 41.8 percent, from 92,660 to 131,422 [2].

Significant racial and ethnic disparities in ESKD rates persist [2]. Among Asian individuals, new ESKD cases surged from 2,507 in 2000 to 6,256 in 2019, an increase of 149.5 percent, representing the largest increase among any racial or ethnic group [2].

Similarly, new cases increased from 25,917 to 33,700 among Black individuals, from 11,297 to 20,790 among Hispanic individuals, from 742 to 1,458 among Native Hawaiian or other Pacific Islander individuals, and from 51,156 to 67,919 among White individuals [2]. Despite these documented disparities, most current clinical ESRD risk calculators do not include race as a variable. Traditional risk factors such as diabetes and hypertension, high-risk genotypes, and differences in baseline kidney function do not fully explain the racial differences in ESRD [1]. This underscores the need for studies to explore whether race is a helpful factor in estimating ESRD risk based on baseline eGFR levels and time horizon [1]. This study aims to elucidate the role of race as a risk factor for ESRD progression, thereby contributing to a deeper understanding of health inequities in kidney disease.

APOL1 Risk Variants

Apolipoprotein L1 (APOL1) risk variants, common in individuals of African ancestry, are linked to an increased risk of ESRD [1]. Individuals with two high-risk APOL1 variants have a 7.3- to 29-fold increased risk of developing ESRD [1]. Although therapies targeting APOL1-related injuries are being explored, unexplained variance remains, as not all carriers of two high-risk variants develop kidney disease. This study will assess the role of comorbid conditions and exposures in the progression to ESRD among patients with high-risk APOL1 alleles.

Proteinuria

Proteinuria is a well-known risk factor for CKD progression to ESRD. Racial differences in CKD progression have been associated with varying levels of proteinuria, potentially accounting for some of the disparities in ESRD risk [1]. However, the specific role of proteinuria in the disparity of ESRD incidence among Black individuals remains unclear [1]. This study aims to clarify this role and its contribution to racial disparities in ESRD risk.

Socioeconomic Factors

The study will also examine the impact of socioeconomic factors on racial disparities in ESRD. Differences in socioeconomic status (SDoH) may contribute significantly to these disparities. The assessment will include an analysis of socioeconomic variables to understand their role in ESRD risk prediction and progression.

Significance

Identifying and understanding racial disparities in ESRD progression is crucial for developing targeted interventions and informing clinical and public health policies. Such insights can lead to more equitable healthcare practices, reduce the burden of ESRD on vulnerable populations, and ultimately improve patient outcomes.

Proposed Methods

Study Design

This study employs a retrospective cohort design, utilizing data from the "All of Us Controlled Tier Dataset v7." The study population comprises patients with baseline serum creatinine measurements or those diagnosed with chronic kidney disease (CKD) stages 1-4.

Study population and data collection

Using the Observational Medical Outcomes Partnership (OMOP) standard, we analyzed data from 202,490 patients with baseline serum creatinine measurements. Inclusion criteria comprised individuals aged 18 years and older. Following the exclusion of 50,323 individuals of unspecified or other races and 26,020 patients with underlying conditions such as acute glomerulopathies, congenital abnormalities, or traumatic kidney injury, a total of 126,147 Black and White individuals were included in the study. These exclusions were implemented to enhance the interpretability of the results, given that the excluded underlying conditions have different disease courses [Segal2020].

Prediction model construction and evaluation

A comprehensive manual compilation was conducted to identify 236 candidate predictors, guided by the ONCE framework and existing literature. These predictors were systematically classified into six distinct feature groups based on medical rationale: 3 demographic variables (age, gender and race), 135 chronic conditions, 39 diagnoses and procedures, 1 episode count, 1 medical cost variable, and 57 medication-related features .

Statistical Analysis

Part 1: Prediction Models

Machine Learning Algorithms

The study will explore several approaches for developing and evaluating risk prediction models:

1. Evaluation of Existing Risk Prediction Models: Assess the performance of current models in predicting ESRD.
2. Training New Risk Prediction Models with Race as a Predictor: Develop new models that include race as a variable to determine its impact on predictive accuracy.
3. Training New Risk Prediction Models without Race as a Predictor: Develop models that exclude race to evaluate the predictive performance without this variable.
4. Advanced Fairness-Aware Machine Learning Methods (Optional): Implement methods that address fairness and bias in predictive modeling to ensure equitable outcomes across different demographic groups.

5. Advanced Multi-Task Learning Methods (Optional): Explore multi-task learning approaches that can simultaneously predict multiple related outcomes, potentially improving model performance and utility.

Part 2: Contributions of genetic and socioeconomic status (SDoH) in risk prediction

This study aims to further assess whether genetic risk factors and socioeconomic status can explain racial disparities in ESRD risk.

1. **APOL1 Risk Variants:** To evaluate the impact of APOL1 risk variants on ESRD progression, we will perform a Cox proportional hazards regression analysis. The analysis will include APOL1 genotype (carriers of one or two high-risk variants) as the primary independent variable, adjusting for potential confounders such as age, sex, comorbid conditions, and baseline estimated glomerular filtration rate (eGFR). We will also assess the interaction between APOL1 risk variants and comorbid conditions to explore how these factors jointly influence ESRD risk.

2. **Proteinuria:** The association between proteinuria levels and ESRD risk will be analyzed using multivariable logistic regression. Proteinuria will be treated as both a continuous and categorical variable to understand its relationship with ESRD progression. The model will adjust for demographic variables (age, sex, race), baseline eGFR, diabetes, hypertension, and other relevant clinical factors. We will further stratify the analysis by race to determine if the impact of proteinuria on ESRD risk differs among racial groups.

3. **Socioeconomic Factors:** The influence of socioeconomic factors on ESRD risk will be examined using multivariable linear and logistic regression models. Key socioeconomic variables will be included in the models. The analysis will adjust for clinical variables, and demographic characteristics. Interaction terms between socioeconomic factors and race will be included to assess whether the effect of socioeconomic status on ESRD risk varies by racial group.

All statistical analyses will be conducted using R (version 4.0.3). Statistical significance will be defined as a two-tailed p-value < 0.05 . Results will be reported as hazard ratios (HRs) or odds ratios (ORs) with 95 percent confidence intervals (CIs). Model diagnostics and assumptions will be checked, and sensitivity analyses will be performed to assess the robustness of the findings.

Anticipated Results

WIn this retrospective study on the role of race in predicting end-stage renal disease (ESRD) progression among chronic kidney disease (CKD) patients, we anticipate that existing risk prediction models will show moderate accuracy but significant racial disparities. New models incorporating race are expected to improve accuracy but raise fairness concerns. Machine learning techniques may enhance predictive power yet still reveal persistent racial disparities. Fairness-aware and multi-task learning methods are projected to offer more

equitable and comprehensive predictions. Additionally, APOL1 variants, proteinuria, and socioeconomic factors are anticipated to significantly impact ESRD risk, with notable differences across racial groups. The study aims to highlight the multifactorial nature of ESRD risk and enhance understanding and equitable prediction of racial disparities.

Appendix

Feature	Rollup/ Item Count	Standard	Code	Source Description
Chronic Condition:				
Acidosis	15,101	OMOP	PheCode:276.41	acidosis
Acquired coagulation factor deficiency	632	OMOP	PheCode:286.4	acquired coagulation factor deficiency
Acquired deformity of limb	27,431	OMOP	PheCode:1089	acquired absence of limb
Acquired hypothyroidism	26,755	OMOP	PheCode:244.2	acquired hypothyroidism
Acute glomerulonephritis	213	OMOP	PheCode:580.13	acute glomerulonephritis, nos
Acute renal failure syndrome	23,977	OMOP	PheCode:585.1	acute renal failure
Alteration of mental status	9,415	OMOP	PheCode:292.4	altered mental status
Amyloidosis	690	OMOP	PheCode:270.33	amyloidosis
Anemia	72,526	OMOP	PheCode:285	other anemias
Anemia in chronic kidney disease	6,285	OMOP	PheCode:285.21	anemia in chronic kidney disease
Anemia of chronic disease	10,157	OMOP	PheCode:285.2	anemia of chronic disease
Anuria	525	OMOP	PheCode:599.6	oliguria and anuria
Arteriovenous fistula	928	OMOP	CCS:57	creation, revision and removal of arteriovenous fistula or vessel-to-vessel cannula for dialysis

Atherosclerosis of arteries of the extremities	2,626	OMOP	PheCode:440.2	atherosclerosis of the extremities
Atherosclerosis of coronary artery without angina pectoris	29,416	OMOP	PheCode:414.2	ascvd
Atherosclerosis of renal artery	1,036	OMOP	PheCode:440.1	atherosclerosis of renal artery
Bacteremia	5,716	OMOP	PheCode:038.3	bacteremia
Changes in skin texture	2,588	OMOP	PheCode:687.3	changes in skin texture
Chronic glomerulonephritis	675	OMOP	PheCode:580.14	chronic glomerulonephritis, nos
Chronic graft-versus-host disease	187	OMOP	PheCode:081.12	chronic graft-versus-host disease
Chronic kidney disease stage 1	1,745	OMOP	PheCode:585.4	chronic kidney disease, stage i or ii
Chronic kidney disease stage 2	6,000	OMOP	PheCode:585.4	chronic kidney disease, stage i or ii
Chronic kidney disease stage 3	15,725	OMOP	PheCode:585.33	chronic kidney disease, stage iii
Chronic kidney disease stage 4	4,461	OMOP	PheCode:585.34	chronic kidney disease, stage iv
Chronic pain syndrome	12,163	OMOP	PheCode:355.1	chronic pain syndrome
Chronic renal failure	4,470	OMOP	PheCode:585.3	chronic renal failure [ckd]
Chronic ulcer of lower extremity	6,077	OMOP	PheCode:707.3	chronic ulcer of unspecified site
Chronic vascular insufficiency of intestine	507	OMOP	PheCode:441.2	chronic vascular insufficiency of intestine
Clostridioides difficile infection	3,258	OMOP	PheCode:008.52	intestinal infection due to c. difficile

Complication associated with insulin pump	84	OMOP	PheCode:250.3	insulin pump user
Complication of peritoneal dialysis	3	OMOP	CCS:91	peritoneal dialysis
Complication of renal dialysis	491	OMOP	PheCode:585.31	renal dialysis
Congenital anomaly of the kidney	1,500	OMOP	PheCode:751.22	other specified congenital anomalies of kidney
Congenital osteodystrophy	25	OMOP	PheCode:756.5	congenital osteodystrophies
Congestive heart failure	15,994	OMOP	PheCode:428; PheCode:428.1	congestive heart failure (nonhypertensive); congestive heart failure (chf) nos
Deficiency anemias	1,340	OMOP	PheCode:281; PheCode:281.9	other deficiency anemia; deficiency anemias
Degenerative skin disorder	21,082	OMOP	PheCode:702.4	degenerative skin disorders
Diabetes mellitus	56,223	OMOP	PheCode:250	diabetes mellitus
Disorder of artery	59,202	OMOP	PheCode:447	other disorders of arteries and arterioles
Disorder of cardiovascular system	171,486	OMOP	PheCode:459; PheCode:459.9	other disorders of circulatory system; circulatory disease nec
Disorder of eye due to type 1 diabetes mellitus	1,282	OMOP	PheCode:250.13	type 1 diabetes with ophthalmic manifestations
Disorder of eye due to type 2 diabetes mellitus	7,405	OMOP	PheCode:250.23	type 2 diabetes with ophthalmic manifestations
Disorder of hard tissues of teeth	13,476	OMOP	PheCode:521	diseases of hard tissues of teeth

Disorder of kidney and/or ureter	66,542	OMOP	PheCode:586.1	anatomical abnormalities of kidney and ureters
Disorder of mineral metabolism	21,551	OMOP	PheCode:275	disorders of mineral metabolism
Disorder of muscle	68,136	OMOP	PheCode:359.2	myopathy
Disorder of parathyroid gland	8,126	OMOP	PheCode:252	disorders of parathyroid gland
Disorder of penis	5,688	OMOP	PheCode:604	disorders of penis
Disorder of phosphate, calcium and vitamin D metabolism	16,641	OMOP	PheCode:275.5	disorders of calcium/phosphorus metabolism
Disorder of phosphorus metabolism	5,951	OMOP	PheCode:275.53	disorders of phosphorus metabolism
Disorder of plasma protein metabolism	4,166	OMOP	PheCode:270.38	other specified disorders of plasma protein metabolism
Disorder of porphyrin metabolism	2,962	OMOP	PheCode:277.1	disorders of porphyrin metabolism
Disorder of the urea cycle metabolism	480	OMOP	PheCode:270.21	disorders of urea cycle metabolism
End stage renal failure on dialysis	101	OMOP	CCS:58	hemodialysis
End stage renal disease	4,391	OMOP	PheCode:585.32	end stage renal disease
Essential hypertension	116,321	OMOP	PheCode:401.1	essential hypertension
Frank hematuria	7,015	OMOP	PheCode:593.1	gross hematuria
Gangrene of limb due to atherosclerosis of artery of limb	58	OMOP	PheCode:440.21	atherosclerosis of native arteries of the extremities with ulceration or gangrene
Gangrenous disorder	2,235	OMOP	PheCode:791	gangrene
Glomerulonephritis	1,866	OMOP	PheCode:580.1	glomerulonephritis
Gout	10,014	OMOP	PheCode:274.1	gout

Gouty arthropathy	1,164	OMOP	PheCode:274.11	gouty arthropathy
Gram positive sepsis	2,808	OMOP	PheCode:038.2	gram positive septicemia
Granulomatosis with polyangiitis	253	OMOP	PheCode:446.4	wegener's granulomatosis
Hydronephrosis	7,652	OMOP	PheCode:595	hydronephrosis
Hypercalcemia	6,928	OMOP	PheCode:275.51	hypocalcemia
Hypercoagulability state	1,751	OMOP	PheCode:286.8	hypercoagulable state
Hyperkalemia	12,557	OMOP	PheCode:276.1	hyperpotassemia
Hyperparathyroidism	7,563	OMOP	PheCode:252.1	hyperparathyroidism
Hyperparathyroidism due to renal insufficiency	3,506	OMOP	PheCode:588.2	secondary hyperparathyroidism (of renal origin)
Hypertensive complication	28,186	OMOP	PheCode:401.3	other hypertensive complications
Hypertensive heart and chronic kidney disease	2,393	OMOP	PheCode:401.22	hypertensive chronic kidney disease
Hypertensive heart and renal disease	6,355	OMOP	PheCode:401.2	hypertensive heart and/or renal disease
Hypertrophy of kidney	162	OMOP	PheCode:586.3	vascular disorders of kidney/hypertrophy
Hypervolemia	6,203	OMOP	PheCode:276.6	fluid overload
Hypocalcemia	4,856	OMOP	PheCode:275.51	hypocalcemia
Hypoglycemia	6,698	OMOP	PheCode:251.1	hypoglycemia
Hypoparathyroidism	1,108	OMOP	PheCode:252.2	hypoparathyroidism
Hypothyroidism	37,806	OMOP	PheCode:244	hypothyroidism
Iatrogenic hypotension	1,646	OMOP	PheCode:458.2	iatrogenic hypotension
Impaction of intestine	1,039	OMOP	PheCode:560.2	impaction of intestine
Impaired renal function disorder	650	OMOP	PheCode:588	disorders resulting from impaired renal function
Injury of globe of eye	5,462	OMOP	PheCode:360	disorders of the globe

Iron deficiency anemia	28,890	OMOP	PheCode:280; PheCode:280.1	iron deficiency anemias; iron deficiency anemias, unspecified or not due to blood loss
Ketoacidosis due to type 1 diabetes mellitus	329	OMOP	PheCode:250.11	type 1 diabetes with ketoacidosis
Ketoacidosis due to type 2 diabetes mellitus	329	OMOP	PheCode:250.21	type 2 diabetes with ketoacidosis
Low blood pressure	21,466	OMOP	PheCode:458.9	hypotension nos
Lupus erythematosus	3,975	OMOP	PheCode:695.4	lupus (localized and systemic)
Mechanical complication of cardiac device, implant and/or graft	237	OMOP	PheCode:854	complications of cardiac/vascular device, implant, and graft
Megaloblastic anemia due to folate deficiency	348	OMOP	PheCode:281.13	folate-deficiency anemia
Membranous glomerulonephritis	331	OMOP	PheCode:580.12	non-proliferative glomerulonephritis
Metabolic encephalopathy	4,082	OMOP	PheCode:348.8	encephalopathy, not elsewhere classified
Multiple congenital cysts of kidney	10,996	OMOP	PheCode:751.21	cystic kidney disease
Myoclonus	1,061	OMOP	PheCode:333.2	myoclonus
Nephritic syndrome	1,079	OMOP	PheCode:580.32	nephritis and nephropathy with pathological lesion
Nephropathy co-occurrent and due to systemic lupus erythematosus	537	OMOP	PheCode:580.31	nephritis and nephropathy in diseases classified elsewhere
Nephrosclerosis	1,665	OMOP	PheCode:580; PheCode:580.4	nephritis; nephrosis; renal sclerosis; renal sclerosis, nos

Nephrotic syndrome	1,030	OMOP	PheCode:580.2	nephrotic syndrome without mention of glomerulonephritis
Non-autoimmune hemolytic anemia	134	OMOP	PheCode:283.2	non-autoimmune hemolytic anemias
Oliguria	74	OMOP	PheCode:599.6	oliguria and anuria
Pediatric failure to thrive	10	OMOP	PheCode:264.2	failure to thrive (childhood)
Peripheral circulatory disorder due to type 1 diabetes mellitus	435	OMOP	PheCode:250.15	diabetes type 1 with peripheral circulatory disorders
Peripheral circulatory disorder due to type 2 diabetes mellitus	5,883	OMOP	PheCode:250.25	diabetes type 2 with peripheral circulatory disorders
Peripheral vascular complication	7,417	OMOP	PheCode:443.8	other specified peripheral vascular diseases
Peripheral vascular disease	17,603	OMOP	PheCode:443.9	peripheral vascular disease, unspecified
Peripheral venous insufficiency	10,944	OMOP	PheCode:456	chronic venous insufficiency [cvi]
Polyneuropathy due to diabetes mellitus	10,744	OMOP	PheCode:250.6	polyneuropathy in diabetes
Postoperative shock	505	OMOP	PheCode:958.1	postoperative shock
Proliferative glomerulonephritis	203	OMOP	PheCode:580.11	proliferative glomerulonephritis
Proteinuria	9,985	OMOP	PheCode:269	proteinuria
Renal disorder due to type 1 diabetes mellitus	1,289	OMOP	PheCode:250.12	type 1 diabetes with renal manifestations
Renal disorder due to type 2 diabetes mellitus	11,845	OMOP	PheCode:250.22	type 2 diabetes with renal manifestations
Renal failure syndrome	27,154	OMOP	PheCode:585; PheCode:585.2	renal failure; renal failure nos
Renal function tests abnormal	3,043	OMOP	PheCode:589	abnormal results of function study of kidney
Renal osteodystrophy	948	OMOP	PheCode:588.1	renal osteodystrophy

Respiratory failure	14,239	OMOP	PheCode:509.1	respiratory failure
Retinal edema	3,811	OMOP	PheCode:362.9	retinal edema
Retinopathy due to diabetes mellitus	5,892	OMOP	PheCode:250.7	diabetic retinopathy
Screening finding	1,216	OMOP	PheCode:1010.1	screening for infectious and parasitic diseases
Secondary diabetes mellitus	4,187	OMOP	PheCode:249	secondary diabetes mellitus
Sepsis	15,437	OMOP	PheCode:994.2	sepsis
Sepsis due to Gram negative bacteria	2,570	OMOP	PheCode:038.1	gram negative septicemia
Septic shock	2,862	OMOP	PheCode:994.21	septic shock
Septicemia due to enterococcus	267	OMOP	PheCode:038	septicemia
Shock	5,732	OMOP	PheCode:797	shock
Small kidney	191	OMOP	PheCode:586.11	small kidney
Systemic lupus erythematosus	3,808	OMOP	PheCode:695.42	systemic lupus erythematosus
Systemic sclerosis	810	OMOP	PheCode:709.3	systemic sclerosis
Thrombotic microangiopathy	205	OMOP	PheCode:446.8	thrombotic microangiopathy
Transplanted kidney present	2,208	OMOP	PheCode:V42.0	kidney replaced by transplant
Tubulointerstitial nephritis	4,866	OMOP	PheCode:580.3	nephritis and nephropathy without mention of glomerulonephritis
Type 1 diabetes mellitus	6,400	OMOP	PheCode:250.1	type 1 diabetes
Type 2 diabetes mellitus	53,150	OMOP	PheCode:250.2	type 2 diabetes
Vascular insufficiency of intestine	1,189	OMOP	PheCode:441	vascular insufficiency of intestine
Diagnosis and procedure features:				
Administration of medication	26,626	OMOP	CCS:240	medications (injections, infusions and other forms)

Arteriovenous anastomosis for renal dialysis	138	OMOP	CCS:57	creation, revision and removal of arteriovenous fistula or vessel-to-vessel cannula for dialysis
Bilirubin.indirect [Mass/volume] in Serum or Plasma	56,671	OMOP	Other lab:800010891	other lab:ibc
Calcium.ionized [Moles/volume] in Serum or Plasma	2,931	OMOP	Other lab:800035258	other lab:ionca
Creatinine [Mass/volume] in Body fluid	1,309	OMOP	LOINC:12190-5	creatinine, fluid (group:crefld)
Erythrocyte distribution width [Ratio] by Automated count	187,906	OMOP	LOINC:788-0	rdw (group:rdw)
Ferritin [Mass/volume] in Serum or Plasma	62,352	OMOP	LOINC:2276-4	ferritin (group:fer)
Fructosamine [Moles/volume] in Serum or Plasma	1,348	OMOP	LOINC:15069-8	loinc:fructosamine
Hemodialysis	340	OMOP	CCS:58	hemodialysis
Hepatitis B virus core IgG Ab [Units/volume] in Serum by Immunoassay	4	OMOP	LOINC:13919-6	hbv core ab(s) (group:hbsabt)
Hepatitis B virus surface Ab [Presence] in Serum	11,714	OMOP	LOINC:22322-2	loinc:hepatitis b virus surface ab
Hepatitis B virus surface Ab [Presence] in Serum by Immunoassay	19,798	OMOP	LOINC:10900-9	hbv surface ab (group:hbsab)

Hepatitis B virus surface Ab [Units/volume] in Serum	14,449	OMOP	LOINC:16935-9	loinc:hepatitis b virus surface ab
Hepatitis B virus surface Ab [Units/volume] in Serum by Radioimmunoassay (RIA)	1,532	OMOP	LOINC:5194-6	hbv surface ag (group:hbsag)
Hepatitis B virus surface Ag [Presence] in Serum or Plasma by Immunoassay	38,030	OMOP	LOINC:5196-1	loinc:hepatitis b virus surface ag
Hepatitis C virus Ab [Presence] in Serum or Plasma by Immunoassay	42,997	OMOP	LOINC:13955-0; Other lab: 1400004747; 1400034786; 1000003489; 1000110810; 1200125475; 1200111187	hcv ab (group:hcvab); other lab:zzhcv; antihcv; zhcv-ab; hcv-ab; hcvab; hcv-ab
Hepatitis C virus Ab [Presence] in Serum by Immunoblot	678	OMOP	Other lab:1400025801	other lab:riba
HLA Ab [Presence] in Serum	84	OMOP	Other lab:1200067960	other lab:pra
Iron binding capacity [Mass/volume] in Serum or Plasma	55,243	OMOP	LOINC:2500-7	tibc (group:tibc)
Iron [Mass/volume] in Serum or Plasma	62,427	OMOP	LOINC:2498-4	loinc:iron
Iron saturation [Mass Fraction] in Serum or Plasma	50,295	OMOP	Other lab:1000097091	other lab:%fe sat

Nucleated erythrocytes [#/volume] in Body fluid by Manual count	1,460	OMOP	LOINC:13530-1	fluid nrbc (group:fnrbc)
Parathyrin.intact [Mass/volume] in Serum or Plasma	24,176	OMOP	LOINC:2731-8; Other lab: 1000071228; 1000073374; 1200028400; 1200081825; 1200078856; 1000089371; 1000079908; 800011757	loinc:parathyrin.intact; other lab:pth in; pthint; pth_int; pthin; pth,int; pthint; pth,i
Parathyroid Hormones	24,176	OMOP	Other lab :1200046864; 800023374; 800035825	other lab:pth
Partial nephrectomy	93	OMOP	CCS:104	nephrectomy, partial
Peritoneal dialysis	104	OMOP	CCS:91	peritoneal dialysis
Protein [Mass/volume] in Urine	25,654	OMOP	LOINC:2888-6	urine total protein (group:utp)
Reticulocytes [#/volume] in Blood	11,184	OMOP	Other lab: 1200048816; 1200073330; 1200042119	other lab:ret-ab; ret, abs; retic a
Reticulocytes/100 erythrocytes in Blood	6,253	OMOP	Other lab:1200010512	other lab:retic%
Therapeutic procedure	26,350	OMOP	CCS:231	other therapeutic procedures
Total nephrectomy	28	OMOP	CCS:104 nephrectomy, complete	
Total iron binding capacity measurement	2,382	OMOP	Other lab:1400020871; 1400066956; 1200008067	other lab:zztbc; tbc

Transferrin [Mass/volume] in Serum or Plasma	14,126	OMOP	Other lab: 1000018950; Other lab:1200059866	other lab:trfn; other lab:trsfrn
Urate [Mass/volume] in Serum or Plasma	40,505	OMOP	Other lab:1200050030	other lab:uric ac
Vancomycin [Mass/volume] in Serum or Plasma	5,376	OMOP	Other lab:1000014920	other lab:vancmcn
Episode counts:				
Direct skilled nursing services of a registered nurse (rn) in the home health or hospice setting, each 15 minutes	911	OMOP	CCS:236	home health services
Medical costs:				
Durable medical equipment, miscellaneous	1,494	OMOP	CCS:243	dme and supplies
Medication features:				
Aliskiren	140	OMOP	RXNORM: 325646	aliskiren
Alteplase	5,852	OMOP	RXNORM: 8410	alteplase
Aluminum hydroxide	27,125	OMOP	RXNORM: 612	aluminum hydroxide
Amlodipine	40,548	OMOP	RXNORM: 17767	amlodipine
Calcitriol	2,997	OMOP	RXNORM: 1894	calcitriol
Calcium acetate	1,788	OMOP	RXNORM: 214342	calcium acetate
Carvedilol	12,439	OMOP	RXNORM: 20352	carvedilol
Cascara sagrada	49	OMOP	RXNORM: 66869	cascara sagrada
Ceftazidime	1,161	OMOP	RXNORM: 2191	ceftazidime

Cinacalcet	804	OMOP	RXNORM: 407990	cinacalcet
Citric acid	9,970	OMOP	RXNORM: 91198	citric acid/sodium citrate
Daptomycin	1,189	OMOP	RXNORM: 22299	daptomycin
Darbepoetin alfa	1,443	OMOP	RXNORM: 283838	darbepoetin alfa,recombinant
Dextran	24	OMOP	RXNORM: 42635	dextran
Dextran 70	2,159	OMOP	RXNORM: 3274	dextran hm
Dextran 75	3	OMOP	RXNORM: 3275	dextran 75
Doxercalciferol	351	OMOP	RXNORM: 11516	doxercalciferol
Elbasvir	116	OMOP	RXNORM: 1734635	elbasvir/grazoprevir
Emtricitabine	4,133	OMOP	RXNORM: 276237	emtricitabine
Epoetin alfa	2,087	OMOP	RXNORM: 105694	epoetin alfa,recombinant
Etelcalcetide	6	OMOP	RXNORM: 1876119	etelcalcetide
Ethyl chloride	248	OMOP	RXNORM: 4141	ethyl chloride
Etravirine	167	OMOP	RXNORM: 475969	etravirine
Grazoprevir	102	OMOP	RXNORM: 1734635	elbasvir/grazoprevir
Heparin	52,525	OMOP	RXNORM: 5224	heparin
Hepatitis b immune globulin	59	OMOP	RXNORM: 26746	hepatitis b
Hepatitis b surface antigen vaccine	5521	OMOP	RXNORM: 797752N	hepatitis b
Hydralazine	27,835	OMOP	RXNORM: 5470	hydralazine

Insulin aspart protamine, human	2,648	OMOP	RXNORM: 352385	insulin aspart protamine, human
Insulin aspart, human	16,108	OMOP	RXNORM: 51428	insulin aspart, human
Insulin detemir	2,856	OMOP	RXNORM: 139825	insulin detemir
Insulin glargine	15,769	OMOP	RXNORM: 274783	insulin glargine
Insulin glulisine, human	379	OMOP	RXNORM: 400008	insulin glulisine, human
Insulin isophane	4,782	OMOP	RXNORM: 1605101	insulin isophane
Insulin lispro	20,940	OMOP	RXNORM: 86009	insulin lispro
Insulin lispro protamine, human	580	OMOP	RXNORM: 314684	insulin lispro protamine, human
Insulin, regular, human	14,771	OMOP	RXNORM: 253182	insulin, regular, human
Iron sucrose	4,576	OMOP	RXNORM: 24909	iron sucrose
Iron-dextran complex	558	OMOP	RXNORM: 5992	iron dextran
Lanthanum	2	OMOP	RXNORM: 1311070	lanthanum
Mannitol	2,705	OMOP	RXNORM: 6628	mannitol
Methoxy polyethylene glycol-epoetin beta	64	OMOP	RXNORM: 729596	methoxy polyethylene glycol-epoetin beta
Midodrine	2,219	OMOP	RXNORM: 6963	midodrine
Minoxidil	1,656	OMOP	RXNORM: 6984	minoxidil
Nevirapine	129	OMOP	RXNORM: 53654	nevirapine
Nifedipine	7,716	OMOP	RXNORM: 7417	adalat
Paricalcitol	337	OMOP	RXNORM: 73710	paricalcitol

Pitavastatin	380	OMOP	RXNORM: 861634	pitavastatin
Protriptyline	86	OMOP	RXNORM: 8886	protriptyline
Saquinavir	34	OMOP	RXNORM: 83395	saquinavir
Sevelamer	1,970	OMOP	RXNORM: 660890; RXNORM: 237125	sevelamer carbonate; sevelamer hcl
Sodium bicarbonate	43,436	OMOP	RXNORM: 36676	sodium bicarbonate
Sodium citrate	14,964	OMOP	RXNORM: 56466	sodium citrate
Sodium ferric gluconate complex	627	OMOP	RXNORM: 261435	ferric na gluconate
Sodium polystyrene sulfonate	3,646	OMOP	RXNORM: 56512	sodium polystyrene sulfonate
Vancomycin	35,740	OMOP	RXNORM: 11124	vancomycin
Water	6,453	OMOP	RXNORM: 11295	water

Table 1: End Stage Renal Disease Predictor Candidates Informed by ONCE

Feature	Rollup/ Item Count	Standard	Code	Source Description
Demographic:				
Age at CDR Date	202,490	OMOP	NA	Age
Gender Identity	413,457	OMOP	Male: 45880669; Female: 45878463	Gender
Race	307,662	OMOP	White: 8527; Black or African American: 8516	Race

Chronic Conditions:				
Tobacco dependence caused by cigarettes	21	OMOP	NA	Smoking
Diagnosis and Procedure Features:				
Glomerular filtration rate/1.73 sq M.predicted [Volume Rate/Area] in Serum, Plasma or Blood by Creatinine-based formula (MDRD)	75,162	OMOP	LOINC:77147-7	Estimated Glomerular Filtration Rate (eGFR)
Hemoglobin A1c/Hemoglobin.total in Blood	102,028	OMOP	LOINC; 4548-4	Hemoglobin A1c (HbA1c)
Systolic blood pressure	339,162	OMOP	LOINC: 8480-6	Systolic Blood Pressure (SBP)
Triglyceride (TG)	143,556	OMOP	LOINC: LP15275-8	Triglyceride

Table 2: End Stage Renal Disease Predictor Candidates Informed by Literature[1][2][3]

References

- [1] Fabian Bock, Thomas G. Stewart, Cassianne Robinson-Cohen, Jennifer Morse, Edmond K. Kabagambe, Kerri L. Cavanaugh, and Kelly A. Birdwell et al. Racial disparities in end-stage renal disease in a high-risk population: The southern community cohort study. *BMC Nephrology*, 20(1), 2019.
- [2] Bridget M. Kuehn. End-stage kidney disease doubles. *JAMA*, 327(16):1540, 2022.
- [3] Zvi Segal, Dan Kalifa, Kira Radinsky, Bar Ehrenberg, Guy Elad, Gal Maor, Maor Lewis, Muhammad Tibi, Liat Korn, and Gideon Koren. Machine learning algorithm for early detection of end-stage renal disease. *BMC Nephrology*, 21(1), 2020.