Chronic Kidney Disease:

Evaluating Area Level Socioeconomic Characteristics, Individual Characteristics, and Patterns of Care by Census Tract in the Twin Cities Metro Area

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DEDICATION

This dissertation is dedicated to my parents. To my mom, Tania Ghazi, who has continuously supported my dreams, even those that involved moving to another continent. This is also to my dad, Ghassan Ghazi. Though he passed away when I was three years old, I believe he has been with me throughout this journey and has watched over me.

ABSTRACT

Chronic kidney disease (CKD) is a major public health problem that affects 15% of the United States adult population. CKD is asymptomatic until advanced stages; therefore, diagnosis and treatment are usually delayed. CKD has been shown to be associated with low socioeconomic status (SES). Disadvantaged socioeconomic populations have a disproportionate burden of CKD and have contributed to the growing CKD epidemic. This dissertation characterizes the interplay between neighborhood characteristics and CKD using the Fairview Health Services electronic health record (EHR) database, a large health system in Minnesota that services the Twin Cities metro area and surrounding communities.

For all manuscripts, we used census tracts as our geographical unit of analysis. Data for census tract was obtained from the American Community Survey 5-year data [2008-2012]. We linked each patients' residence, obtained from their EHR data, to the appropriate census tract and tract characteristics. We defined a low and high SES tract as belonging to the first and fourth quartile, respectively of the distribution of each census tract SES measure in the metropolitan area.

In the first manuscript, we evaluated whether adding neighborhood SES to current screening recommendations – patients with hypertension and/or diabetes - improves the sensitivity and/or specificity for detecting CKD. Overall, CKD was prevalent in 13% of our cohort (2008-2019). Additional screening of patients who live in low neighborhood SES improved our sensitivity but decreased our specificity to detect CKD compared to current screening recommendations.

In the second manuscript, we examine: 1) if there is an independent association of neighborhood SES and individual insurance type with CKD prevalence and 2) the

association of neighborhood racial composition, a measure of racial segregation, with CKD prevalence. We observed that patients living in low vs. high SES neighborhood had higher CKD prevalence. Moreover, for patients <65 years being on Medicaid compared to other insurance was associated with higher CKD prevalence. We found no association between neighborhood racial composition (percent blacks in tracts) and CKD prevalence.

The third manuscript explores whether neighborhood SES is associated with quality of care received by patients with CKD. Interestingly, we found that quality of care measures (prescribing appropriate medications, testing for proteinuria, or documenting CKD in patients' charts) were not associated with neighborhood SES. However, overall adherence to CKD guidelines is low (for example, only 27% of patients with CKD had their proteinuria level evaluated).

Overall, area SES contributes to CKD burden among patients seen at Fairview Health Services. In the future, health systems may want to consider a multifactorial approach, including neighborhood characteristics and a patient's individual level SES, to improve detection and management of CKD.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS ..... ***i***

DEDICATION ..... ***iii***

ABSTRACT ..... ***iv***

LIST OF TABLES ..... ***viii***

LIST OF SUPPLEMENTAL TABLES ..... ***ix***

LIST OF FIGURES ..... ***xi***

LIST OF SUPPLEMENTAL FIGURES ..... ***xii***

LIST OF ABBREVIATIONS ..... ***xiii***

CHAPTER 1 – INTRODUCTION ***1***

I. BACKGROUND 1

A. INTRODUCTION TO CHRONIC KIDNEY DISEASE 1
B. PUBLIC HEALTH BURDEN OF CHRONIC KIDNEY DISEASE 3
C. CHRONIC KIDNEY DISEASE AND SOCIOECONOMIC STATUS 3
D. SCREENING FOR CHRONIC KIDNEY DISEASE 12
E. CHRONIC KIDNEY DISEASE AND PATTERNS OF CARE 13
F. ADVANTAGE OF ELECTRONIC HEALTH RECORDS 14

II. SPECIFIC AIMS 16

CHAPTER 2 - ADDITION OF NEIGHBORHOOD SOCIOECONOMIC STATUS TO DIABETES AND HYPERTENSION IMPROVED IDENTIFICATION OF PATIENTS WITH CHRONIC KIDNEY DISEASE USING ELECTORINIC HEALTH RECORDS ***19***

Synopsis Digest 19

Introduction 21

Methods 22

Results 25

Discussion 27

Tables and Figures 32

CHAPTER 3 - NEIGHBORHOOD SOCIOECONOMIC STATUS, HEALTH INSURANCE, AND NEIGHBORHOOD RACIAL COMPOSITION ASSOCIATION WITH CHRONIC KIDNEY DISEASE ***55***

Synopsis Digest 55

Introduction 57

Methods 58
Results 62
Discussion 64
Tables and Figures 70
CHAPTER 4 - NEIGHBORHOOD SOCIOECONOMIC STATUS AND PATTERNS OF KIDNEY CARE: DATA FROM ELECTRONIC HEALTH RECORDS 91
Synopsis Digest 91
Introduction 93
Methods 94
Results 99
Discussion 102
Tables and Figures 106
CHAPTER 5 – SYNTHESIS 134
Significance and Implications 134
REFERENCES 137
APPENDIX – CENSUS DATA 146
APPENDIX – ICD CODES 149
APPENDIX – CHAPTER 2 155
APPENDIX – CHAPTER 3 166
APPENDIX – CHAPTER 4 211

LIST OF TABLES

TABLE 1. STUDIES LOOKING AT THE ASSOCIATION OF SES WITH KIDNEY OUTCOMES WITHIN A GEOGRAPHICAL UNIT 8
TABLE 2. SCREENING APPROACHES 32
TABLE 3. BASELINE CHARACTERISTICS OF FAIRVIEW PATIENTS 34
TABLE 4. THE SENSITIVITY, SPECIFICITY, PPV, NPV AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD 35
TABLE 5. HEALTH CARE PROVIDERS AWARENESS* OF CKD BY CENSUS TRACT SOCIOECONOMIC STATUS 36
TABLE 6. OVERALL CHARACTERISTICS OF THE FAIRVIEW COHORT (CHAPTER 3)..... 71
TABLE 7. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS AND INSURANCE STATUS WITH CKD PREVALENCE IN INDIVIDUALS <65 YEARS 72
TABLE 8. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS AND INSURANCE STATUS WITH CKD PREVALENCE IN INDIVIDUALS ≥65 YEARS 74
TABLE 9. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT RACIAL COMPOSITION WITH CKD PREVALENCE BY RACE 76
TABLE 10. COHORT FLOW CHART OF FAIRVIEW PATIENTS FROM THE 7 COUNTY MINNEAPOLIS/ST PAUL METROPOLITAN AREA 106
TABLE 11. CHARACTERISTICS OF NONPREGNANT ADULTS WITH HYPERTENSION AND CHRONIC KIDNEY DISEASE* 107
TABLE 12. OVERALL CHARACTERISTICS OF ADULTS WITH CHRONIC KIDNEY DISEASE* AND OF THOSE WHO HAD UACR MEASURED VS. NOT 108
TABLE 13. CHARACTERISTICS OF ADULTS WITH CHRONIC KIDNEY DISEASE* WHO HAD CKD IDENTIFIED IN THE ELECTRONIC HEALTH RECORDS VS. NOT 109
TABLE 14. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH ANGIOTENSIN MEDICATION PRESCRIPTION COMPLIANCE *..... 110
TABLE 15. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH URINE ALBUMIN TO CREATININE MEASUREMENT..... 111
TABLE 16. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH CHRONIC KIDNEY DISEASE (CKD) IDENTIFICATION. 112
TABLE 17. QUANTITATIVE SELECTION BIAS ANALYSIS FOR ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH ANGIOTENSIN PRESCRIPTION COMPLIANCE 113
TABLE 18. QUANTITATIVE SELECTION BIAS ANALYSIS FOR ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH URINE ALBUMIN TO CREATININE (UACR) MEASUREMENT 115
TABLE 19. QUANTITATIVE SELECTION BIAS ANALYSIS FOR ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH CHRONIC KIDNEY DISEASE (CKD) IDENTIFIED 116

LIST OF SUPPLEMENTAL TABLES

TABLE S1. GENERALIZABILITY ANALYSIS: COMPARING FAIRVIEW POPULATION TO CENSUS DATA 40
TABLE S2. ADDITIONAL SCREENING APPROACHES 41
TABLE S3. BASELINE CHARACTERISTICS OF PATIENTS WHO WILL BE SCREENED OR NOT BASED ON APPROACH 1 (STANDARD SCREENING APPROACH)* 42
TABLE S4. BASELINE CHARACTERISTICS OF PATIENTS WHO WILL BE SCREENED OR NOT BASED ON APPROACH 2 (HYPERTENSION AND/OR DIABETES AND/OR LOW CENSUS TRACT SOCIOECONOMIC STATUS- WEALTH) AND APPROACH 7 (LOW CENSUS TRACT SOCIOECONOMIC STATUS - WEALTH*) 43
TABLE S5. THE SENSITIVITY, SPECIFICITY, PPV, NPV, AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD 46
TABLE S6. HEALTHCARE PROVIDER AWARENESS* BY CENSUS TRACT SOCIOECONOMIC STATUS IN BLACKS AND WHITES 47
TABLE S7. THE SENSITIVITY, SPECIFICITY, PPV, NPV, AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD FOR MALES 48
TABLE S8. THE SENSITIVITY, SPECIFICITY, PPV, NPV AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD FOR FEMALES 49
TABLE S9. THE SENSITIVITY, SPECIFICITY, PPV, NPV, AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD AMONG PATIENTS <65 YEARS OF AGE 50
TABLE S10. THE SENSITIVITY, SPECIFICITY, PPV, NPV, AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD AMONG PATIENTS ≥65 YEARS OF AGE 51
TABLE S11. THE SENSITIVITY, SPECIFICITY, PPV, NPV AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD FOR BLACKS 52
TABLE S12. THE SENSITIVITY, SPECIFICITY, PPV, NPV, AND NUMBER NEEDED TO SCREEN FOR EACH SCREENING APPROACH TO DETECT CKD FOR WHITES 53
TABLE S13 . BASELINE CHARACTERISTICS OF PATIENTS WHO WERE INCLUDED IN OUR COHORT VS. PATIENTS EXCLUDED 54
TABLE S14. COMPARISON OF FAIRVIEW PATIENTS TO THE 7-COUNTY MINNEAPOLIS/ST PAUL METROPOLITAN AREA 78
TABLE S15. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS AND INSURANCE STATUS WITH CKD PREVALENCE IN INDIVIDUALS <65 YEARS AND BY HYPERTENSION STATUS 79
TABLE S16. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS AND INSURANCE STATUS WITH CKD PREVALENCE IN INDIVIDUALS <65 YEARS AND BY DIABETES STATUS 82
TABLE S17. QUANTITATIVE SELECTION BIAS ANALYSIS FOR ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS AND INSURANCE STATUS WITH CKD PREVALENCE FOR INDIVIDUALS <65 YEARS 85

TABLE S18. QUANTITATIVE SELECTION BIAS ANALYSIS FOR ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH CKD PREVALENCE FOR INDIVIDUALS ≥65 YEARS 87
TABLE S19. QUANTITATIVE SELECTION BIAS ANALYSIS FOR ASSOCIATION OF TRACT RACIAL COMPOSITION WITH CKD PREVALENCE* 89
TABLE S20. COMPARISON OF PATIENTS INCLUDED IN ANALYSES VS. EXCLUDED FROM ANALYSES 90
TABLE S21. COMPARISON OF FAIRVIEW PATIENTS TO THE 7-COUNTY MINNEAPOLIS/ST PAUL METROPOLITAN AREA 117
TABLE S22. ANGIOTENSIN MEDICATION PRESCRIPTION ADHERENCE: INTERACTION OF NEIGHBORHOOD SES WITH RACE (BLACK VS. WHITE) 118
TABLE S23. ANGIOTENSIN MEDICATION PRESCRIPTION ADHERENCE: INTERACTION OF NEIGHBORHOOD SES WITH SEX (MALE VS. FEMALE) 119
TABLE S24. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH ANGIOTENSIN MEDICATION PRESCRIPTION ADHERENCE1 BY SEX 120
TABLE S25. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH ANGIOTENSIN MEDICATION PRESCRIPTION ADHERENCE BY RACE 121
TABLE S26. URINE ALBUMIN TO CREATININE MEASUREMENT: INTERACTION OF NEIGHBORHOOD SES WITH RACE (BLACK VS. WHITE) 122
TABLE S27. URINE ALBUMIN TO CREATININE MEASUREMENT: INTERACTION OF NEIGHBORHOOD SES WITH SEX (MALE VS. FEMALE) 123
TABLE S28. URINE ALBUMIN TO CREATININE MEASUREMENT: INTERACTION OF NEIGHBORHOOD SES WITH HYPERTENSION HISTORY (YES VS. NO) 124
TABLE S29. URINE ALBUMIN TO CREATININE MEASUREMENT: INTERACTION OF NEIGHBORHOOD SES WITH DIABETES HISTORY (YES VS. NO) 125
TABLE S30. CKD IDENTIFICATION IN THE EHR: INTERACTION OF NEIGHBORHOOD SES WITH RACE (BLACK VS. WHITE) 126
TABLE S31. CKD IDENTIFICATION IN THE EHR: INTERACTION OF NEIGHBORHOOD SES WITH SEX (MALE VS. FEMALE) 127
TABLE S32. CKD IDENTIFICATION IN THE EHR: INTERACTION OF NEIGHBORHOOD SES WITH HYPERTENSION HISTORY (YES VS. NO) 128
TABLE S33. CKD IDENTIFICATION IN THE EHR: INTERACTION OF NEIGHBORHOOD SES WITH DIABETES HISTORY (YES VS. NO) 129
TABLE S34. MULTILEVEL REGRESSION MODEL FOR THE ASSOCIATION OF TRACT LEVEL SOCIOECONOMIC STATUS WITH CKD IDENTIFIED IN THE EHR1 FOR THE IDENTIFIED EFFECT MODIFIERS 130
TABLE S35. DESCRIPTION OF COHORT EXCLUDED FROM ANALYSES (CHAPTER 4)133

LIST OF FIGURES

FIGURE 1. CLASSIFICATION OF CKD USING EGFR AND URINE ALBUMIN TO CREATININE RATIO (UACR)[1] 2
FIGURE 2. COHORT FLOW CHART OF FAIRVIEW PATIENTS FROM THE 7 COUNTY MINNEAPOLIS/ST PAUL METROPOLITAN AREA 33
FIGURE 3. COHORT FLOW CHART OF FAIRVIEW PATIENTS FROM THE 7 COUNTY MINNEAPOLIS/ST PAUL METROPOLITAN AREA 70

LIST OF SUPPLEMENTAL FIGURES

FIGURE S1. COHORT CONSTRUCTION (CHAPTER 2) 37
FIGURE S2. COHORT CONSTRUCTION (CHAPTER 3 AND CHAPTER 4) 77

LIST OF ABBREVIATIONS

ACC/AHA – American College of Cardiology/American Heart Association

ACEi – angiotensin converting enzyme inhibitors

ACS – American Community Survey

ADA – American Diabetes Association

ARBs - angiotensin receptor blockers

ARIC – Atherosclerosis Risk in Communities

BMI – body mass index

BP – blood pressure

CI – confidence interval

CKD - chronic kidney disease

CKD-EPI - Chronic Kidney Disease Epidemiology Collaboration

CVD – cardiovascular disease

EHR – electronic health record

ESKD – end stage kidney disease

HITECH – Health Information Technology for Economic and Clinical Health Act

HR – hazard rate

ICD – International Classification of Diseases

IDMS – isotope dilution mass spectrometry

KEEP – Kidney Early Evaluation Program

MDH – Minnesota Department of Health

NNS – number needed to screen

NPV – negative predictive value

OR – odds ratio

PPV – positive predictive value

PR – prevalence ratio

REGARDS – Reasons for Geographic and Racial Differences in Stroke

SeeKD – See Kidney Disease

SES – socioeconomic status

UA – urinalysis

UACR – urine albumin to creatinine ratio

UPCR – urine protein to creatinine ratio

US – United States

USRDS – United States Renal Data System

CHAPTER 1 – INTRODUCTION

I. BACKGROUND

A. INTRODUCTION TO CHRONIC KIDNEY DISEASE

Chronic kidney disease (CKD) is asymptomatic until later stages. However, CKD can be detected by measuring serum creatinine or the amount of protein in the urine by a urinalysis (UA) [urine albumin to creatinine ratio (UACR), urine protein to creatinine ratio (UPCR)] or a urine dipstick.[1] The Kidney Disease: Improving Global Outcomes workgroup defines CKD as having kidney damage (structural or functional) or having an estimated glomerular filtration rate (eGFR) < 60 ml/min/1.73 m^2 for 3 months or more, irrespective of cause.[2] eGFR is a measure of kidney function and is mathematically derived using a patient's standardized serum creatinine level, age, sex (female vs. male) and race (black vs. other) using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation.[3] Serum creatinine should be assayed using a validated isotope dilution mass spectrometry (IDMS) traceable equation as assigned by the National Institute of Diabetes and Digestive and Kidney Diseases. Markers of kidney damage include albuminuria/proteinuria (high levels of protein or albumin in the urine), renal histological abnormalities, or structural abnormalities detected by UA, biopsy or imaging, respectively. Lower levels of eGFR and higher level of protein or albumin in the urine reflect worse kidney function. Risk of adverse outcomes (kidney failure, cardiovascular disease [CVD], stroke, and death) increases with worsening CKD stage (**Figure 1**). Symptoms of end stage kidney disease (ESKD), stage 5, include symptoms of uremia (fatigue, progressive weakness, nausea, vomiting, increase frequency of urination, muscle twitches and cramps etc.).

The two main causes and risk factors of CKD include hypertension and diabetes, which are responsible for up to two thirds of the cases.[4] Other conditions that might cause CKD include glomerulonephritis, inherited diseases, repeated urinary tract infections, obstruction of the urinary tract, and other diseases affecting the immune system. Non-

modifiable risk factors of CKD include: race (African American, Hispanic, Native Americans and Asian Americans), older age, and having family history of CKD.[5] Risk factors of CKD also include low birth weight, smoking, cardiovascular disease, nephrotoxic medications, kidney stones, acute kidney injury, environmental exposures, and socioeconomic status (SES).[5]

Strategies to improve kidney function for stages 1-4 include: lifestyle modifications, aggressive blood pressure (BP) control, optimally managing comorbidities and addressing risk factors that increase CVD (for example: hyperlipidemia to treat with statins), avoiding nephrotoxic agents and monitoring for complications of CKD (anemia, electrolyte abnormality).[1,6] Additionally, in patients with diabetic kidney disease or nondiabetic kidney disease with proteinuria it is recommended to take angiotensin converting enzyme inhibitors [ACEi]/angiotensin receptor blockers [ARBs]). If patients progress to ESKD, they will require either dialysis or a kidney transplant.

Figure 1. Classification of CKD using eGFR and urine albumin to creatinine ratio[1]

	UACR categories (mg/mmol), description and range		
eGFR categories	**<3 Normal to mildly increased**	**3-30 Moderately increased**	**>30 Severely increased**
	A1	**A2**	**A3**
Stage 1- normal or high eGFR >90 mL/min per 1.73m$_2$	No CKD in the absence of markers of kidney damage		
Stage 2- Mild CKD 60-89 mL/min per 1.73m$_2$			
Stage 3A- Mild-Moderate CKD 45-59 mL/min per 1.73m$_2$			
Stage 3B- Moderate-Severe CKD 30-44 mL/min per 1.73m$_2$			
Stage 4- Severe CKD 15-29 mL/min per 1.73m$_2$			
Stage 5- End Stage CKD			

UACR: urine albumin to creatinine ratio; eGFR: estimated glomerular filtration rate; CKD: chronic kidney disease

Risk of CKD patients progressing to adverse outcomes

Green – low risk; yellow – moderately increased risk; orange – high risk; red – very high risk

B. PUBLIC HEALTH BURDEN OF CHRONIC KIDNEY DISEASE

Currently, 135.8 million Americans are at increased risk of developing kidney disease and 26 million Americans and 200 million individuals worldwide have CKD.[7,8] 48% of people with reduced kidney function are unaware that they have CKD. It is estimated that over 50% of Americans born today will develop CKD stage 3 or worse during their lifetime.[9] Furthermore, CKD disproportionately burdens those groups already experiencing health disparities, including African Americans/Blacks, Hispanics, Pacific Islanders, and American Indians.[10,11] Although advances in healthcare have decreased age-adjusted death rates from cardiovascular and oncological diseases, death rates from kidney disease have been increasing since the 1990's.[12] In fact, CKD is now among the 25 leading diseases and injuries contributing to years of life lost due to premature mortality in the United States (US).[13]

In addition to high prevalence and increase in morbidity, CKD is associated with increased health care expenditures. In 2017, overall Medicare expenditure for patients with CKD exceeded $84 billion, an increase of 6.3% from 2016. This represents 12.5% of total Medicare dollars. Total expenditures when adding ESKD and CKD costs was an additional $36 billion representing 33.8% of total Medicare fee-for-service spending.[14] The incidence of ESKD plateaued between 2007 and 2011 but rose again between 2012 and 2017. In 2017, 124,500 patients had incident ESKD, 97% were on dialysis and 3% received a preemptive kidney transplant.

Trends of increasing number of patients with a disease that has poor overall outcomes and a large burden of cost has sounded the alarm bell for increased CKD awareness and underscores the urgent need to characterize patients at risk of CKD.

C. CHRONIC KIDNEY DISEASE AND SOCIOECONOMIC STATUS

CKD has been shown to be associated with low SES. A recent systematic review and meta-analysis by Vart et al. on 3,632,531 participants (from the US, Europe, Australia, China, Singapore and Thailand) studied the association of individual level SES (income,

wealth, education, occupation, and a composite score) with CKD, defined as (1) low eGFR [eGFR alone]; (2) high albuminuria/proteinuria alone; (3) low eGFR, high albuminuria/proteinuria, or both; or (4) renal failure. This review showed that low SES was associated with prevalence of low eGFR (odds ratio (OR): 1.41, 95% confidence interval (CI) [1.21, 1.62]), high albuminuria/proteinuria (OR: 1.52, 95%CI [1.22, 1.82]), and both low eGFR and high albuminuria (OR: 1.38, 95%CI [1.03, 1.73]).[15] Another metanalysis showed that low SES, particularly low individual level SES (income and education) and low combined area level SES (z score of 6 to 7 census derived SES indicators) were associated with CKD prevalence ($p<0.001$). Progression to ESKD was associated with lower individual level SES (income levels and occupational status) and lower combined area level SES ($p<0.001$, $p=0.006$, $p=0.009$, respectively).[16]

Why should we account for geography?

It is well known that there is geographical variation in health, health care resources, prevalence and incidence of various diseases, and SES across the United States.[17-19] This is also true for CKD.[20] With the advancement of geographical information systems, it is now possible to link patient and population data to location identifiers.[20] Studies that have looked at geographical variation of CKD and ESKD consisted of: 1) well established cohorts such as the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study that looked at differences across states; or 2) the US veteran's population that looked at the variation of CKD progression across US counties; or 3) looking at the distribution of dialysis and transplant centers mainly using the United States Renal Data System (USRDS).[20-22] These studies mask the variation across smaller geographical units (census tracts) and have focused predominately on advanced stages of kidney disease.

CKD and SES

Several studies evaluated the association of area level SES and their interaction with kidney disease without adjusting for individual level SES (**Table 1**).[22-24] For example, in an analysis of 1,253,541 patients from the USRDS, area level poverty (zip code) was

associated with 1.24 higher incidence (95% CI [1.22, 1.25]) of ESKD, after adjusting for distribution of age, sex, race/ethnicity within the area unit, and time period.[24] Another study by Bowe et al. assessed the geographical variation at the county level of CKD progression among 2,107,570 veterans.[22] After adjusting for age, race, gender, diabetes, hypertension, and initial eGFR, they found that the odds of rapid eGFR decline were highest if participants lived in low vs. high SES counties (OR:1.15; 95%CI [1.09, 1.22]). These studies have several limitations including: focusing primarily on ESKD rather than earlier stages of CKD; wrongly inferring causality from observational studies; focusing on veterans – a non-generalizable predominately male population; and using large heterogeneous area units (counties do not accurately reflect neighborhoods SES).

Other studies evaluated the association of community and individual level SES with kidney disease (**Table 1**).[25-30] Among 4,735 participants (65 years or older) from the Cardiovascular Health Study, living in a census tract with the lowest SES (composite measure of wealth, income, education, and occupation) compared to the highest SES was associated with 40% greater risk of progressive CKD (HR:1.4, 95% CI [1.0, 1.9]) over 4 years after adjusting for age, gender, baseline creatinine, diabetes, hypertension, study site, lifestyle risk factors, and individual SES (income and education).[26] In the Atherosclerosis Risk in Communities (ARIC) study, among 12,856 participants and over 9 years of follow up, only in white men was block level SES (composite measure) associated with CKD progression. White men participants living in low block level SES had 1.6 times (95% CI [1.0, 2.5]) the rate of CKD progression than those living in high block level SES, after adjusting for age, baseline creatinine, body mass index (BMI), and individual level SES (income, education and occupation).[25] Also in ARIC, investigators found that among 14,086 individuals with normal kidney function at baseline, higher zip code level deprivation was associated with increased incidence of both CKD and ESKD in a dose-response manner after adjusting for age, sex, race and baseline eGFR.[30] This association was attenuated but remained significant for incident ESKD (but not CKD) after adjusting for smoking status, alcohol intake, physical activity, BMI, hypertension,

diabetes, total cholesterol, high density lipoprotein cholesterol and lipid-lowering medication use.

In conclusion, these studies demonstrated mixed results of the association of several neighborhood SES measures on CKD and ESKD while accounting for individual risk factors. Furthermore, some of these studies have found a differential association by race and gender while others did not. Limitations of these studies include using large geographical areas which may mask the variation within and using combined outcome measures for CKD in ARIC (both international classification of disease [ICD] and lab results) which are subject to misclassification. These studies have been based on well-established cohorts that may not reflect the general population or the needs of a current healthcare system and its patients. Furthermore, in several studies race was adjusted for in the models and authors failed to look at race specific results knowing that blacks and whites occupy low and high SES neighborhoods differently, i.e. they do not address residential segregation.

Role of health insurance

Health insurance has been used as a proxy of individual level SES when other indicators, such as individual level education and income were not available.[31-35] The validity of this measure is unknown. However, Medicaid eligibility criteria, although state dependent, is always tied to family income and is based on federal poverty guidelines.[36] The majority of Medicaid beneficiaries have incomes below the poverty line, thus insurance can serve as a crude proxy for individual level SES.[37] In Minnesota, eligibility for Medicaid (≥18 years) include: adults with household incomes up to 138% of the poverty level, pregnant women with household incomes up to 278% of the poverty level, aged, and blind and disabled populations.[38] On the other hand, Medicare provides nearly universal insurance coverage for individuals ≥65 years. However, those without supplemental insurance plans face large copayment and deductibles for services and prescription drugs. Individuals with supplemental insurance plans receive more preventive services.[39-42] It has also been reported that patients with supplemental insurance receive better care and have better

overall short term survival following a myocardial infarction than patients with Medicare and no supplemental insurance plans. Similar to the <65 age group, insurance health coverage of adults ≥65 years may be considered a surrogate for individual level SES. Not having supplemental insurance may be a crude proxy of the subset of Medicare beneficiaries with lower income. In Minnesota, 46% of all Minnesota Medicare enrollees were enrolled in private Medicare plans (a plan that replaces the original Medicare). In December 2019, in Minnesota, 558,730 individuals (54% of the population ≥65 years) retained the original Medicare plan and 472,142 (46% of the population ≥65 years) were enrolled in Medicare Advantage and other health plans.[38,43] Insurance coverage does not fully capture an individual's SES. It may be viewed as a measure of SES, but more importantly it has been associated with clinical care and health outcomes. Overall, having insurance coverage improves outcomes of several diseases.[44] Of note, there have been no studies looking at the association of health insurance coverage with CKD.

Potential mechanism for the association of CKD and neighborhood SES

In a review by Nicholas et al., the authors proposed a potential framework in which socioeconomic disadvantage might lead to CKD. These include the following: 1) residential segregation might lead to poor educational systems, poor housing, increase in environmental and infectious disease exposures which in turn can contribute to low educational attainment, 2) discrimination can lead to chronic stress, substance abuse, inactivity and overeating, and 3) uninsured/underinsured lead to limited health care access and utilization which in turn reduce CKD risk factor treatment and prevention. These factors are all intermingled and could directly or indirectly (increase CVD complications and influence inflammatory factors) lead to accelerated decline in kidney function.[45,46]

Table 1. Studies looking at the association of SES with kidney outcomes within a geographical unit

Kidney disease and area level SES					
Study	**Patients**	**Area of analysis**	**Exposure**	**Outcomes**	**Results**
Volkova et al. 2008[23]	Georgia, North Carolina, and South Carolina N=34,767	Census tract	**Area level SES**: neighborhood poverty = proportion of the census tract population living below the poverty level	ESKD	Association between neighborhood poverty and ESKD incidence varied between Blacks and Whites. RR comparing high poverty to low poverty in the overall cohort, in Blacks and in Whites was: 4.50 (95%CI [4.32, 4.71], 2.92 (95%CI [2.72, 3.13]), and 1.99 (95% CI [1.86, 2.13]) respectively
Garrity et al. 2016[24]	USRDS N=1,253,541	Zip code tabulation areas	**Area level SES**: poverty status	ESKD incidence by time period in the Unites States adult population	Area-level poverty status was associated with a 1.24 (95% CI [1.22, 1.25]) fold higher ESKD incidence, after adjusting for distribution of age, sex, and race/ethnicity within a zip code
Bowe et al. 2017[22]	Veterans Affairs databases N=2,107,570	County level	**Area level SES**: county level characteristics: rurality, poverty rate, and the percentage of African Americans	Rapid eGFR decline (defined as eGFR slope < –5 ml/min per 1.73 m_2/year)	Higher odds of rapid eGFR decline when living in counties with high percentage of minorities and immigrants (OR:1.25; 95%CI [1.20, 1.31]) and in counties with low SES (OR:1.15; 95%CI [1.09,1.22])

SES: socioeconomic status; ESKD: end stage kidney disease; RR: relative risk; USRDS: united states renal data system; GFR: estimated glomerular filtration rate, OR: odds ratio; CI: confidence interval

Table 1 (continued)

Kidney disease, area level SES and individual level SES					
Study	**Patients**	**Area of analysis**	**Exposure**	**Outcomes**	**Results**
Merkin et al. 2005[25]	Atherosclerosis Risk in Communities study [ARIC] N=12,856	Census Block	**Individual level SES** (self-reported): income, education, and occupation **Area level SES**: 6 components representing income, wealth, education and occupation	Progression of CKD (pCKD): serum creatinine ≥ 0.4mg/dl compared to baseline OR hospitalization or death coded for conditions related to CKD	- White men and black women have statistically significant trend of less pCKD incidence with increasing quartiles of area-level SES -Only for White men, HR for pCKD in lowest vs. highest SES area quartile was significant with HR=1.6 (95%CI [1.0, 2.5]) after adjusting for age, center, baseline creatinine level, BMI, and individual-level SES
Merkin et al. 2007[26]	Elderly Cardiovascular Health Study participants (≥65 years) in 4 US states N=4,735	Census Block	**Individual level SES** (self-reported): income and education **Area level SES**: 6 components representing income, wealth, education and occupation	pCKD: serum creatinine ≥ 0.4mg/dl compared to baseline OR hospitalization OR death coded for conditions related to CKD	-People living in lowest SES areas have 40% greater risk of pCKD compared to those living in highest SES areas after adjusting for individual level SES, lifestyle risk factors, diabetes, and hypertension (p for trend: 0.01) -No association between pCKD and individual level income or education in crude and fully adjusted model

SES: socioeconomic status; CKD: chronic kidney disease; HR: hazard rate; CI: confidence interval; BMI: body mass index
ARIC included: Maryland, North Carolina, Mississippi, Minnesota); Cardiovascular health study included: North Carolina, Maryland, California, Pennsylvania; BMI: body mass index

Table 1 (continued)

Kidney disease, area level SES and individual level SES					
Study	**Patients**	**Area of analysis**	**Exposure**	**Outcomes**	**Results**
Shoham et al. 2007[27]	ARIC N=12,631	County level	**Individual level SES**: social class was categorized as working class or non–working class at ages 30, 40, or 50 years **Area-level SES**: composite of census scores during the same period	CKD: hospital discharge diagnosis and/or eGFR< 45 mL/min/1.73 m^2	-Adjusted OR of CKD for working class vs. non–working class at age 30 was 1.4 (95% CI [1.0, 2.0]) in whites and 1.9 (95% CI [1.1, 3.0]) in blacks - At age 50, area SES is associated with CKD. This association is no longer significant after adjusting for age, confounders, hypertension and diabetes in whites and blacks - Individual education level also is associated with CKD, but adjustment for confounders and mediators reduced the strength of association
McClellan et al. 2010[28]	REasons for Geographic And Racial Differences in Stroke [REGARDS]* N=22,538	Census tract	**Individual level SES**: individual poverty: family income below $15,000 **Area level SES**: poor neighborhood: 25% or more of the households were below the federal poverty level	eGFR	-Family income was independently associated with eGFR level irrespective of race -Neighborhood poverty was not associated with eGFR

SES: socioeconomic status; CKD: chronic kidney disease; eGFR: estimated glomerular filtration rate; OR: odds ratio; CI: confidence interval
ARIC included: Maryland, North Carolina, Mississippi, Minnesota); REGARDS included: North Carolina, South Carolina, Georgia, Alabama, Mississippi, Tennessee, Arkansas, Louisiana

Table 1 (continued)

Kidney disease, area level SES and individual level SES					
Study	**Patients**	**Area of analysis**	**Exposure**	**Outcomes**	**Results**
Crews et al. 2014[29]	REGARDS N=23,314	County level	**Individual level SES**: self-reported household income **Area level SES**: geographically concentrated county poverty using data obtained from the 2000 US Census; county affluence/impoverished; neighborhood poverty z-score; Gini index, a measure of wealth inequality; rural urban commuting area codes	ESKD	-Association of low income with increased risk of ESKD is strong and independent of geospatially-linked measures of county poverty and no evidence of effect modification [HR for income <$20,000 vs. ≥$75,000: 3.75 (1.62-8.64) adjusted for county characteristics]
Vart et al. 2018[30]	ARIC N= 14,086	Census block	**Individual level SES** (self-report): annual household income and educational attainment **Area level SES**: area deprivation index (ADI)	Incident ESKD, incident CKD and change in eGFR using four measurements over ~23 years	-HR for ESKD and CKD in the low income vs. high income individuals was 1.50 (95% CI [1.14,1.98]) (P-trend =0.003) and 1.01 (95% CI [0.92, 1.10]), respectively in the fully adjusted model. -eGFR decline was steeper 15% in low income compared to high income (p-trend <0.001) -Similar results with lower educational attainment and higher ADI (neighborhood deprivation)

SES: socioeconomic status; ESKD: end stage kidney disease; eGFR: estimated glomerular filtration rate; HR: hazard rate; CI: confidence interval; ARIC included: Maryland, North Carolina, Mississippi, Minnesota); REGARDS included: North Carolina, South Carolina, Georgia, Alabama, Mississippi, Tennessee, Arkansas, Louisiana

D. SCREENING FOR CHRONIC KIDNEY DISEASE

As previously stated, CKD is a major public health problem. However, patient awareness of CKD in the general US population remains low. Only 9.4% of individuals with CKD were aware that they had impaired renal function and only 52% of individuals with severe CKD were aware of having kidney dysfunction.[47,48] CKD is asymptomatic until advanced stages but can be detected easily and inexpensively by measuring serum creatinine, urine protein or albumin concentration, or by using a urine dipstick.[49] Early detection of CKD may slow down progression of CKD to ESKD by advising patients to avoid nephrotoxic agents, and using appropriate medications that may improve patient outcomes.[50-52]

Risk factors for CKD include older age, being black, smoking, hypertension, diabetes mellitus, and obesity.[5] The National Kidney Foundation, the Renal Physicians Association, and the American Diabetes Association (ADA) support screening of patients with diabetes. Further screening of African Americans, at risk ethnic groups, individuals >60 years of age and those with a family history of CKD is recommended by National Kidney Foundation and Renal Physicians Association.[53] However, the American College of Physicians recommends against screening in asymptomatic adults without CKD risk factors and stated that there is insufficient evidence of the benefits of screening, as there are no randomized clinical trials that show the benefit of screening in high risk populations on clinical outcomes.[54,55] However, there is sufficient indirect evidence that community screening for CKD is valuable in patients with risk factors (diabetes, hypertension etc.).[56,57] It has been shown that screening of high risk individuals is appropriate to identify and manage CKD.[58]

In Canada, the See Kidney Disease (SeeKD) targeted screening program, used a convenience sample approach, and targeted individuals at risk for CKD using an individual and community approach.[59] They found that most of the participants (84.9%) reported one CKD risk factor (belonging to a high risk ethnic group, having hypertension

or having diabetes), and the prevalence of unrecognized CKD was 18.8%. More participants were recruited using individual targeted approach (targeting high risk individuals) compared to community based approach (targeting an event in a community location in proximity to a high risk population) (57.3% vs. 42.8%). Another screening pilot for CKD in the U.S, the Kidney Early Evaluation Program (KEEP), targeted screening for CKD in high risk populations (patients with hypertension, or diabetes, or who have a first order relative with hypertension or diabetes) and identified 14% of the screened population with an eGFR <60 mL/min/1.73 m^2 had no prior knowledge of kidney disease had eGFR <60 mL/min/1.73 m^2.[57] However, none of these studies have looked at the added benefit of screening for CKD based on neighborhood SES status. These studies have also been volunteer-based, which limits the generalizability of the results.

E. CHRONIC KIDNEY DISEASE AND PATTERNS OF CARE

To reduce the burden of CKD, there is a need to improve prevention, detection, and treatment as well as reduce complications associated with CKD care. Goals and strategies to improve CKD are now included in Healthy People 2020, the US Surgeon General's goal for public health.[60] Despite guidelines, consensus panels and workshops promoting better CKD screening and treatment, studies that look at patterns of care among CKD patients are limited.[61,62]

In patients with CKD, it is recommended to test for albuminuria using UACR. A spot albumin-to-creatinine ratio is a more sensitive and specific marker of CKD than a spot urine protein/creatinine ratio, although both predict clinical outcomes.[63] ACEi and ARBs are recommended to treat all patients with CKD who also have either diabetes and/or albuminuria.[64,65] ACEi/ARBs reduce proteinuria and in turn reduce the risk of CKD progression.[66,67] Therefore, it's important to screen patients with CKD for albuminuria by measuring UACR.

Several studies have looked at screening rates for albuminuria, appropriate ACEi/ARB prescription in patients with CKD, and documentation of CKD in the Electronic Health Record (EHR). In a study of 11,774 patients with CKD stages 3 and 4 from a multi-specialty primary care group practice in Massachusetts, low rates of adherence to many CKD practice guidelines, including annual urine protein quantification (30%), and inappropriate prescription patterns [not prescribed appropriate medications or prescribed nephrotoxic medications] were found.[68] Furthermore, an analysis of Southern California Kaiser Permanente reported that over a 12 months period primary care providers saw the majority of patients with CKD (85%) and only 79% had CKD coded in their system. They reported that in patients with prevalent CKD, 21% had no proteinuria assessed and 16% had no ACEi/ARB on their medication list.[69] Overall in the US, 69.4% of individuals with CKD and diabetes received recommended medical treatment with ACEi/ARBs and only 25.8% of CKD patients were evaluated for albuminuria in 2007.[70] Other aspects of CKD care include reducing of patients' risk of CVD, anemia, metabolic acidosis, bone disorder, and early referral to nephrologists.[71]

Only one study to our knowledge has looked at patterns of care by neighborhood SES characteristics. This study encompassed 5,387 dialysis facilities in the US. Investigators found that facilities with the lowest pre-ESKD nephrology care (patients saw nephrologist before initiation of dialysis) were more likely to be located in urban counties, counties with higher percentage of blacks, and in counties with low educational attainment (below high school).[72] Of note, county results are broad; they do not encompass the heterogeneity in smaller neighborhood areas. In conclusion, adherence to guideline recommendations for screening and management of CKD is suboptimal. None of the previous studies looking at quality of CKD care assessed the role of neighborhood SES.

F. ADVANTAGE OF ELECTRONIC HEALTH RECORDS

Since the passage of the Health Information Technology for Economic and Clinical Health Act (HITECH) in 2009, the use of EHRs are becoming standard practice in the

US. The HITECH Act offers incentives to professionals and hospitals for EHR use tied to existing and emerging requirements (up to date problem list, capturing vital statistics etc).[73,74] The HITECH act has been effective – nearly 95% of US hospitals have adopted EHRs. While originally used for billing, EHR data has already contributed to research and enabled researches to understand complex diseases. Thus, data from EHRs can inform population health research. EHR studies compared to traditional studies that use primary data collection, are less expensive, more time efficient, larger and more generalizable. However, some drawbacks of EHR include less precise and comprehensive capturing of data and incomplete follow up data.[75] Despite their drawbacks, EHRs can be used for epidemiological research and provide a means to efficiently examine clinical evidence on a broad population.[76]

Moreover, EHRs can provide data on demographic characteristics and risk factors of patients with CKD (for all stages). From a public health perspective, kidney function can be monitored along with risk factors. Findings can then be used to identify patients at risk, identify disparities in prevalence and care, improve health care quality and health outcomes. EHRs capture population level data on CKD, and because CKD requires laboratory data for diagnosis, it is ideal disease to electronically phenotype.[77]

II. SPECIFIC AIMS

CKD, an abnormality in kidney function or structure present for ≥ 3 months, is a silent epidemic affecting 15% of the US adult population.[49] Risk factors for CKD include older age, being black, smoking, hypertension, diabetes mellitus, and obesity.[5] Additionally, CKD has been shown to be associated with low SES.[15,16] Currently, screening for CKD in high risk groups, such as patients with diabetes or hypertension, is recommended and advocated by the Kidney Disease: Improving Global Outcomes guidelines.[49] Despite that, a large number of patients with CKD are unaware they have CKD. It is unknown whether adding SES to traditional screening will improve the ability to detect patients at high risk for CKD.[7,8] We propose to utilize data from Fairview Health Services, a large health care organization in the seven county metropolitan Twin Cities area, to evaluate whether adding a patients' census tract SES level to known risk factors of CKD will improve our ability to identify patients at high risk of having CKD. These results could be incorporated into a screening instrument that would enhance our ability to identify patients who should be tested for CKD.

Some studies have looked at the association between individual and area level SES factors on CKD and ESKD. However, these studies were limited as they focused on large geographical areas, used composite measures for SES that are not useful in policy discussions, focused on ESKD - a rare event- rather than CKD, and did not appropriately estimate neighborhood effects.[22-30,72,78] Furthermore, the association of neighborhood characteristics and insurance status with CKD remain unclear. Therefore, we will investigate the association of neighborhood SES, neighborhood racial composition, and insurance status with CKD prevalence. Thus, we gain further insight into factors associated with CKD. Knowing that CKD awareness is low among patients and physicians, we will also assess aspects of CKD care by neighborhood SES. These results will help guide the design of community level interventions intended to improve kidney outcomes and contribute to improvements in screening and management of CKD, as well as allocating appropriate funds in the Twin Cities to improve kidney health.

Aim 1: Evaluate whether census tract measures of SES improve the ability to identify patients at high risk of CKD in the Twin Cities Metro Area.

Hypothesis 1: Adding census tract SES to traditional risk factors will improve the ability to identify those who are at high risk of CKD.

Aim 2: Determine if census tract characteristics and health insurance are associated with CKD prevalence in the Twin Cities Metro Area.

Hypothesis 2A: Census tract SES and health insurance coverage are independently associated with CKD prevalence; patients living in low SES tracts or on Medicaid if <65 years or have Medicare with no supplemental insurance plan if ≥65 years will have higher CKD prevalence than patients living in high SES neighborhood, have other insurance if <65 years, or have Medicare with supplemental insurance plan if ≥65 years, respectively.

Hypothesis 2B: Area racial composition is associated with CKD prevalence; blacks living in predominantly black areas have greater prevalence of CKD than blacks living in predominantly white areas.

Aim 3: Examine patterns of CKD care received by census tract level SES factors in the Twin Cities Metro Area.

Hypothesis 3A: Area level socioeconomic disparities in care of patients with CKD (proportion of persons who receive recommended medical treatment with ACEi/ARBs) will be observed; individuals living in lower SES tracts are less likely to receive recommended medications than individuals in higher SES tracts.

Hypothesis 3B: Area level socioeconomic disparities in albuminuria screening for patients with CKD (proportion of persons who receive medical evaluation with UACR) will be observed; individuals living in lower SES tracts are less likely to be screened for albuminuria than individuals in higher SES tracts.

Hypothesis 3C: Area level socioeconomic disparities in CKD documented in the EHR will be observed; individuals with CKD in lower SES tracts are less likely to have CKD documented in the EHR than individuals in higher SES tracts.

CHAPTER 2 - ADDITION OF NEIGHBORHOOD SOCIOECONOMIC STATUS TO DIABETES AND HYPERTENSION IMPROVED IDENTIFICATION OF PATIENTS WITH CHRONIC KIDNEY DISEASE USING ELECTORINIC HEALTH RECORDS

Synopsis Digest

Rational & Objective

Current guidelines recommend screening for CKD in patients with diabetes and hypertension. CKD is a silent disease, usually detected at later stages, and it is associated with low SES. We assessed whether adding census tract SES status to the standard screening approach improves our ability to identify patients with CKD.

Study Design

Screening test analysis

Settings & Participants

EHR of 256,162 patients seen at a healthcare system in the 7-county Minneapolis/St Paul area and linked census tract data.

Exposures

First quartile of census tract SES [median value of owner occupied housing units (wealth <$165,200), percentage of residents >25 years with a Bachelor's degree or more (education <20.4%) household income (income <$35,935)], hypertension and diabetes.

Outcomes

CKD [eGFR< 60/mL/min/1.73m$_2$ or proteinuria]

Analytic Approach

Sensitivity, specificity, and number needed to screen (NNS) to detect CKD if we screen patients who have hypertension and/or diabetes and/or who live in low SES tracts (belonging to the first quartile of any of the three measures of tract SES) vs. standard approach.

Results

CKD was prevalent in 13% of our cohort. Sensitivity, specificity, and NNS of detecting CKD after adding tract SES to the screening approach was 67% [95%CI: 66.2, 67.2],

61% [95%CI: 61.1, 61.5] and 5, respectively. With the standard approach, sensitivity of detecting CKD was 60% [95% CI: 59.4, 60.4], specificity was 73% [95%CI: 72.4, 72.7] and NNS was 4, respectively.

Conclusions

Leveraging patients' addresses from the EHR and adding tract level SES to standard screening approach increases the sensitivity of detecting patients with CKD at a cost of decreased specificity. Improving the ability to detect CKD at an early stage is of utmost importance, as highlighted by the recent Presidential Executive Order on Advancing American Kidney Health.

Introduction

CKD is a major public health problem. Currently, 26 million Americans and 200 million individuals worldwide have CKD.[7,8] CKD is asymptomatic until advanced stages; therefore, diagnosis is usually delayed. Provider-level CKD awareness remains low, indicated by incorrect documentation of CKD using ICD 9/10 diagnostic codes.[79] However, CKD can be detected easily and inexpensively by measuring serum creatinine, urine protein or albumin concentration, and by urine dipstick.[49] Early detection of CKD allows the opportunity to slow down the progression of CKD and reduce the incidence of cardiovascular complications.[50-52] The Presidential Executive Order on Advancing American Kidney Health issued on July 10, 2019 states that the policy of the US is to "prevent kidney failure whenever possible through better diagnosis, treatment, and incentives for preventive care".[80] This reinforces the importance of screening patients for CKD.

Screening of patients with hypertension, diabetes, blacks, Hispanics, American Indians, individuals >60 years of age, and those with a family history of CKD is recommended by the National Kidney Foundation, Renal Physician Association, and the ADA.[9,53] There are geographical variations in prevalence and incidence of CKD and SES across the US.[20] Studies have shown an increased risk for CKD and ESKD in individuals living in areas with low SES.[22-24] Despite this evidence, guidelines do not recommend screening for CKD in this population.

EHRs capture clinical data and provide a large amount of health information on a diverse and broad patient population that is not subject to a prespecified set of inclusion criteria unlike data from cohort studies and randomized clinical trials. Furthermore, with the increasing use of EHRs to study population health data and the advance of geographical information systems, we are now able to link patient data to location identifiers and subsequently to area level characteristics. Since neighborhood measures of SES are linked to CKD, understanding this association is important for informing intervention and

policy efforts.[23,25-27] The purpose of this study is to evaluate whether adding neighborhood level SES to current screening recommendations will improve the sensitivity and/or specificity for detecting CKD.

Methods

Data

Patients were identified from the EHR database of Fairview Health Services, the primary affiliate of the University of Minnesota. EHR data was included from 6/1/2008 to 4/1/2019. The data incorporates all visits, labs, billing, and patients' geocoded addresses.[81] The Institutional Review Board at the University of Minnesota approved this study.

Population Definition

The population included all adult patients (≥18 years) in the Fairview health system who have their address geocoded, are from the 7-county Minneapolis/St Paul metropolitan area, and have at least one primary care provider (PCP) visit in the Fairview health system. We only included patients with an outpatient creatinine within the 18 months after their first documented PCP visit during this time period (**Figure 2**). Index creatinine was defined as the first outpatient creatinine available during this time period . Patients who opted out of using their data for research were excluded.

Geographic Unit and SES Measures for Analyses

We selected census tracts as the geographic unit of analysis. Census tracts are small, relatively permanent and consist of homogeneous populations (average number of people in census tract = 4,000).[82] We used three separate measures to operationalize tract level SES: median value of owner-occupied housing units, percentage of residents over age 25 with a Bachelor's degree or more, and median household income as identified from the 2012 ACS 5-Year Data [2008-2012].[19,83] These measures reflect wealth, education, and income of the tract.[84] Tract measures of SES remained relatively unchanged during this

time period (18 months from first documented PCP visit) in the 7-county metropolitan area.[19,20]

We defined a low SES tract as belonging to the first quartile of the distribution of each SES measure in the metropolitan area. Each patient was matched to the appropriate census tract. A patient was considered to be living in low census tract SES if tract median value of owner occupied housing units (wealth) was <$165,200, tract percentage of residents over age 25 years with a Bachelor's degree or more (education) was <20.4%, or tract median household income (income) was <$35,935 (**APPENDIX – CENSUS DATA)**.

Variables

Age, race, sex, and smoking status were defined from the EHR using the last value before or at the time of the index creatinine. All creatinine measures were traceable to an IDMS reference measurement. Comorbidities were considered present if at least two ICD-9/10 codes (**APPENDIX – ICD CODES)** for that condition were present at or before the date of the index creatinine.[85] Baseline labs and vitals were defined using the last value at or before the date of the index creatinine and included: BP, BMI, UACR, urine protein to creatinine ratio UPCR, and UA. eGFR was calculated using the CKD-EPI creatinine equation.[3] We manually abstracted clinical and laboratory data for 50 random patient charts and compared it with data pulled directly from EHR to ensure data quality *(data not shown)*.

CKD was defined as having outpatient index eGFR <60/mL/min/1.73m^2 or having proteinuria [last measure available of UACR >30mg/g or UPCR >150mg/g or UA >30mg/g within 18 months from the first documented PCP visit] (lab-diagnosed CKD). Additionally, awareness of CKD by healthcare providers was defined as having CKD documented in the patients EHR (having at least two ICD9/10 codes for CKD, ESKD, dialysis, or kidney transplant before and up until 90 days after the date of the index creatinine) among patients with lab-diagnosed CKD.

Screening Approaches

We investigated three screening approaches: a) Approach 1 (standard), screening patients with known history of hypertension and/or diabetes; b) Approach 2 (standard and/or 1 low SES tract measure), screening patients with known history of hypertension and/or diabetes and/or who live in census tract with low SES (one measure); c) Approach 3 (standard and/or any of 3 low SES tract measures), screening patients with known history of hypertension and/or diabetes and/or who live in census tract with low SES (wealth) and/or low SES (education) and/or low SES (income) (**Table 2**). Additionally, we included an approach that screened patients who had a history of hypertension and/or diabetes and/or who lived in a census tract that has high prevalence of CKD (≥14.8% of census tract has CKD [cutoff for the highest quartile of CKD prevalence in the US derived from National Health and Nutrition Examination Survey data[8]]). For this approach [Approach 4 (standard plus high CKD tract prevalence)], we only based our analysis on tracts with >200 patients to ensure we had adequate sample size to assess tract prevalence of CKD.

Statistical Analyses

We compared baseline demographic and clinical characteristics of patients who were screened vs. not, and among those who were screened, those who did and did not have CKD. Categorical variables were presented as frequencies and continuous variables as mean (standard deviation) values. Differences between groups were tested by Chi-square test and t-test for categorical and continuous variables respectively. Pearson correlation was used to test the association between the census tract SES variables.

We calculated sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and number of patients needed to screen to detect one CKD case for each approach. Number needed to screen (NNS) was defined as the number of individuals screened divided by number of cases of CKD detected.[86] We estimated the difference of these screening assessments between different approaches and Approach 1 by using

bootstrap standard errors (1,000 bootstrap replications). We also estimated provider awareness of CKD by tract SES and race. For these analyses, we are assuming all CKD cases are ascertained.

Since we only included patients who had creatinine measured, we are subject to selection bias. We quantitatively assessed this bias by dividing the observed number of patients with and without CKD for each approach with a selection factor [probability of a patient being included in cohort given CKD and approach status]. We then estimated selection bias adjusted sensitivity and specificity values using a range of selection probabilities for each approach (**Data S1**).

Additionally, preplanned sensitivity analysis included the following: changing the time from the first PCP visit to index creatinine from 18 months to 12 and 24 months; stratifying by race, sex and age (<65 and ≥65 years); evaluating screening approaches limited to hypertension or diabetes or each of the tract low SES separately (**Table S2)**; using a more restrictive definition of CKD (eGFR <45/mL/min/1.73m$_2$ or proteinuria [UACR > 300mg/g or UPCR > 500mg/g or UA >100mg/g]); using only routine outpatient eGFR values (i.e. labs measured during annual clinic wellbeing visits) to define index creatinine; and using the median of the distribution for wealth, education and income to define low SES tract. Statistical analyses were conducted using R.[87]

Results

Cohort Characteristics

We included 256,162 patients in our cohort (**Figure 2**). Patients were on average 50 years, 46% were men, 9% were black, and 13% had CKD (**Table 3**). Fairview patients resided in 676 of the 704 census tracts in the metropolitan area. Our cohort's race, sex and geographical distribution was representative of the metropolitan area (**Table S1**). As expected, the tract SES measures were correlated. Tract income was moderately correlated with tract measures of education and wealth (r =0.30 and 0.33, respectively).

On the other hand, there was a strong correlation between tract measure of education and wealth (r=0.68).

In screening approaches except for that limited to census tract SES, individuals to be screened for CKD were older, more likely to be smokers, had more comorbidities, and had higher prevalence of CKD compared to individuals who were not screened (**Table S3, Table S4**).

Screening and CKD Detection

Details of the screening approaches were shown in **Table 4**. Adding any of the tract measures SES resulted in a similar increase in sensitivity of detecting CKD compared to the traditional approach (4-5%). Adding SES [Approach 3: standard and/or 1 of 3 low tract SES variables] increased the number screened from 81,497 with standard approach to 108,745, increased sensitivity by 7% [6.5%, 7.5%], and decreased specificity for detecting CKD by 11% [-11.4%, -11.1%] (**Data S2**). The 95% CI of the differences in sensitivity and specificity were very precise given the large sample size. PPV and NPV remained relatively constant across all screening approaches ranging from 19% to 25% and 92%, respectively. Using screening approaches limited to clinical characteristics or SES alone, resulted in very low sensitivity and high specificity (**Table S5**).

Screening patients who have hypertension and/or diabetes and/or who live in a census tract with high prevalence of CKD (Approach 4) increased the sensitivity to detect CKD cases by 15%, decreased specificity by 20% and the NNS increased by 1 compared to Approach 1 (standard) (**Table 4**).

Provider awareness of CKD

Provider awareness of CKD was low, only 5,409 patients out of 34,437 with lab-based diagnosis of CKD had CKD documented in the EHR. Overall, provider awareness of CKD was higher in blacks than whites and did not differ by tract SES (**Table 5, Table S6**).

Selection Bias Assessment and Sensitivity Analyses

In our bias analysis, we found that the corrected sensitivity and specificities varied greatly compared to measures observed in the included cohort (**Data S1**). For example, in Approach 1 (standard), sensitivity to detect CKD was 17% to 40% lower than observed (60%), while specificity was 7% to 16% higher than observed (73%). For Approach 3 (standard and/or 1 of 3 low tract SES variables), sensitivity and specificity were 17% to 42% lower and 9% to 21% higher, respectively, than observed values (67% and 61%). Similarly, for approach 4 (standard and/or high CKD tract prevalence) sensitivity and specificity were 15% to 42% lower and 10% to 24% higher, respectively, than observed (75% and 52%).

Changing the time from the first PCP visit to index creatinine from 18 months to 12 months or 24 months or limiting analysis to include only annual routine outpatient eGFR to define CKD resulted in similar sensitivity, PPV and NNS for all screening approaches **(APPENDIX – CHAPTER 2**). Findings (change in sensitivity and specificity when adding low tract SES) were consistent in subgroups by sex and age (**Table S7**, **Table S8**, **Table S9**, **Table S10**). Blacks however had greater improvement in sensitivity when adding tract SES to traditional risk factors (**Table S11**, **Table S12**).

Discussion

We examined the added value of screening for CKD among people living in low SES census tracts. The key findings are: 1) adding low tract SES to hypertension and/or diabetes increases the sensitivity and decreases the specificity of detecting CKD compared to current screening recommendations, 2) in addition to screening patients with hypertension and/or diabetes, screening patients who live in areas with high prevalence of CKD improves sensitivity and decreases specificity, and 3) provider awareness of CKD is low.

Our results should be interpreted with caution as they are only applicable to patients who

had their creatinine measured. Patients excluded from our cohort were healthier and younger than those included in the analysis (**Table S13**). Not only that, but our bias analyses estimated smaller sensitivity values for each approach. Thus, the benefit of these screening approaches to identify patients with CKD should be established in a random cohort not subject to selection bias before implementing any changes to current practice.

Several studies have assessed the effectiveness of targeted screening interventions for CKD. The SeeKD screening program in Canada and the KEEP in US targeted at risk individuals for CKD.[59,57] SeeKD screening program targeted participants with hypertension, diabetes, or those who belong to high risk ethnic group vs. the KEEP study targeted people who have first order relative with hypertension or CKD. Prevalence of CKD (eGFR <60 ml/min/1.73m$_2$) in the screened population ranged between 16 and 19%. These studies did not included SES, have been volunteer based, and do not reflect routine clinical practice. Only one study in Netherlands has assessed the added value of low individual level SES to detect CKD. Investigators used a subsample of the Prevention of Renal and Vascular End Stage Renal Disease study and compared three different screening approaches: traditional (hypertension, diabetes or history of cardiovascular disease), additional screening of elderly persons (>60 years), and patients with low individual level SES (≤primary school education). The ability to detect CKD improved from 36% (traditional) to 59% (with elderly), and to 51% (with low individual level SES). The NNS was fairly similar between these approaches (5.6, 6.5 and 6.5, respectively).[86] In our analyses, using an EHR based cohort and census tract level SES, we also showed that SES improves the sensitivity of detecting CKD and the NNS is relatively low (~6). This is consistent with previous studies that show an association between individual and area level SES and CKD.[15,16]

Implementing additional screening of patients based on area level SES may be challenging. There have been no randomized clinical trials establishing the benefit of CKD screening.[54,88] However, high prevalence of CKD, the fact that early stages of CKD are often undiagnosed, and increased risk of CVD, fractures, cognitive impairment,

frailty, and mortality among CKD patients[54], argue in favor of selecting a screening test that increases the sensitivity of detecting CKD. In CKD, the focus has been on improving sensitivity rather than PPV of any screening test, given the non-invasive nature of testing for CKD. However, an approach that improves sensitivity, decreases specificity and will lead to a greater number of false positives. This could lead to unnecessary tests, psychological impacts from being identified as a patient with CKD, polypharmacy, adverse events from medications, and financial burden.[54] Treatment strategies for early stage CKD include antihypertensive medications, statins, low protein diet, and intensive diabetes control. [88] A systematic analysis found that it would be cost effective (<$50,000/quality-adjusted-life-years) to screen for CKD, by eGFR and/or proteinuria, in patients with diabetes or hypertension .[89] We found that adding SES improves sensitivity of detecting CKD. Given the burden of CKD, this approach would be favorable. However, further analysis to assess the burden on patients are needed to establish the magnitude of which a decrease in specificity is acceptable.

Another challenge is that neighborhood SES can be defined in various ways, and there are no established threshold for low SES.[90] Moreover, patients with low SES receive fewer preventive services and disparities exist even in the fully insured patients, as physicians exhibit implicit bias based on patients' individual characteristics.[91-93] Introducing a screening intervention that includes SES could increase physician bias, and patients might be treated differently if physicians were aware of their neighborhood SES. On the other hand, incorporating SES into screening tools may aid in rectifying the sizable health disparities that are correlated to geographic characteristics in the US. The American College of Physicians recent policy paper on social determinants of health calls for health professionals to be knowledgeable about screening and identifying social determinants of health and treating patients whose health is affected by social determinants of health.[*94*] The National Academy of Medicine recommends social and environment measurements to be included in EHR and to incorporate social data in clinical care.[95] There should be careful consideration of the potential harm in misusing social determinants of health in clinical care and by researchers, for example excluding

certain populations from targeted therapy on the basis of their social characteristics. The feasibility of additionally screening for area SES should also be assessed from the physician's perspective and how it affects clinical management.

Several studies have found low physician awareness of patient CKD. In a large managed care cohort of 10,000 patients with CKD (stages 3 to 5), 14% of physician documented CKD with the correct ICD codes.[96] A similar low awareness of CKD was identified in a geriatric population in the Mid-South Veterans Administration network.[97] Among patients with CKD stage 2 and 3, 1.2% and 20% had a diagnosis code of kidney disease present in the EHR respectively. However, when awareness is higher, substantial improvements in CKD screening and management have been documented. For example, Kaiser Permanente's CKD population care management system achieves higher accuracy and better outcomes: 79% of patients with CKD had a diagnosis code for CKD.[69] While these studies address provider awareness of CKD screening guidelines, there is a dearth of knowledge if SES affects provider awareness of CKD and further research is needed to optimize CKD recognition.

There are several limitations to this study. First, we are using a single healthcare system and that may not be representative of the general population in Minnesota. However, we have shown that the patients in Fairview are representative of the metropolitan area. Second, our analyses were limited to neighborhood SES as individual level SES are not routinely collected in the EHR. Third, we used only a one-time eGFR measurement to determine CKD prevalence. Fourth, we limited our analysis to tracts with ≥ 200 patients to assess whether prevalence of CKD in tract improves the sensitivity to detect CKD (Approach 4). However, our findings showed that this method resulted in a 15% increase in sensitivity when compared with the standard screening approach. This shows that there is value in studying a healthcare system's area level CKD prevalence to improve early detection of CKD. Fifth, we relied on ICD codes to determine comorbidities of patients, and these may be subject to misclassification bias. In order to minimize this source of error, we used at least two ICD codes to confirm the diagnosis which should improve

specificity. We adjudicated 50 patient charts and found that ICD code diagnoses were consistent with that in patient clinic notes. Finally, we relied on a relatively insensitive marker, ICD codes, to determine physician awareness of CKD. However, greater CKD documentation by ICD codes has been associated with lower eGFR and a decrease in nephrotoxic drug use. This argues in favor of the validity of this measure for provider awareness.[96]

Our study is the first to look at the benefit of screening for CKD among persons living in low SES tracts in the US. Strengths of our study include: large cohort size, utilizing EHR records from routine clinical practice, not limiting our analysis to ESKD, availability of geographic data, and using small geographic areas to determine area level SES. Furthermore, our findings that adding tract level SES improves the yield of diagnosing CKD were consistent across multiple sensitivity analysis.

In conclusion, our study shows that adding neighborhood level SES to the standard screening approach (hypertension and/or diabetes) increases the sensitivity of identifying patients with CKD at a cost of decreased specificity. Improving the ability to detect CKD at an early stage is of utmost importance, as highlighted by the recent Presidential Executive Order on Advancing American Kidney Health.[8] Further research is needed to evaluate the benefit and impact of incorporating area SES in screening for CKD.

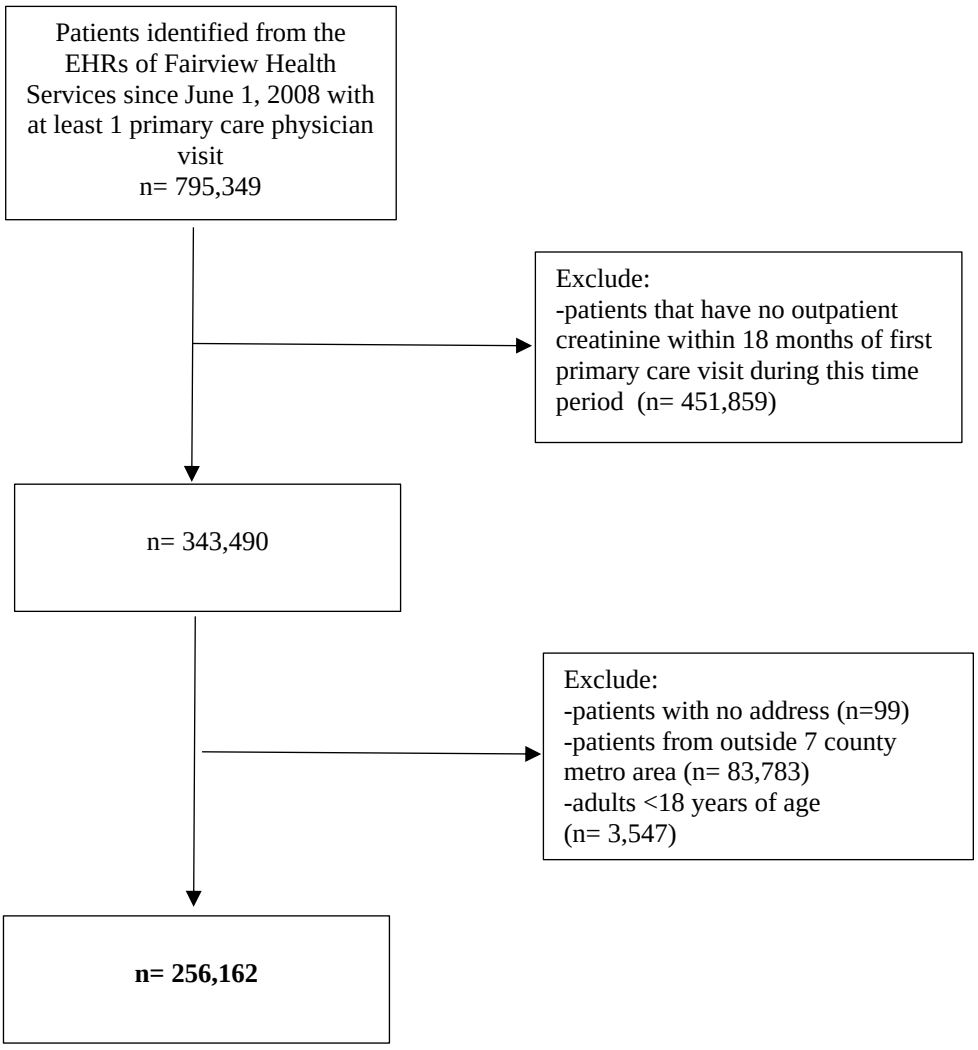
Tables and Figures

Table 2. Screening Approaches

Approach 1 (standard screening approach)	
screen patients who have a history of HTN and/or DM	
Approach 2: Screen based on low tract SES (1 variable only), with history of HTN and/or DM	
~~Approach 2A:~~	screen patients who have a history of HTN and/or DM, and/or who live in census tract where median value of owner occupied housing units is in the first quartile (< $165,200)
~~Approach 2B:~~	screen patients who have a history of HTN and/or DM, and/or who live in census tract where percent of residents >25 years with a Bachelor's degree or more is in the first quartile(<20.4%)
~~Approach 2C:~~	screen patients who have a history of HTN and/or DM, and/or who live in census tract where tract median household income is in the first quartile (<$35,935)
Approach 3: Screen based on history of HTN and/or DM, plus any of the three low SES tract variables	
screen patients who have history of HTN and/or DM and/or who live in census tract where median value of owner occupied housing units is in the first quartile (< $165,200) and/or who live in census tract where percent of residents > 25 years with a Bachelor's degree or more is in the first quartile (<20.4%) and/or who live in census tract where median household income is in first quartile (<$35,935)	
Approach 4: Screen based on history of HTN and/or DM plus high CKD tract prevalence	
screen patients who have history of HTN and/or DM and/or who live in the census tract where prevalence of CKD is in the highest (fourth) quartile (≥14.8%)	

HTN: hypertension, DM: diabetes, SES: socioeconomic status; CKD: chronic kidney disease

Figure 2. Cohort flow chart of Fairview patients from the 7 county Minneapolis/St Paul metropolitan area



EHR: Electronic Health Record, 7-county metro area: 7 county metro area of Minneapolis and St Paul, ESKD: End Stage Kidney Disease

* Primary care physician visits were defined as a completed outpatient office visits to family practice, family practice-internal medicine, internal medicine, obstetrics/gynecology, gerontology or geriatrics clinic visit.

Table 3. Baseline characteristics of Fairview patients

	Cohort included n= 256,162
CKD, n(%)	34,437 (13%)
Individual level characteristics	
Age, mean (SD)	50 ± 18
Black, n(%)	22,511 (9%)
Male, n(%)	118,894 (46%)
Ever smoker, n(%)	95,186 (37%)
Baseline characteristics	
Systolic BP, mmHg	124 ± 18
Diastolic BP, mmHg	76 ± 11
Medical History	
Hypertension, n(%)	71,744 (28%)
Diabetes, n(%)	24,773 (10%)
Obesity (BMI ≥ 30 kg/m2), n(%)	73,362 (36%)
Cardiovascular disease, n(%)	14,704 (6%)
Stroke, n(%)	3,733 (2%)
Hyperlipidemia, n(%)	60,791 (24%)
Cancer, n(%)	8,204 (3%)
Tract median value of owner occupied housing units	
Q1: < $165,200	25,225 (10%)
Q2: $165,200 - $188,100	32,801 (13%)
Q3: $188,100 - $231,300	87,210 (34%)
Q4: ≥ $231,300	110,870 (43%)
Tract % of Residents > 25 years with a Bachelor's degree or more	
Q1: < 20.4%	28,247 (11%)
Q2: 20.4% - 34.1%	65,160 (26%)
Q3: 34.1% - 48.1%	82,889 (32%)
Q4: ≥ 48.1%	79,815 (31%)
Tract median household income	
Q1: <$35,935	29,488 (12%)
Q2: $35,935 - $47,379	34,352 (13%)
Q3: $47,379 - $62,343	56,891 (22%)
Q4: ≥ $62,434	135,274 (53%)

CKD: chronic kidney disease; BP: blood pressure; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; SD: standard deviation; Q1: quartile1; Q2: quartile 2; Q3: quartile 3; Q4: quartile 4

Table 4. The sensitivity, specificity, PPV, NPV and number needed to screen for each screening approach to detect CKD

	All patients (n= 256,162; 34,437 have CKD)					**Tracts with >200 patients** (n= 224,679; 30,494 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or low tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low tract SES, education)**	**Approach 2C (HTN and/or DM and/or low tract SES, income)**	**Approach 3 (HTN and/or DM, and/or 1 of 3 low tract SES variables, 1st Q)**	**Approach 1 (HTN and/or DM)**	**Approach 4 (HTN and/or DM and/or high CKD tract prevalence)**
Number screened	81,497	98,699	99,933	102,171	108,745	72,078	115,646
CKD detected	20,636	22,078	22,306	22,224	22,978	18,434	22,956
Sensitivity	60 [59.4, 60.4]	64 [63.6, 64.6]	65 [64.3, 65.3]	65 [64.0, 65.1]	67 [66.2, 67.2]	60 [59.9, 61.0]	75 [74.8, 75.8]
Specificity	73 [72.4, 72.7]	65 [65.2, 65.6]	65 [64.8, 65.2]	64 [63.7, 64.1]	61 [61.1, 61.5]	72 [72.2, 72.6]	53 [52.0, 52.5]
PPV	25 [25.0, 25.6]	22 [22.1, 22.6]	22 [22.1, 22.6]	22 [21.5, 22.0]	21 [20.9, 21.4]	26 [25.3, 25.9]	20 [19.6, 20.0]
NPV	92 [91.9, 92.2]	92 [92.0, 92.3]	92 [92.1, 92.4]	92 [91.9, 92.2]	92 [92.1, 92.4]	92 [91.9, 92.2]	93 [92.9, 93.2]
Number needed to screen	4	5	5	5	5	4	5

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

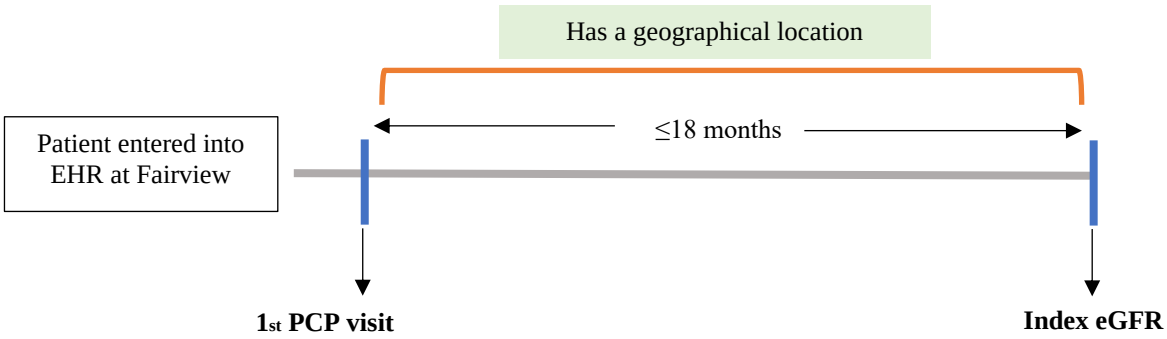
Table 5. Health care providers awareness* of CKD by census tract socioeconomic status

Median value of owner occupied housing units, n(%)				
	Q1: < $165,200	**Q2: $165,200 - $188,100**	**Q3: $188,100 - $231,300**	**Q4: ≥ $231,300**
Healthcare provider awareness	682/3,526 (19%)	674/4,648 (15%)	1,949/12,355 (16%)	2,103/13,901 (15%)
% of Residents > 25 years with a Bachelor's degree or more, n(%)				
	Q1: < 20.4%	**Q2: 20.4% - 34.1%**	**Q3: 34.1% - 48.1%**	**Q4: ≥ 48.1%**
Healthcare provider awareness	689/4,032 (17%)	1,496/9,391 (16%)	1,734/11,430 (15%)	1,489/9,577 (16%)
Median household income, n(%)				
	Q1: <$35,935	**Q2: $35,935 - $47,379**	**Q3: $47,359 - $62,343**	**Q4: ≥ $62,343**
Healthcare provider awareness	674/3,727 (18%)	857/5,078 (15%)	1,266/8,074 (16%)	2,609/17,537 (15%)

CKD: chronic kidney disease; Q1: quartile1; Q2: quartile 2; Q3: quartile 3; Q4: quartile 4

* Health care provider awareness of CKD: number of patients with CKD documented in charts using ICD9/10 codes by health care providers/ number of patients with lab based diagnosis of CKD

Figure S1. Cohort Construction (Chapter 2)



Data S1: Selection Bias Analyses

Below are the detailed of how we calculated the selection bias adjusted sensitivities and specificities over a range of selection probabilities.

	Have CKD	No CKD
Approach positive	N_1/S_1	N_2/S_2
Approach negative	N_3/S_3	N_4/S_4

S: selection factors (probability that a patient is included in the cohort i.e. seen at Fairview clinics given a patients CKD status and approach status)

Assumptions: $S_1 > S_2$, $S_1 > S_3$, $S_2 > S_4$, and $S_3 = S_4$

S_1: 0.6-0.9

S_2: 0.3-0.6

S_3/S_4: 0.1-0.4

For example: For S_1= 0.6, that means the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and having CKD and having hypertension and/or diabetes (Approach 1 positive) is 60%. For S_2 = 0.3 that means the probability of a patient coming to Fairview clinics and not having CKD and having hypertension and/or diabetes (Approach 1 positive) is 30%. We are assuming that $S_1 > S_2$, since it is more likely that a patient will come to Fairview clinics if they have CKD. For S_3=0.1, that means the probability of a patient seeking care at Fairview and having CKD but not having hypertension and/or diabetes (i.e. Approach 1 is negative) is 10%. We are assuming $S_3 < S_1$, since if a patient has comorbidities (hypertension and/or diabetes) they are more likely to come to Fairview clinics.

Approach 1 (Standard Approach):

Adjusted sensitivity ranges from 19.9% to 42.8% vs. observed sensitivity 59.9%

Adjusted specificity ranges from 79.6% to 88.8% vs. observed specificity 72.6%

Approach 2A (HTN and/or DM and/or tract SES, wealth):

Adjusted sensitivity ranges from 22.9% to 47.2% vs. observed sensitivity 64.1%

Adjusted specificity ranges from 73.9% to 85.0% vs. observed specificity 65.4%

Approach 2B (HTN and/or DM and/or tract SES, education):

Adjusted sensitivity ranges from 23.5% to 47.9% vs. observed sensitivity 64.8%

Adjusted specificity ranges from 73.6% to 84.8% vs. observed specificity 65.0%

Approach 2C (HTN and/or DM and/or tract SES, income):

Adjusted sensitivity ranges from 23.3% to 47.7% vs. observed sensitivity 64.5%

Adjusted specificity ranges from 72.7% to 84.2% vs. observed specificity 63.9%

Approach 3 (HTN and/or DM and/or 1 of 3 tract SES):

Adjusted sensitivity ranges from 25.1% to 50.1% vs. observed sensitivity 66.7%

Adjusted specificity ranges from 70.4% to 82.6% vs. observed specificity 61.3%

Approach 1 (Standard Approach with tracts >200 patients):

Adjusted sensitivity ranges from 20.3% to 43.3% vs. observed sensitivity 60.5%

Adjusted specificity ranges from 79.7% to 88.7% vs. observed specificity 72.4%

Approach 4 (HTN and/or DM and/or high CKD tract prevalence):

Adjusted sensitivity ranges from 33.7% to 60.4% vs. observed sensitivity 75.3%

Adjusted specificity ranges from 62.2% to 76.7% vs. observed specificity 52.3%

Table S1. Generalizability analysis: Comparing Fairview population to census data

	Fairview population (included in our analysis)	**7-county in Minneapolis/St Paul metro area population characteristics***
Median Age[1]	49	36
% Black	9%	8%
% Male	46%	49%
Population by County, n(%)		
Anoka	38,543 (15%)	331,649 (12%)
Carver	3,586 (1%)	91,355 (3%)
Dakota	59,204 (23%)	399,443 (14%)
Hennepin	109,009 (43%)	1,158,039 (40%)
Ramsey	24,773 (10%)	510,885 (18%)
Scott	13,955 (5%)	130,689 (5%)
Washington	7,092 (3%)	238,721 (8%)
Total population	*256,162*	*2,860,781*

[1]Median age in Fairview population before excluding patients <18 years i.e. median age over all ages for both Fairview and 7 county Minneapolis/St Paul metro area.

*Data from 2012 American Community Survey (ACS) 5-Year Data [2008-2012]

Table S2. Additional Screening Approaches

Approach 5: Screen based on history of HTN or DM, or one of three low SES tract variables using a different cutoff: low tract SES is when variable is < median)	
Screen patients who have history of HTN and/or DM and/or who live in census tracts where median value of owner occupied housing units is < median (< $188,100) and/or who live in census tract were percent of residents > 25 years with a Bachelor's degree or more is < median (<34.1%) and/or who live in census tract where median household income is < median ($47,379)	
Approach 6: Screen HTN separate from DM	
~~Approach 6A~~	screen patients who have a history of HTN
~~Approach 6B~~	screen patients who have a history of DM
Approach 7: Screen based only low census tract SES (without knowledge of HTN or DM)	
~~Approach 7A~~	screen patients who live in census tracts where median value of owner occupied housing units is in the first quartile (< $165,200)
~~Approach 7B~~	screen patients who live in census tracts where percent of residents >25 years with a Bachelor's degree or more is in the first quartile (<20.4%)
~~Approach 7C~~	screen patients who live in census tracts where tract median household income is in the first quartile (<$35,935)

HTN:hypertension; DM: Diabetes

Table S3. Baseline characteristics of patients who will be screened or not based on Approach 1 (standard screening approach)*

	Approach 1 (HTN and/or DM)		
	To be screened n= 81,497 (32%)	**Not to be screened** n= 174,665 (68%)	**p-value**
CKD, n(%)	20,636 (25%)	13,801 (8%)	<0.001
Individual level characteristics			
Age, mean (SD)	60 ± 15	45 ± 16	<0.001
Black, n(%)	6,670 (8%)	15,841 (9%)	0.339
Male, n(%)	40,689 (50%)	78,214 (45%)	<0.001
Ever smoker, n(%)	36,624 (45%)	58,562 (34%)	<0.001
Baseline characteristics			
Systolic BP, mmHg	131 ± 19	120 ± 16	<0.001
Diastolic BP, mmHg	78 ± 13	75 ± 11	<0.001
Medical History			
Hypertension, n(%)	71,744 (88%)	0 (0%)	----
Diabetes, n(%)	24,773 (30%)	0 (0%)	----
Obesity (BMI ≥ 30 kg/m2), n(%)	30,426 (49%)	42,936 (30%)	<0.001
Cardiovascular disease, n(%)	11,431 (14%)	3,273 (2%)	<0.001
Stroke, n(%)	2,924 (4%)	809 (0.5%)	<0.001
Hyperlipidemia, n(%)	39,439 (49%)	21,352 (12%)	<0.001
Cancer, n(%)	4,141 (5%)	4,063 (2%)	0.001

CKD: chronic kidney disease, BP: blood pressure, BMI: body mass index; Cardiovascular disease includes: congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; SD: standard deviation

*Approach1 (standard screening approach): to screen patients who have history of hypertension and/or diabetes

Table S4. Baseline characteristics of patients who will be screened or not based on Approach 2 (hypertension and/or diabetes and/or low census tract socioeconomic status- wealth) and Approach 7 (low census tract socioeconomic status – wealth)*

	Approach 2A			Approach 7A		
	To be screened n= 98,699 (34%)	**Not to be screened** n= 157,428 (66%)	**p-value**	**To be screened** n= 25,225 (10%)	**Not to be screened** n= 230,881 (90%)	**p-value**
CKD, n(%)	22,078 (22%)	12,356 (8%)	<0.001	3,526 (14%)	30,904 (13%)	0.009
Individual level characteristics						
Age, mean (SD)	57 ± 17	45 ± 16	<0.001	48 ± 18	50 ± 18	<0.001
Black, n(%)	10,052 (10%)	12,450 (8%)	<0.001	5,010 (20%)	17,489 (8%)	<0.001
Male, n(%)	48,436 (49%)	70,441 (45%)	<0.001	11,459 (45%)	107,401 (47%)	0.001
Ever smoker, n(%)	42,611 (43%)	52,563 (33%)	<0.001	9,587 (38%)	85,576 (37%)	0.003
Baseline characteristics						
Systolic BP, mmHg	130 ± 19	120 ± 16	<0.001	125 ± 19	124 ± 17	<0.001
Diastolic BP, mmHg	78 ± 12	75 ± 11	<0.001	77 ± 12	76 ± 11	<0.001
Baseline characteristics						
Hypertension, n(%)	71,744 (73%)	0 (0%)	-----	6,672 (26%)	65,057 (28%)	0.446
Diabetes, n(%)	24,773 (25%)	0 (0%)	-----	2,955 (12%)	21,807 (9%)	<0.001
Obesity (BMI ≥ 30 kg/m2), n(%)	34,791 (46%)	38,560 (30%)	<0.001	7,346 (39%)	65,997 (36%)	<0.001
Cardiovascular disease, n(%)	11,732 (12%)	2,971 (2%)	<0.001	1,340 (5%)	13,359 (6%)	0.02
Stroke, n(%)	2,989 (3%)	744 (0.5%)	<0.001	300 (1%)	3,423 (2%)	0.02
Hyperlipidemia, n(%)	40,742 (41%)	20,046 (13%)	<0.001	4,463 (18%)	56,313 (24%)	<0.001
Cancer, n(%)	4,410 (4%)	3,793 (2%)	0.004	589 (2%)	7,614 (3%)	0.015

CKD: chronic kidney disease, BP: blood pressure, BMI: body mass index; Cardiovascular disease includes: congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; SD: standard deviation

*Approach 2A: to screen patients who have a history of hypertension and/or diabetes and/or live in census tract where median value of owner occupied housing units is in the first quartile (<$165,200)

*Approach 7A: to screen patients who live in census tract where median value of owner occupied housing units is in the first quartile (<$165,200)

Data S2. Bootstrap results for difference between approaches

Approach 2A (hypertension and/or diabetes and/or low tract SES-wealth) vs. Approach 1(standard)

Mean difference & 95%CI in sensitivity: 4.2% [4.0%, 4.4%]

Mean difference & 95%CI in specificity: -7.1% [-7.2%, -7.0%]

Mean difference & 95%CI in PPV: -2.9% [-3.0%, -2.9%]

Mean difference & 95%CI in NPV: -0.03% [-0.04%, 0.14%]

Approach 2B (hypertension and/or diabetes and/or low tract SES-education) vs. Approach 1(standard)

Mean difference & 95%CI in sensitivity: 4.9% [4.6%, 5.1%]

Mean difference & 95%CI in specificity: -7.6% [-7.7%, -7.5%]

Mean difference & 95%CI in PPV: -3.0% [-3.1%, -2.9%]

Mean difference & 95%CI in NPV: 0.01% [-0.03%, 0.2%]

Approach 2C (hypertension and/or diabetes and/or low tract SES-income) vs. Approach 1(standard)

Mean difference & 95%CI in sensitivity: 4,6% [4.4%, 4,8%]

Mean difference & 95%CI in specificity: -8.6% [-8.7%, -8.5%]

Mean difference & 95%CI in PPV: -3.6% [-3.7%, -3.4%]

Mean difference & 95%CI in NPV: -0.02% [-0.1%, 0.07%]

Approach 3 (hypertension and/or diabetes and/or any of 3 low tract SES measures) vs. Approach 1(standard)

Mean difference & 95%CI in sensitivity: 6.8% [6.5%, 7.1%]

Mean difference & 95%CI in specificity: -11.2% [-11.4%, -11.1%]

Mean difference & 95%CI in PPV: -4.2% [-4.3%, -4.1%]

Mean difference & 95%CI in NPV: 0.1% [0.005 %, 0.3%]

Approach 4(hypertension and/or diabetes and/or high CKD tract prevalence) vs. Approach 1(standard)

Mean difference & 95%CI in sensitivity: 14.8% [14.4%, 15.2%]

Mean difference & 95%CI in specificity: -20.1% [-20.3%, -10.0%]

Mean difference & 95%CI in PPV: -5.7% [-5.8%, -5.6%]

Mean difference & 95%CI in NPV: 0.5% [0.8%, 1.2%]

Table S5. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD

	All patients (n= 256,162; 34,437 have CKD)						
	Approach 1 (HTN and/or DM)	**Approach 5 (HTN and/or DM, and/or 1 of 3 low census tract SES variables, median)**	**Approach 6A (HTN)**	**Approach 6B (DM)**	**Approach 7A (low census tract SES, wealth)**	**Approach 7B (low census tract SES, education)**	**Approach 7C (low census tract SES, income)**
Number screened	81,497	185,376	71,744	24,773	25,225	28,247	29,488
CKD detected	20,636	28,222	18,656	7,400	3,526	4,032	3,727
Sensitivity	60 [59.4, 60.4]	82 [81.5, 82.3]	54 [53.6, 54.7]	21 [21.1, 21.9]	10 [9.9, 10.6]	12 [11.4, 12.1]	11 [10.5,11.1]
Specificity	73 [72.4, 72.7]	34 [34.0, 34.4]	76 [75.9, 76.2]	92 [92.1, 92.3]	90 [90.1, 90.3]	89 [88.9, 89.2]	88 [88.2, 88.5]
PPV	25 [25.0, 25.6]	16 [15.5, 15.8]	26 [25.7, 26.3]	30 [29.3, 30.4]	14 [13.6, 14.4]	14 [13.9, 14.7]	13 [12.3, 13.0]
NPV	92 [91.9, 92.2]	93 [92.3, 92.7]	91 [91.2, 91.6]	88 [88.2, 88.4]	87 [86.5, 86.7]	87 [86.5, 86.8]	86 [86.3, 86.6]
Number needed to screen	4	7	4	3	7	7	8

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

Table S6. Healthcare provider awareness* by census tract socioeconomic status in blacks and whites

Blacks (n=20,651)			
Median value of owner occupied housing units, n(%)			
Q1: < $165,200	**Q2: $165,200 - $188,100**	**Q3: $188,100 - $231,300**	**Q4: ≥ $231,300**
127/400 (32%)	108/323 (33%)	179/576 (31%)	117/394 (30%)
% of Residents > 25 years with complete college education, n(%)			
Q1: < 20.4%	**Q2: 20.4% - 34.1%**	**Q3: 34.1% - 48.1%**	**Q4: ≥ 48.1%**
103/328 (31%)	194/599 (32%)	144/480 (30%)	90/286 (31%)
Median household income, n(%)			
Q1: <$35,935	**Q2: $35,935 - $43,379**	**Q3: $43,479 - $62,343**	**Q4: ≥ $62,343**
116/389 (30%)	116/305 (38%)	139/433 (32%)	159/564 (28%)
Whites (n=172,290)			
Median value of owner occupied housing units, n(%)			
Q1: < $165,200	**Q2: $165,200 - $188,100**	**Q3: $188,100 - $231,300**	**Q4: ≥ $231,300**
344/2179 (16%)	433/3380 (13%)	1477/9404 (16%)	1646/10831 (15%)
% of Residents > 25 years with complete college education, n(%)			
Q1: < 20.4%	**Q2: 20.4% - 34.1%**	**Q3: 34.1% - 48.1%**	**Q4: ≥ 48.1%**
399/2761 (15%)	1035/6916 (15%)	1315/8751 (15%)	1151/7366 (16%)
Median household income, n(%)			
Q1: <$35,935	**Q2: $35,935 - $43,379**	**Q3: $43,479 - $62,343**	**Q4: ≥ $62,343**
411/2527 (16%)	577/3717 (16%)	878/5960 (16%)	2033/13583 (15%)

CKD: chronic kidney disease; Q1: quartile1; Q2: quartile 2; Q3: quartile 3; Q4: quartile 4

* Health care provider awareness of CKD: number of patients with CKD documented in charts using ICD9/10 codes by health care providers/ number of patients with lab based diagnosis of CKD

Table S7. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD for males

	All patients (n= 118,894; 13,441 have CKD)					**Tracts with >200 patients** (n=104,838; 11,879 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or low tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low tract SES, education)**	**Approach 2C (HTN and/or DM and/or low tract SES, income)**	**Approach 3 (HTN and/or DM and/or 1 of 3 low census tract SES variables, 1st Q)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM and/or high CKD tract prevalence)**
Number screened	41,680	48,436	48,929	50,023	61,211	35,995	55,524
CKD detected	8,576	9,059	9,133	9,125	9,356	7,644	9,225
Sensitivity	64 [63.1, 64.8]	68 [66.8, 68.3]	68 [67.3, 68.9]	68 [67.3, 68.8]	70 [68.9, 70.5]	64 [63.5, 65.2]	78 [76.9, 78.4]
Specificity	70 [69.3, 69.8]	63 [62.4, 62.9]	62 [62.0, 62.5]	61 [60.9, 61.5]	59 [58.4, 58.9]	70 [69.2, 69.8]	50 [49.9, 50.5]
PPV	21 [20.7, 21.5]	19 [18.4, 19.1]	19 [18.3, 19.0]	18 [17.9, 18.6]	18 [17.3, 18.0]	21 [20.8, 21.7]	17 [16.3, 16.9]
NPV	94 [93.6, 94.0]	94 [93.6, 94.0]	94 [93.7, 94.1]	94 [93.6, 93.9]	94 [93.8, 94.0]	94 [93.7, 94.0]	95 [94.4, 94.8]
Number needed to screen	5	5	5	6	7	5	6

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

Table S8. The sensitivity, specificity, PPV, NPV and number needed to screen for each screening approach to detect CKD for females

	All patients (n= 137,268; 21,026 have CKD)					**Tracts with >200 patients** (n=119,841; 18,615 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low tract SES, education)**	**Approach 2C (HTN and/or DM and/or low tract SES, income)**	**Approach 3 (HTN and/or DM, and/or 1 of 3 low tract SES variables, 1st Q)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM, and/or high CKD tract prevalence)**
Number screened	40,817	50,263	51,004	52,148	55,802	36,083	60,122
CKD detected	12,060	13,019	13,173	13,099	13,622	10,790	13,731
Sensitivity	57 [56.7, 58.0]	62 [61.3, 62.6]	63 [62.0, 63.3]	62 [61.6, 62.9]	65 [64.1, 65.4]	58 [57.3, 58.7]	74 [73.1, 74.4]
Specificity	75 [75.0, 75.5]	68 [67.7, 68.2]	67 [67.2, 67.7]	66 [66.1, 66.7]	64 [63.4, 63.9]	75 [74.7, 75.3]	54 [53.9, 54.5]
PPV	30 [29.1, 30.0]	26 [25.6, 26.3]	26 [25.4, 26.2]	25 [24.7, 25.5]	24 [24.1, 24.7]	30 [29.4, 30.4]	23 [22.5, 23.2]
NPV	91 [90.5, 90.9]	91 [90.6, 91.0]	91 [90.7, 91.1]	91 [90.4, 90.8]	91 [90.7, 91.1]	91 [90.5, 90.8]	92 [91.6, 92.0]
Number needed to screen	3	4	4	4	4	3	4

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

Table S9. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD among patients <65 years of age

	All patients (n= 204,707; 15,752 have CKD)					**Tracts with >200 patients (n= 188,955; 15,752 have CKD)**	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low tract SES, education)**	**Approach 2C (HTN and/or DM and/or low tract SES, income)**	**Approach 3 (HTN and/or DM, and/or 1 of 3 low tract SES variables, 1st Q)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM, and/or high CKD tract prevalence)**
Number screened	50,490	65,663	66,618	68,703	74,435	43,835	79,511
CKD detected	7,498	8,294	8,407	8,465	8,804	6,422	8,531
Sensitivity	48 [46.8, 48.4]	53 [51.9, 53.4]	53 [52.6, 54.2]	54 [52.9, 54.5]	56 [55.1, 56.6]	48 [46.7, 48.4]	63 [62.3, 63.9]
Specificity	75 [75.2, 75.6]	70 [69.4, 69.9]	69 [68.9, 69.4]	68 [67.9, 68.3]	65 [65.0, 65.5]	77 [77.1, 77.5]	57 [56.7, 57.1]
PPV	15 [14.5, 15.2]	13 [12.4, 12.9]	13 [12.4, 12.9]	12 [12.1, 12.6]	12 [11.6, 12.1]	15 [14.3, 15.0]	11 [10.5, 10.9]
NPV	94 [93.9, 94.2]	95 [94.5, 94.7]	95 [94.6, 94.8]	95 [94.5, 94.8]	95 [94.5, 94.8]	95 [94.6, 94.8]	95 [94.8, 95.1]
Number needed to screen	7	8	8	8	9	7	9

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

Table S10. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD among patients ≥65 years of age

	All patients (n= 51,455; 18,685 have CKD)					**Tracts with >200 patients** (n= 51,455; 18,685 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low tract SES, education)**	**Approach 2C (HTN and/or DM and/or low tract SES, income)**	**Approach 3 (HT and/or DM, and/or 1 of 3 low tract SES variables, 1st Q)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM, and/or high CKD tract prevalence)**
Number screened	31,007	33,066	33,315	33,468	34,310	28243	36,135
CKD detected	13,138	13,784	13,899	13,759	14,174	12,012	14,425
Sensitivity	70 [69.7, 70.9]	74 [73.1, 74.4]	74 [73.0, 75.0]	74 [73.0, 74.3]	75 [75.2, 76.7]	71 [70.1, 71.4]	85 [84.4, 85.5]
Specificity	45 [44.9, 46.0]	41 [40.6, 41.7]	41 [40.2, 41.2]	40 [39,3, 40.3]	39 [38.0, 39.1]	45 [44.3, 45.5]	40 [39.4, 40.4]
PPV	42 [41.8, 42.9]	42 [41.2, 42.2]	42 [41.2, 432.3]	41 [40.6, 41.6]	41 [40.8, 41.9]	43 [41.9, 43.1]	41 [40.4, 41.5]
NPV	73 [72.2, 73.5]	73 [72.7, 74.0]	74 [72.9, 74.2]	73 [71.9, 73.2]	74 [73.0, 74.3]	73 [72.1, 73.4]	75 [74.4, 76.1]
Number needed to screen	2	2	2	2	2	2	3

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

Table S11. The sensitivity, specificity, PPV, NPV and number needed to screen for each screening approach to detect CKD for blacks

	All patients (n= 20,651; 1,693 have CKD)					**Tracts with >200 patients** (n= 16,981; 1,346 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low tract SES, education)**	**Approach 2C (HTN and/or DM and/or low tract SES, income)**	**Approach 3 (HTN and/or DM, and/or 1 of 3 low tract SES variables, 1st Q)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM, and/or high CKD tract prevalence)**
Number screened	6,264	9,345	8,982	9,084	10,265	5,034	8,217
CKD detected	1,069	1,210	1,190	1,219	1,244	852	976
Sensitivity	63 [60.8, 65.4]	71 [69.2, 73.6]	70 [68.0, 72.4]	72 [69.8, 74.1]	73 [71.3, 75.6]	63 [60.1, 65.8]	73 [70.0, 74.9]
Specificity	73 [72.0, 73.2]	57 [56.3,7.7]	59 [58.2, 59.6]	58 [57.8, 59.2]	52 [51.6,54.8]	73 [72.6, 73.9]	54 [54.4, 55.9]
PPV	17 [16.1, 18.0]	13 [12.3, 13.6]	13 [12.6, 13.9]	13 [12.7, 14.1]	12 [11.4,12.8]	17 [15.9, 17.9]	12 [11.1, 12.6]
NPV	96 [95.3,95.9]	96 [95.3, 96.0]	96 [95.3, 96.0]	96 [95.5, 96.3]	96 [95.2, 96.1]	96 [95.4, 96.2]	96 [95.3, 96.2]
Number needed to screen	6	8	8	8	8	6	8

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

Table S12. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD for whites

	All patients (n= 172,290; 25,800 have CKD)					**Tracts with >200 patients** (n= 153,455; 23,262 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low tract SES, education)**	**Approach 2C (HTN and/or DM and/or low tract SES, income)**	**Approach 3 (HTN, DM, and/or 1 of 3 low tract SES variables, 1st Q)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM, and/or high CKD tract prevalence)**
Number screened	59,236	67,194	69,695	71,309	74,005	53,401	83,242
CKD detected	15,742	16,644	16,887	16,795	17,325	14,338	17,837
Sensitivity	61 [60.4, 61.6]	65 [63.9, 65.1]	65 [64.9, 66.0]	65 [64.4, 65.7]	67 [66.6, 67.7]	62 [61.0, 62.3]	77 [76.1, 77.2]
Specificity	70 [70.1, 70.5]	65 [65.2, 65.7]	64 [63.7, 64.1]	63 [62.6, 63.0]	61 [61.1, 61.6]	70 [69.7, 70.2]	50 [49.5, 50.0]
PPV	27 [26.2, 26.9]	25 [24.4, 25.1]	24 [23.9, 24.5]	24 [23.2, 23.8]	23 [23.1, 23.7]	27 [26.4, 27.2]	21 [21.1, 21.7]
NPV	91 [90.9,91.2]	91 [91.1, 91.4]	91 [91.1, 91.5]	91 [90.9, 91.2]	91 [91.2, 91.6]	91 [90.9, 91.3]	92 [92.1, 92.5]
Number needed to screen	4	4	4	4	4	4	5

CKD: chronic kidney disease, PPV: positive predictive values, NPV: negative predictive values, HTN: hypertension, DM: diabetes, SES: socioeconomic status.

Table S13 . Baseline Characteristics of patients who were included in our cohort vs. patients excluded

	Cohort included n= 256,162	**Cohort of excluded adults with no available creatinine (inpatient or outpatient & had ≥ 1 PCP visit & are from Minnesota** n= 226,495	**p-value**
CKD, n(%)	34,437 (13%)	-----	-----
Individual level characteristics			
Age, mean (SD)	50 ± 18	35 ± 14	<0.001
Black, n(%)	22,511 (9%)	14,831 (7%)	<0.001
Male, n(%)	118,894 (46%)	101,213 (45%)	<0.001
Ever smoker, n(%)	95,186 (37%)	59,807 (26%)	<0.001
Baseline characteristics			
Systolic BP, mmHg	124 ± 18	120 ± 14	<0.001
Diastolic BP, mmHg	76 ± 11	74 ± 9	<0.001
Medical History			
Hypertension, n(%)	71,744 (28%)	5,148 (2%)	<0.001
Diabetes, n(%)	24,773 (10%)	1,732 (0.8%)	<0.001
Obesity (BMI ≥ 30 kg/m2), n(%)	73,362 (36%)	48,925 (26%)	<0.001
Cardiovascular disease, n(%)	14,704 (6%)	809 (0.4%)	<0.001
Stroke, n(%)	3,733 (2%)	280 (0.1%)	<0.001
Hyperlipidemia, n(%)	60,791 (24%)	7,836 (4%)	<0.001
Cancer, n(%)	8,204 (3%)	1,195 (0.5%)	<0.001
Median value of owner occupied housing units			
Q1: < $165,200	25,225 (10%)	41,496 (18%)	<0.001
Q2: $165,200 - $188,100	32,801 (13%)	33,355 (15%)	
Q3: $188,100 - $231,300	87,210 (34%)	69,239 (31%)	
Q4: ≥ $231,300	110,870 (43%)	182,342 (36%)	
% of Residents > 25 years with complete college education			
Q1: < 20.4%	28,247 (11%)	45,579 (20%)	<0.001
Q2: 20.4% - 34.1%	65,160 (26%)	66,256 (29%)	
Q3: 34.1% - 48.1%	82,889 (32%)	53,742 (24%)	
Q4: ≥ 48.1%	79,815 (31%)	60,877 (27%)	
Median household income			
Q1: <$35,935	29,488 (12%)	37,368 (17%)	<0.001
Q2: $35,935 - 47,379	34,352 (13%)	35,986 (11%)	
Q3: $47,379 - $62,343	56,891 (22%)	52,481 (23%)	
Q4: ≥ $62,434	135,274 (53%)	100,472 (44%)	

PCP: primary care physician; CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure; Q1: quartile1; Q2: quartile 2; Q3: quartile 3; Q4: quartile 4

This definition for excluded cohort makes sure I have comorbidities available, since they have a primary care physician (PCP) visit. I only included patients from MN so we can compare to current cohort. For baseline characteristics and medical history, I used all data available (history of any disease if ≥ 2 ICD codes present at any time). For blood pressure (BP), I used the most recent BP available.

CHAPTER 3 - NEIGHBORHOOD SOCIOECONOMIC STATUS, HEALTH INSURANCE, AND NEIGHBORHOOD RACIAL COMPOSITION ASSOCIATION WITH CHRONIC KIDNEY DISEASE

Synopsis Digest

Rationale and Objective

The association of neighborhood characteristics and insurance status with chronic kidney disease (CKD) remain unclear. Therefore, we investigated: 1) the association of neighborhood socioeconomic (SES) and insurance type with CKD prevalence and 2) the association of neighborhood racial composition with CKD prevalence by race.

Study Design

Cross sectional study (6/1/2017 – 12/31-2018)

Settings & Participants

Electronic health records of patients seen at a healthcare system in the 7-county metropolitan area in Minnesota and linked census tract data.

Exposures

Census tract measures [median value of owner occupied housing units (wealth), percentage of residents >25 years with ≥ Bachelor's degree (education), median household income (income), and percent blacks], individual level insurance status (<65 years: Medicaid vs. other insurance; ≥65 years: Medicare vs. supplemental insurance plan), and race (black, white).

Outcomes

CKD prevalence [estimated glomerular filtration rate (eGFR)< 60/mL/min/1.73m$_2$ or proteinuria]

Analytic Approach

Multilevel Poisson regression with robust error variance with a random intercept at the census tract level was used to estimate the association between: 1) tract SES [low (first quartile) vs. high (fourth quartile)], insurance and CKD and 2) tract percent blacks and CKD stratified by race.

Results

We included 185,269 patients. Tract SES (wealth and education) and insurance are independently associated with CKD prevalence. After adjusting for demographic and clinical characteristics, patients (<65 and ≥ 65 years) living in low vs. high SES tracts had higher CKD prevalence (Prevalence Ratio PR, 95%CI of low vs. high tract SES for education among patients <65 years: 1.11 [1.05, 1.18] and 1.08 [1.04, 1.12] for ≥65 years). Patients (<65 years) on Medicaid vs. other insurance had higher CKD prevalence (PR, 95%CI: 1.51 [1.43, 1.60]). For patients ≥65 years, insurance type was not associated with prevalence of CKD in the fully adjusted model. As the percent of blacks increase in tracts, there was no increase in prevalence of CKD for both blacks or whites after adjusting for demographic characteristics, comorbidities and neighborhood SES.

Conclusions

Low neighborhood SES and insurance type (only for patients <65 years) are associated with prevalence of CKD.

Introduction

CKD is a significant public health problem in the US affecting 26 million Americans (14.8% of the US adult population).[8] CKD contributes to poor quality of life, leads to premature death, and is costly on both the public and private sector (total expenditure for CKD and ESKD represents 33.8% of total Medicare fee-for-service spending). Disadvantaged socioeconomic populations have a disproportionate burden of CKD.

Understanding the interplay between SES and CKD is important, particularly as the healthcare community undertakes initiatives related to the Presidential Executive Order on Advancing American Kidney Health.[80] Factors such as residential segregation, disparities, discrimination and underinsured/uninsured all contribute to the development of CKD.[45] A recent systematic review of 3,632,531 participants and 832,497 cases of CKD showed that low SES was associated with CKD [low eGFR/high albuminuria] (OR=1.4, 95% CI [1.2, 1.6]).[15] Area level SES was less studied than individual level SES and most studies focused on ESKD.[22-24] Moreover, residential racial segregation has been shown to be associated with increased mortality in black but not white patients who have ESKD and are on dialysis.[98,99] However, there has been no documentation of the role of area racial segregation on CKD. Most of these previous analyses examined neighborhood SES using large geographical areas (county or zip code) that may mask the variation within.[22,27,29] Furthermore, the association of SES and CKD was predominately assessed using population level data from cohort studies or was limited to veterans only, limiting the generalizability of the results. Also, composite measures of neighborhood SES were commonly used and are not ideal when it comes to informing policy decisions regarding specific SES measures.

Low neighborhood SES is associated with worsening of kidney function. Meanwhile, health insurance is associated with clinical care and clinical outcomes. For instance, having insurance coverage, improves health outcomes of several diseases.[44] There is

evidence that social factors, such as neighborhood SES plays an important role in health outcomes.[100-102] However, research to date has not jointly assessed the independent association of neighborhood SES and health insurance on CKD prevalence.

The aim of this study was to determine 1) whether neighborhood SES and health insurance status are independently associated with CKD prevalence and 2) whether neighborhood racial composition, as a measure of racial segregation, is associated with CKD prevalence in both black and white individuals.

Methods

Data

Patients were identified from the EHR database of Fairview Health Services, the primary affiliate of the University of Minnesota. We identified patients from 6/1/2017 through 12/31/2018. The EHR data incorporates all outpatient visits, labs, and billing data, geocoded addresses (latitude and longitude), and census tract of patients' residence.[81] The Institutional Review Board at the University of Minnesota approved this study.

Population Definition

The population included all adult patients (≥18 years of age) who have their address geocoded and are from the 7-county Minneapolis/St Paul metropolitan area (excluded n= 73,978). Patients should have at least one measure of outpatient creatinine during this time period [6/1/2017-12/31/2018] (excluded n=271,898), have insurance data available (data available on all patients), and have at least one PCP visit in the Fairview health system during this time period (excluded n= 260,077) (**Figure 3**, **Figure S2**). We defined index creatinine as the last available creatinine during this time period. Patients who opted out of research or moved from 6/1/2017 to 12/31/2018 were excluded.

Geographic Unit and Neighborhood Characteristics

We selected census tracts as the geographic unit of analysis. Census tracts are small, relatively stable areas, and designed to include homogeneous populations.[82] We included three measures to operationalize tract level SES: median value of owner-occupied housing units, percentage of residents over age 25 with a Bachelor's degree or more, and median household income as identified from the 2012 ACS 5-Year Data [2008-2012].[83] These measures reflect wealth, education, and income of the tract.[84] Low and high SES census tract were defined as belonging to the first and fourth quartile of the distribution of each of the measures using census data of the 7-county metropolitan area. We used percent of blacks in each tract [number of "Black or African American alone" divided by "Total Population"] from the 2008-2012 ACS data to identify tract racial composition.

We linked each patient's residence to the appropriate census tract and tract characteristics. A patient was considered to be living in low and high census (1^{st} and 4^{th} quartile) tract SES if tract median value of owner occupied housing units was <$165,200 and ≥ $231,300, tract percent of residents over 25 years of age with a Bachelor's degree or more was <20.4% and ≥48.1%, or tract median household income was <$35,935 and ≥$62,343 (**APPENDIX – CENSUS DATA)**.

Variables

We identified sex and race (**APPENDIX – CHAPTER 3**) from the EHR. Age and smoking status were defined using the last value before or at the time of the index creatinine. All creatinine measures were traceable to an IDMS reference measurement. Similarly, we defined patients' most recent insurance status as either having Medicaid vs. have other insurance for individuals <65 years and having Medicare [part A, B, C] vs. having supplemental insurance plan for individuals ≥65 years (**APPENDIX – CHAPTER 3**). Comorbidities were considered present if at least two ICD-9/10 codes for that condition were present at or before the date of the index creatinine.[85] We used the last value at or before the date of the index creatinine for each of the following covariates: BMI [obesity: BMI ≥ 30kg/m^2], UACR, UPCR, and UA.

eGFR was calculated using the CKD-EPI creatinine equation.[3] CKD was defined as having outpatient index eGFR <60/mL/min/1.73m^2 or having proteinuria [last measure available of UACR > 30mg/g or UPCR > 150mg/g or UA >30mg/g during the time period between 6/1/2017 and 12/31/2018]. We manually abstracted clinical and laboratory data for 100 random patient charts and compared it with data pulled directly from EHR to ensure data quality *(data not shown)*.

Statistical Analysis

We evaluated the data for positivity violations or the presence of off-support data by using stratified tabulation to assess the number of participants for each insurance status by tract SES and the number of participants with and without CKD by race (**APPENDIX – CHAPTER 3**).[103]

We compared the baseline demographic and clinical characteristics of patients <65 and ≥65 years by tract SES and insurance status, and of black vs. white patients. Categorical variables were presented as frequencies and continuous variables as mean (standard deviation) values. Differences between groups were tested by Chi-square test and t-test for categorical and continuous variables respectively. Pearson correlation was used to test the association among the census tract SES variables.

We used a multilevel model with a random intercept at the census tract level to estimate the tract level SES and insurance status association with CKD prevalence stratified by age (<65 and ≥65 years). Since CKD prevalence was a common outcome, we estimated the PR and 95% CI using Poisson regression with robust error variance.[104-106] We fit the following models: Model 1: tract SES (for each measure separately), insurance status; Model 2: model 1 + age, sex, race, obesity, smoking; and Model 3: model 2 + history of CVD, stroke, cancer, hyperlipidemia, hypertension, and diabetes. Effect modification (on the multiplicative and additive scale) of the tract SES/insurance – CKD relationship was examined by race, hypertension, and diabetes.[107] Similarly, we used a multilevel model

with random intercept at the census tract level and Poisson regression with robust error variance to estimate the association of percent blacks in tracts (continuous variable, by 5% increments) with CKD prevalence. We stratified our analysis by race and we fit the following models: Model 1: tract racial composition; Model 2: model 1 + insurance (Medicaid or Medicare vs. other insurance or supplemental insurance plan), age, sex, obesity, smoking, insurance status + history of CVD, stroke, cancer, hyperlipidemia, hypertension, and diabetes; and Model 3: Model 2 + tract wealth, tract education, and tract income. We examined effect modification (on the multiplicative and additive scale) by hypertension and diabetes.

Since we only included patients who had their kidney function measured, our analysis is subject to selection bias. We assessed the impact selection bias could have had on our results using different selection probabilities. We estimated an adjusted crude PR by multiplying each cell of the two by two table (exposure: patients in low vs. high SES/ 1^{st} vs. 4^{th} quartile of percent tract blacks, outcome: patients with and without CKD) with a selection factor [probability of a patient being included in cohort given CKD presence and tract characteristics]. A range of selection factors were subjectively estimated. We estimated the sensitivity corrected adjusted PR by multiplying the adjusted crude PR with an additional adjusted proportion [observed adjusted PR/observed crude PR].[108]

Preplanned sensitivity analysis included the following: limiting our analyses to using a restrictive definition of CKD (eGFR <45 ml/min/1.73 m^2/year or UACR ≥ 300mg/g or UPCR ≥ 500mg/g or UA ≥ 100mg/g) rather than eGFR<60 ml/min/1.73m^2 or UACR > 30mg/g or UPCR > 150mg/g or UA >30mg/g; only including creatinine measured during routine clinic visits (i.e. labs measured during annual clinic wellbeing visits) vs. creatinine obtained during any type of outpatient visit; defining insurance status as having continuous coverage by a single provider from 6/1/2017 through 12/31/2019 (more restrictive definition) rather than using the most recent insurance coverage documented in that time period; changing the time period from 18 months (6/1/2017-12/31/2019) to 12

months (12/31/2018-12/31/2019); and modeling tract racial composition as a categorical variable (13 categories). Statistical analyses were conducted using R and Stata.[87,109]

Results

Cohort Characteristics

There were 791,222 patients identified from the EHR. After excluding the majority of the records due to no PCP visit and no creatinine from 6/1/2017 to 12/31/2018, we included 185,269 in our cohort (**Figure 3**). Patients were on average 55 years (69% <65 years), 9% were black, 45% were males and 20% had CKD (**Table 6**). Fairview patients resided in 676 of the 704 census tracts in the metropolitan area (median of 187 patients per tract, interquartile range [106, 365]). Compared to the metropolitan area characteristics, our cohort had similar distribution of patients by county and percent of blacks, but consisted of an older population with lower rates of Medicaid enrollment (**Table S14**). Tract income was moderately correlated with tract wealth and education (r=0.33 and 0.30 respectively). However, tract wealth was highly correlated with tract education (r=0.68). All tract SES measures were negatively correlated with percent blacks in tracts (r~ -0.34).

We had sufficient number of patients in each SES strata by age and insurance strata. We had an adequate number of black and white patients overall and with CKD for every 5% increment of percent blacks in tracts up until 60% (**APPENDIX – CHAPTER 3**). Our analyses are therefore feasible and are not subject to structural confounding or positivity violations.[78] Among patients <65 years, 5,259 had Medicaid (21% with CKD) and 118,430 had other insurance (12% with CKD). Higher percentage of CKD and comorbidities were found in patients who lived in low SES tracts, whites, and patients with Medicaid or Medicare without a supplemental insurance plan (**APPENDIX – CHAPTER 3**).

Neighborhood SES, insurance status, neighborhood racial composition and CKD

Among patients <65 and ≥65 years, low SES tract (wealth and education) was associated with greater rates of prevalent CKD compared with high SES tracts after adjusting for demographics, comorbidities and insurance status (PR, 95%CI of low vs. high tract SES for education among patients <65 years: 1.11 [1.05, 1.18], among patient ≥65 years: 1.08 [1.04, 1.12]). However, we found no association between CKD and tract income when comparing low (1st quartile) vs. high (4th quartile) SES tracts. There was no evidence of effect modification (on the multiplicative and additive scale) of the tract SES-CKD association by race or diabetes (**Table 7**, **Table 8**, **APPENDIX – CHAPTER 3**). The prevalence ratio magnitude of the association of CKD with the second and third quartile of tract wealth SES and tract education SES vs. fourth quartile was smaller than that observed comparing the first vs. fourth quartile of tract wealth and tract education SES. Hypertension, however, modified the association between tract SES (education and income) with CKD prevalence (**Table S15, APPENDIX – CHAPTER 3**). Among patients with a history of hypertension, those living in low education SES tracts (first quartile) had a 5% [0.98, 1.13] greater prevalence of CKD compared to those living in high education SES tracts (fourth quartile). Conversely, among patients without a history of hypertension, those living in low education SES tracts (first quartile) had a 19% [1.08, 1.32] greater prevalence of CKD compared to those living in high education SES tracts (fourth quartile).

In fully adjusted models, being on Medicaid was associated with greater prevalence of CKD compared to patients with other insurance (PR: 1.51, [1.42, 1.59]) (**Table 7**). There was effect modification of the Medicaid-CKD association by hypertension and diabetes for patients <65years on both the additive and multiplicative scale (**Table S15, Table S16, APPENDIX – CHAPTER 3**). Among patients with and without a history of hypertension, those on Medicaid had 35% and 81% greater prevalence rates of CKD, respectively, compared to patients who have other insurance. Similarly, among patients with and without diabetes history, those on Medicaid had 23% and 81% greater prevalence of CKD, respectively, compared to patients who have other insurance. We

found no association between insurance status (Medicare vs. supplemental insurance plan) and CKD in patients ≥65 years (**Table 8**).

As the percent of blacks increase in tracts, there was no increase in prevalence of CKD for either blacks or whites after adjusting for demographic characteristics, comorbidities and neighborhood SES (**Table 9**). There was also no effect modification by hypertension or diabetes (on both the multiplicative and additive scale).

Sensitivity and Bias Analysis

In our bias analyses, over a range of selection probability, we found that the adjusted PRs for the association of tract SES/insurance status with CKD, and tract racial composition with CKD was smaller than the observed PRs (**Table S17**, **Table S18**, **Table S19**). For example, among those <65 years, the PR for the association of neighborhood SES for wealth (low vs. high) and insurance (Medicaid vs. other insurance) with CKD was 1.2 and 1.5 in the fully adjusted model. After adjusting for selection bias, the PR ranges between 0.8-1.1 and 1.1-1.5, respectively. For blacks living in areas with percent blacks in tracts <2% (1st quartile) vs. >10% (4th quartile) PR of CKD was 0.96 in the fully adjusted model. After adjusting for selection bias, PR ranged between 0.6 and 0.9.

We observed similar results to those in the primary analysis when: a) we used a more restrictive definition of CKD, b) we limited our analysis to creatinine obtained during routine clinic visits, c) we used a more restrictive definition for insurance, c) we changed our time period from 18 months (6/1/2017 – 12/31/2018) to 12 months (12/31/2017 – 12/31/2018), and d) percent blacks in tracts was modeled as a categorical variable (**APPENDIX – CHAPTER 3**).

Discussion

Our main finding is that both low tract SES and insurance coverage (Medicaid vs. other insurance <65 years) were associated with increased prevalence of CKD. We found no

association between neighborhood racial composition and prevalent CKD in both blacks and whites.

Since we only included patients who had their eGFR measured, we are subject to selection bias. Included patients were older, more likely to be smokers, have Medicare without supplemental insurance plan and have more comorbidities than the excluded patients. However, the percentage of patients in each quartile of tract SES was similar (**Table S20**). In order to account for this bias, we estimated a PR, adjusted for selection bias. The magnitude of the association of tract SES status/insurance status and neighborhood racial composition with CKD was attenuated after adjustment for selection bias. Our results should therefore be interpreted with caution. We note as well that we are only able to study the association, and not the causal effect, of neighborhood SES on CKD. Future studies could use a matching sampling design and identify areas in the Twin Cities that are homogenous with respect to SES and examine the influence of neighborhood characteristics on kidney function.[110]

Previous studies have looked at the association of SES with ESKD and CKD. The variation of the association of SES with CKD has been shown in several narrative literature reviews.[111-113] A recent meta-analysis showed that low individual level SES (income and education) and low combined level SES (individual indicators or area level SES indicators) were associated with CKD prevalence.[16] The relative estimations remained consistent and were less heterogeneous after adjusting for comorbidities, health access and health related behaviors. This meta-analysis did not differentiate between area and individual level SES effect on CKD due to the scarcity and heterogeneity of the data. Vart et al. in a systematic review showed that low individual level SES was associated with lower eGFR, irrespective of how SES was defined.[15] Only four cohort studies in the U.S have studied the association of area level SES with CKD prevalence. Unlike our analysis, these studies were population based and were able to adjust for self-reported individual level SES.[25-28] In a study of 12,631 participants from the ARIC study,

association of area level SES (composite measure of census scores for tracts at age 30, 40, 50) and CKD (hospital discharge diagnosis or eGFR <45 ml/min/1.73 m_2) was studied. Living in the lowest tertile of census tract was associated with CKD only at age 50 after adjusting for age, sex, study site, individual social class (working class vs. non) [OR: 1.6, 95% CI: 1.0-2.4]. However, this association was attenuated after adjusting for hypertension and diabetes [OR: 1.4, 95% CI: 0.9-2.2].[27] There was no effect modification by race detected. On the other hand, in a study of 4,735 participants from the elderly Cardiovascular Health Study (aged ≥65 years), people living in lowest area SES quartile (composite measure at the census block group level) had 40% greater risk of progressive CKD (creatinine elevation ≥0.4 mg/dL or CKD hospitalization) after adjusting for demographics, individual level SES (income and education), hypertension and diabetes [HR: 1.4, 95% CI: 1.0-1.7]. The role of neighborhood SES and kidney function remain unclear and findings from the literature and our study are mixed. Moreover, the role of neighborhood racial composition on CKD has not been explored in a previous study. We found no association between racial composition and CKD in blacks or whites.

The mixed results in the literature on the role of neighborhood SES on CKD is, in part, because it is hard to "disentangle people from places".[114] Previous neighborhood and health studies have found various levels of association between neighborhood level measures and outcomes (depression, mental health, obesity).[115] Most of these studies were observational and cross sectional. Challenges such as unmeasured confounders and reverse causation limit the inferences we can obtain from these studies. This is true for our analysis as well. Therefore, future studies should focus on assessing the effect of neighborhood interventions on kidney health using neighborhood randomized trial rather than disentangling the unbiased effect of neighborhood SES on CKD.[116]

This is the first study to look at the association of health insurance and CKD. Previous studies have reported worse health outcomes (hospitalizations, myocardial infarction) for patients on Medicaid or Medicare.[31-35] As far as kidney health, efforts have focused on

ESKD and Medicaid expansion programs. For instance, patients with ESKD and Medicaid or who are uninsured and live in more generous Medicaid eligibility states have better outcomes (early transplant and permanent vascular access).[117] Uninsured patients receive worse pre-dialysis care. Furthermore, racial disparities in cardiovascular events and diabetes complications, including ESKD, are not found among patients with uniform healthcare coverage.[118] Insurance status (Medicaid vs. other insurance) was independently associated with CKD after adjusting for neighborhood SES, demographics and medical history, only for patients <65 years. Interestingly, we found that the prevalence rate of CKD in patients with Medicaid vs. other insurance (<65 years) without a history of hypertension or diabetes was greater than patients with these comorbidities. Similarly, the prevalence rate of CKD in patients living in low education tract (first quartile) vs. high education tract SES (fourth quartile) without a history of hypertension was greater than patients with hypertension. This could be due to the fact that patients with hypertension or diabetes have been advised to avoid nephrotoxic medications and are on medications that protect the kidney, such as renin angiotensin system inhibitors.[61,119] Although, health insurance coverage is a measure of access to care, there is an array of socioeconomic and individual factors that contribute to CKD. A more comprehensive look at barriers to screening and care for CKD are needed.

Our study has several limitations. First, we studied a single healthcare system in Minnesota which may not be representative of the general population and other states. However, we have shown that patients included in this analysis are similar to those in the 7-county metro area. Second, several limitations exist using EHR data including: limited ability to assess individual measures of SES (personal income or education), a coarse race measure that doesn't capture mixed race, and inability to measure total time patients lived in a certain neighborhood. Our results therefore reflect the EHR data available, and a more nuanced analysis will be feasible if the quality of demographic data collected in the EHR is improved. Of note, some researchers have used individual insurance status as a proxy for individual level SES, but the validity of this measure is unknown.[33-35] However,

Medicaid coverage is only provided to adult patients (US citizens) below the federal poverty line, with the exception of people with disabilities.[120]. Most Medicaid beneficiaries have income below the poverty line.[37] On the other hand, Medicare is available for US citizens ≥65 years. In order to receive broader coverage individuals have to pay a yearly deductible. Previous studies have shown that Medicare beneficiaries without supplemental insurance plans receive fewer preventive services and make fewer primary care and specialty clinic visits.[40-42] Since insurance status is multifaceted, it may not be the most appropriate proxy for individual level SES. Third, we were unable to assess the effect of neighborhood characteristics on CKD among the uninsured due to limited number of patients. Fourth, we are assuming that the most recent insurance status of patients reflects their past coverage as well. Given the similar findings when using a restrictive definition of insurance to the main analyses, we believe our findings are robust. We also are considering patients on Medicare plans A, B, and C to be homogeneous, when in fact there could be more nuanced associations with CKD for each group. Fifth, we used only a one-time eGFR measurement to determine CKD prevalence. Our findings however were consistent when using a more restrictive definition of CKD. Sixth, given the heterogeneity of the strata with percent blacks >60%, our results should be interpreted with caution for these tracts. Seventh, we have missing data on some covariates but not our main exposure (neighborhood SES, neighborhood racial composition, insurance status) or outcome (CKD prevalence) measures. We accounted for missing data by using "missingness" as a variable to adjust for rather than by imputation, which is limited to the assumption of randomness.[121,122] Data on race was missing in 6% of our cohort and for other covariates data was missing on ~ 3% of the patients. Finally, we used ICD codes to determine comorbidities. In order to minimize misclassification bias by ICD codes we used at least two ICD codes to confirm diagnoses. We also adjudicated 100 patient charts and found that ICD code diagnoses were consistent with clinic notes (*data not shown)*.

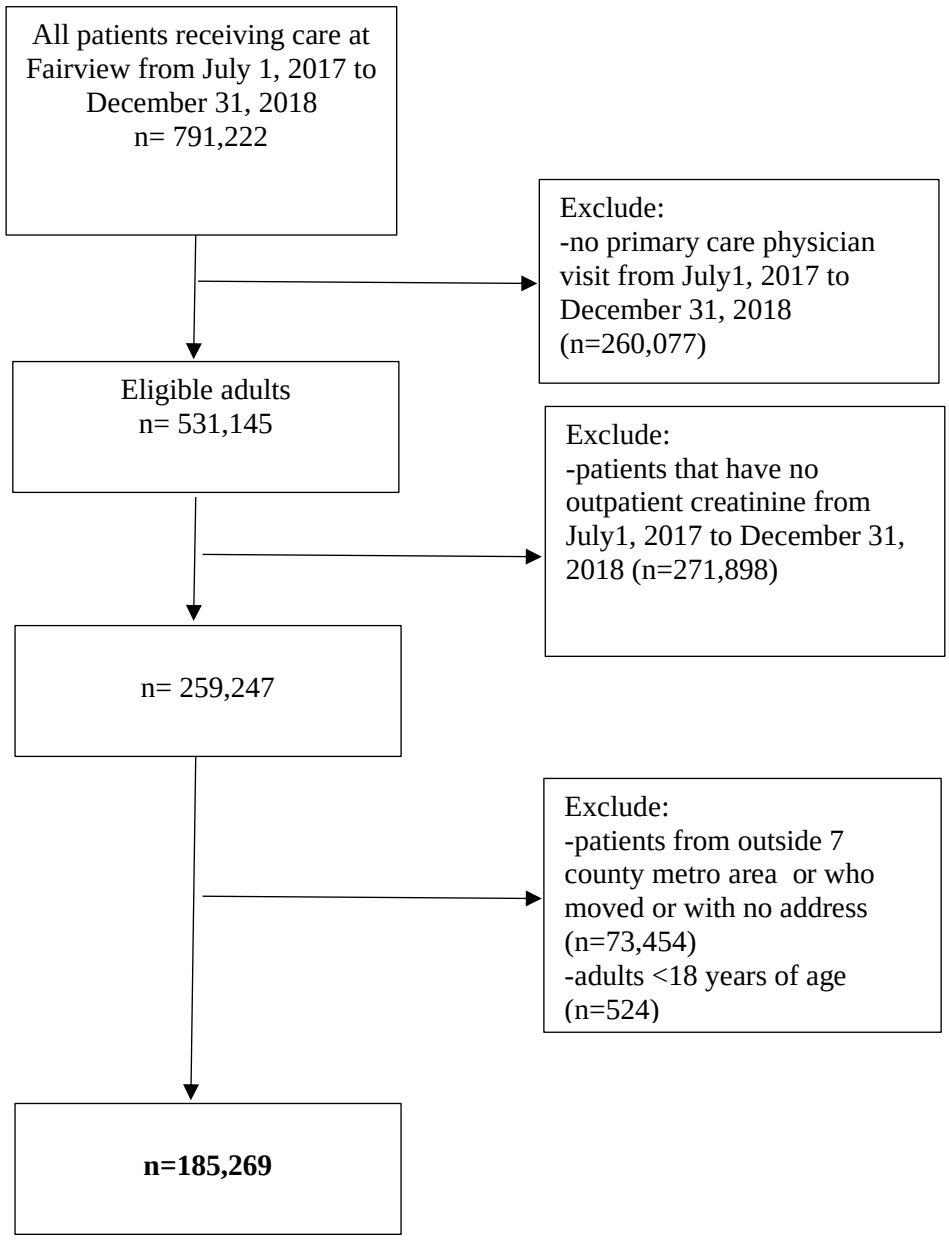
A major strength of this study is the use of a large EHR data set from routine clinical

practice that, unlike structured cohort studies, reflects the population of this healthcare system and the population it is serving. We used small geographic areas to determine area level SES. Moreover to our knowledge, this is the first study assessing the association of neighborhood racial composition with CKD and study the association of insurances status with CKD prevalence (not just limited to ESKD). Most studies regarding kidney disease have focused on ESKD and dialysis facilities and used the USRDS. This study has the benefit of utilizing observational data found in a large EHR health system with no recruitment limitations and encompasses all CKD stages.

In conclusion, we found that patients from low SES tracts and Medicaid recipients (among patients <65 years) have greater rates of CKD compared to patients from high SES tracts and patients with other insurance. These may be two of several socioeconomic and individual factors influencing the complexity of identification, management, and treatment of CKD. Further research aimed at identifying neighborhood structural factors, individual and clinical factors that could be the target of public health interventions to reduce the burden of CKD are needed.

Tables and Figures

Figure 3. Cohort flow chart of Fairview patients from the 7 county Minneapolis/St Paul metropolitan area



* Primary care physician visits were defined as a completed outpatient office visits to family practice, family practice-internal medicine, internal medicine, obstetrics/gynecology, gerontology or geriatrics clinic visit.

Table 6. Overall characteristics of the Fairview Cohort (Chapter 3)

	Overall N=185,269
eGFR, ml/min/1.73m2 [median, interquartile range]	82.35 [68.6, 97.9]
CKD, n(%)	37,098 (20%)
Individual level demographic characteristics	
Age, mean (SD)	55.0 ± 17.8
Male, n(%)	84,116 (45%)
Race, n(%)	
Black	16,130 (9%)
White	146,563 (79%)
Individual social characteristics (n%)	
Ever smokers, n(%)	80,603 (42%)
Medicaid (among patients <65 years), n(%)	5,259 (4%)
Medicare (among patients ≥65 years), n(%)	11,719 (20%)
Vitals	
Systolic BP, mmHg	127.2 ± 17.8
Diastolic BP, mmHg	77.0 ± 11.3
Medical History	
Hypertension, n(%)	83,270 (45%)
Diabetes, n(%)	29,913 (16%)
Obese (BMI≥ 30 kg/m2), n(%)	67,467 (40%)
Cardiovascular disease, n(%)	26,789 (15%)
Stroke, n(%)	7,447 (4%)
Hyperlipidemia, n(%)	80,636 (44%)
Cancer, n(%)	14,609 (8%)
Median value of owner occupied housing units	
Q1: < $165,200	16,625 (9%)
Q2: $165,200 - $188,100	22,475 (12%)
Q3: $188,100 - $231,300	63,198 (34%)
Q4: ≥ $231,300	82,940 (45%)
% of residents > 25 years with a Bachelor's degree or more	
Q1: < 20.4%	19,825 (11%)
Q2: 20.4% - 34.1%	46,939 (25%)
Q3: 34.1% - 48.1%	61,027 (33%)
Q4: ≥ 48.1%	57,452 (31%)
Median household income	
Q1: <$35,935	21,363 (12%)
Q2: $35,935 - $47,379	23,344 (13%)
Q3: $47,379 - $62,343	40,829 (22%)
Q4: ≥ $62,343	99,590 (52%)
Percent tract blacks (median, interquartile range)	4.7 [1.7, 9.9]

eGFR: estimated glomerular filtration rate; CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; Q1: quartile 1; Q2: quartile 2; Q3: quartile 3; Q4: quartile 4

Table 7. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals <65 years

	Median value of owner-occupied housing units				Insurance	
PR, 95%CI	**High SES 4th Q (n=55,332)**	**3rd Q (n=41,562)**	**2nd Q (n=15,145)**	**Low SES 1st Q (n=11,626)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.14 [1.09, 1.19]	1.24 [1.17, 1.31]	1.38 [1.29, 1.48]	1.00	1.71 [1.62, 1.81]
Model 2	1.00	1.16 [1.11, 1.21]	1.26 [1.20, 1.33]	1.42 [1.32, 1.52]	1.00	1.82 [1.74, 1.92]
Model 3	1.00	1.04 [1.00, 1.08]	1.07 [1.02, 1.13]	1.16 [1.09, 1.24]	1.00	1.51 [1.42, 1.59]
	%>25 years with a Bachelor's degree or more				**Insurance**	
PR, 95%CI	**High SES (n=38,118)**	**3rd Q (n=39,882)**	**2nd Q (n=31,605)**	**Low SES (n=14,084)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.18 [1.13, 1.23]	1.28 [1.30, 1.49]	1.39 [1.30, 1.50]	1.00	1.72 [1.62, 1.82]
Model 2	1.00	1.17 [1.13, 1.23]	1.28 [1.22, 1.34]	1.38 [1.29, 1.49]	1.00	1.83 [1.72, 1.94]
Model 3	1.00	1.07 [1.03, 1.12]	1.08 [1.04, 1.13]	1.11 [1.05, 1.18]	1.00	1.51 [1.43, 1.60]

Table 7 (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=67,029)**	**3rd Q (n=26,600)**	**2nd Q (n=15,434)**	**Low SES (n=14,626)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.13 [1.07, 1.18]	1.14 [1.07, 1.21]	1.02 [0.95, 1.09]	1.00	1.75 [1.65, 1.18]
Model 2	1.00	1.15 [1.09, 1.20]	1.16 [1.09, 1.23]	1.04 [0.97, 1.12]	1.00	1.85 [1.75, 1.96]
Model 3	1.00	1.09 [1.04, 1.13]	1.08 [1.03, 1.14]	0.99 [0.94, 1.06]	1.00	1.51 [1.43, 1.60]

CKD: chronic kidney disease; SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract;
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62.343, 3rd Q: $47,379-$62,343, 2nd Q: $35,935-$47,379 low SES(1st Q): <$35,935

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, and diabetes

No interaction between tract SES (any of the three measures) and race or diabetes (multiplicative and additive scale – **APPENDIX – CHAPTER 3**)
There is an interaction between education and income with hypertension history (multiplicative scale and on additive scale – **APPENDIX – CHAPTER 3**)
No interaction between insurance and race; there is an interaction between insurance and hypertension and diabetes on multiplicative and additive scale (**APPENDIX – CHAPTER 3**)

Table 8. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals ≥ 65 years

	Median value of owner-occupied housing units				Insurance	
PR, 95%CI	**High SES 4th Q (n=25,967)**	**3rd Q (n=20,125)**	**2nd Q (n=6,717)**	**Low SES 1st Q (n=4,483)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.13 [1.09, 1.16]	1.12 [1.07, 1.18]	1.18 [1.12, 1.23]	1.00	1.04 [1.02, 1.05]
Model 2	1.00	1.09 [1.07, 1.12]	1.10 [1.05, 1.15]	1.13 [1.05, 1.21]	1.00	1.00 [0.99, 1.02]
Model 3	1.00	1.03 [1.03, 1.07]	1.04 [1.00, 1.09]	1.07 [1.02, 1.12]	1.00	1.01 [0.99, 1.03]
	%>25 years with a Bachelor's degree or more				**Insurance**	
PR, 95%CI	**High SES (n=18,223)**	**3rd Q (n=19,766)**	**2nd Q (n=14,108)**	**Low SES (n=5,195)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.10 [1.06, 1.15]	1.16 [1.11, 1.20]	1.19 [1.14, 1.25]	1.00	1.04 [1.02, 1.05]
Model 2	1.00	1.07 [1.04, 1.11]	1.13 [1.09, 1.17]	1.18 [1.14, 1.23]	1.00	1.00 [0.99, 1.03]
Model 3	1.00	1.03 [1.00, 1.06]	1.05 [1.02, 1.08]	1.08 [1.04, 1.12]	1.00	1.01 [1.00, 1.06]

Table 8 (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=30,449)**	**3rd Q (n=13,181)**	**2nd Q (n=7,287)**	**Low SES (n=6,375)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.05 [1.01, 1.09]	1.07 [1.03, 1.12]	0.99 [0.95, 1.05]	1.00	1.03 [1.02, 1.05]
Model 2	1.00	1.01 [0.98, 1.04]	1.04 [1.00, 1.07]	0.98 [0.94, 1.03]	1.00	1.01 [0.99, 1.02]
Model 3	1.00	1.00 [0.98, 1.03]	1.01 [0.98, 1.04]	0.96 [0.95, 1.04]	1.00	1.01 [0.99, 1.02]

CKD: chronic kidney disease; SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62.343, 3rd Q: $47,379-$62,343, 2nd Q: $35,935-$47,379 low SES(1st Q): <$35,935

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, and diabetes

No interaction between tract SES (any of the three measures) and race, hypertension or diabetes (on both multiplicative and additive scale – **APPENDIX – CHAPTER 3**)
No interaction between insurance (any of the three measures) and race, hypertension or diabetes (on both multiplicative and additive scale – **APPENDIX – CHAPTER 3**)

Table 9. Multilevel regression model for the association of tract racial composition with CKD prevalence by race

	Model 1 (PR, 95% CI)	**Model 2 (PR, 95% CI)**	**Model 3 (PR, 95% CI)**	P-value for interaction of tract % black with race
Blacks (n=16,130)				0.01
PR per 5% increase in blacks in census tract	1.02 [1.01, 1.03]	1.00 [0.99, 1.01]	1.00 [0.99, 1.01]	
Whites (n=151,168)				
PR per 5% increase in blacks in census tract	1.02 [1.01, 1.03]	1.01 [1.00, 1.02]	1.01 [1.00, 1.02]	

CKD: chronic kidney disease; SES: socioeconomic status, PR: prevalence ratio of CKD

Model 1: tract racial composition
Model 2: model 1 + insurance (Medicaid or Medicare vs. other insurance or supplemental insurance plan), age, sex, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, and diabetes
Model 3: Model 2 + tract median value of owner occupied housing units, tract % >25 years with a Bachelor's degree or more, and tract household income

There is no interaction between percent black in tracts and hypertension or diabetes *(on both multiplicative and additive scale* – **APPENDIX – CHAPTER 3**)

Figure S2. Cohort Construction (Chapter 3 and Chapter 4)

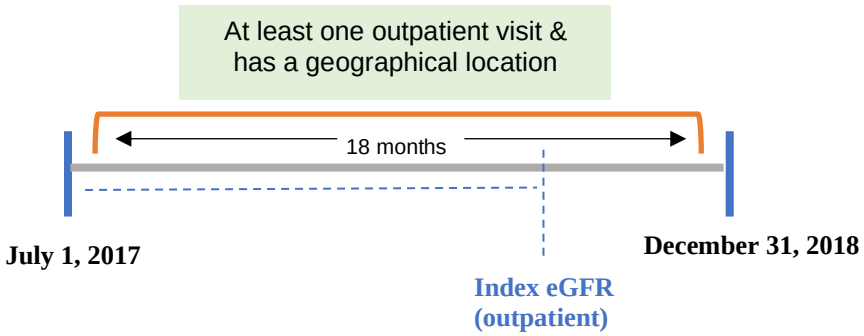


Table S14. Comparison of Fairview patients to the 7-county Minneapolis/St Paul metropolitan area

	Fairview population (included in our analysis)	**Census data (7 county metro area)**
Median Age[1]	55	36*
% Black	9%	8%
% Male	45%	49%
%Medicaid[2]	3%	7%
Number of census tracts	677	704
Population by County, n(%)		
Anoka	27,503 (15%)	331,649 (12%)
Carver	2,158 (1%)	91,355 (3%)
Dakota	44,298 (27%)	399,443 (14%)
Hennepin	75,169 (41%)	1,158,039 (40%)
Ramsey	19,436 (11%)	510,885 (18%)
Scott	10,203 (5%)	130,689 (5%)
Washington	6,502 (4%)	238,721 (8%)
Total population	*185,269*	*2,860,781*

[1]Median age in Fairview population before excluding patients <18 years

[2]Medicaid in Fairview population is calculated for those ≥ 18 years with Medicaid coverage Medicaid coverage (Medicaid or other means-tested public coverage) for census data include individuals ≥18 years with coverage through Medicaid, Medical Assistance or any kind of government assistance plan for those with low incomes or a disability from 2012 American Community Survey: 5-Year Data [2008-2012].

*Census data is not restricted to adults >18 years. Median age here is of all the population.

Table S15. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals <65 years and by hypertension status

Hypertension History (n=40,761)						
	Median value of owner-occupied housing units				**Insurance**	
PR, 95%CI	**High SES 4th Q (n=16,703)**	**3rd Q (n=14,367)**	**2nd Q (n=5,478)**	**Low SES 1st Q (n=4,213)**	**Other Insurance (n=38,945)**	**Medicaid (n=1,816)**
Model 1	1.00	1.08 [1.02, 1.13]	1.19 [1.23, 1.43]	1.33 [1.23, 1.43]	1.00	1.65 [1.55, 1.77]
Model 2	1.00	1.08 [1.03, 1.13]	1.18 [1.10, 1.27]	1.32 [1.22, 1.43]	1.00	1.66 [1.56, 1.78]
Model 3	1.00	1.01 [0.97, 1.06]	1.07 [0.99, 1.14]	1.15 [1.09, 1.25]	1.00	1.35 [1.26, 1.44]
	%>25 years with a Bachelor's degree or more				**Insurance**	
PR, 95%CI	**High SES (n=10,657)**	**3rd Q (n=13,125)**	**2nd Q (n=11,408)**	**Low SES (n=5,571)**	**Other Insurance (n=38,945)**	**Medicaid (n=1,816)**
Model 1	1.00	1.06 [1.00, 1.13]	1.15 [1.08, 1.22]	1.18 [1.09, 1.28]	1.00	1.67 [1.57, 1.79]
Model 2	1.00	1.06 [1.00, 1.12]	1.15 [1.08, 1.22]	1.18 [1.08, 1.27]	1.00	1.68 [1.57, 1.80]
Model 3	1.00	1.02 [0.96, 1.07]	1.06 [1.01, 1.12]	1.05 [0.98, 1.13]	1.00	1.36 [1.27, 1.45]

Model 1: tract SES, insurance status; Model 2: model 1, race, sex, age ; Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

Table S15 (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=22,178)**	**3rd Q (n=8,771)**	**2nd Q (n=5,245)**	**Low SES (n=4,567)**	**Other Insurance (n=38,945)**	**Medicaid (n=1,816)**
Model 1	1.00	1.16 [1.09, 1.22]	1.18 [1.11, 1.26]	1.11 [1.02, 1.21]	1.00	1.67 [1.57, 1.79]
Model 2	1.00	1.16 [1.09, 1.22]	1.17 [1.10, 1.25]	1.10 [1.01, 1.20]	1.00	1.69 [1.57, 1.80]
Model 3	1.00	1.09 [1.04, 1.15]	1.09 [1.03, 1.16]	1.07 [0.98, 1.13]	1.00	1.35 [1.27, 1.44]
No Hypertension History (n=82,928)						
	Median value of owner-occupied housing units				**Insurance**	
PR, 95%CI	**High SES 4th Q (n=38,629)**	**3rd Q (n=27,195)**	**2nd Q (n=9,667)**	**Low SES 1st Q (n=7,437)**	**Other Insurance (n=79,485)**	**Medicaid (n=3,443)**
Model 1	1.00	1.10 [1.03, 1.17]	1.11 [1.03, 1.20]	1.21 [1.09, 1.34]	1.00	1.79 [1.62, 1.95]
Model 2	1.00	1.26 [1.06, 1.20]	1.15 [1.07, 1.24]	1.28 [1.16, 1.42]	1.00	1.91 [1.73, 2.09]
Model 3	1.00	1.07 [1.01, 1.15]	1.08 [1.01, 1.15]	1.16 [1.05, 1.29]	1.00	1.81 [1.63, 2.01]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract; Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Table S15 (continued)

%>25 years with a Bachelor's degree or more					Insurance	
PR, 95%CI	**High SES (n=27,461)**	**3rd Q (n=26,757)**	**2nd Q (n20,197)**	**Low SES (n=8,513)**	**Other Insurance (n=79,485)**	**Medicaid (n=3,443)**
Model 1	1.00	1.17 [1.09, 1.25]	1.26 [1.08, 1.26]	1.26 [1.15, 1.39]	1.00	1.77 [1.61, 1.94]
Model 2	1.00	1.18 [1.11, 1.26]	1.19 [1.11, 1.29]	1.30 [1.18, 1.44]	1.00	1.90 [1.73, 2.09]
Model 3	1.00	1.15 [1.07, 1.22]	1.09 [1.01, 1.17]	1.19 [1.08, 1.32]	1.00	1.81 [1.63, 2.01]
Median household income					**Insurance**	
PR, 95%CI	**High SES (n=44,851)**	**3rd Q (n=17,829)**	**2nd Q (n=10,189)**	**Low SES (n=10,059)**	**Other Insurance (n=79,485)**	**Medicaid (n=3,443)**
Model 1	1.00	1.06 [0.99, 1.13]	1.05 [0.96, 1.15]	0.91 [0.84, 1.00]	1.00	1.81 [1.65, 1.99]
Model 2	1.00	1.08 [1.01, 1.16]	1.08 [0.99, 1.19]	0.94 [0.86, 1.03]	1.00	1.93 [1.76, 2.13]
Model 3	1.00	1.07 [1.00, 1.15]	1.07 [0.98, 1.16]	0.92 [0.84, 1.00]	1.00	1.83 [1.64, 2.03]

Table S16. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals <65 years and by diabetes status

Diabetes History (n=15,446)						
	Median value of owner-occupied housing units				**Insurance**	
PR, 95%CI	**High SES 4th Q (n=5,389)**	**3rd Q (n=5,624)**	**2nd Q (n=2,366)**	**Low SES 1st Q (n=2,067)**	**Other Insurance (n=14,421)**	**Medicaid (n=1,025)**
Model 1	1.00	1.02 [0.96, 1.09]	1.10 [1.03, 1.19]	1.22 [1.14, 1.31]	1.00	1.32 [1.22, 1.42]
Model 2	1.00	1.02 [0.97, 1.09]	1.11 [1.03, 1.19]	1.26 [1.17, 1.35[	1.00	1.34 [1.24, 1.44]
Model 3	1.00	1.01 [0.96, 1.07]	1.06 [0.99, 1.14]	1.21 [1.13, 1.30]	1.00	1.23 [1.15, 1.33]
	%>25 years with a Bachelor's degree or more				**Insurance**	
PR, 95%CI	**High SES (n=3,584)**	**3rd Q (n=4,809)**	**2nd Q (n=4,563)**	**Low SES (n=2,490)**	**Other Insurance (n=14,421)**	**Medicaid (n=1,025)**
Model 1	1.00	1.09 [1.01, 1.15]	1.14 [1.07, 1.22]	1.18 [1.09, 1.27]	1.00	1.32 [1.23, 1.42]
Model 2	1.00	1.08 [1.00, 1.15]	1.15 [1.07, 1.23]	1.18 [1.09, 1.28]	1.00	1.34 [1.25, 1.45]
Model 3	1.00	1.04 [0.98, 1.12]	1.09 [1.03, 1.18]	1.12 [1.04, 1.21]	1.00	1.23 [1.15, 1.33]

Model 1: tract SES, insurance status; Model 2: model 1, race, sex, age; Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and hypertension

Table S16. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=7,765)**	**3rd Q (n=3,541)**	**2nd Q (n=2,264)**	**Low SES (n=1,867)**	**Other Insurance (n=14,421)**	**Medicaid (n=1,025)**
Model 1	1.00	1.06 [0.99, 1.12]	1.08 [1.01, 1.15]	0.98 [0.90, 1.06]	1.00	1.33 [1.24, 1.43]
Model 2	1.00	1.07 [1.01, 1.14]	1.09 [1.01, 1.16]	0.99 [0.91, 1.07]	1.00	1.35 [1.26, 1.46]
Model 3	1.00	1.04 [0.98, 1.11]	1.06 [0.99, 1.14]	0.98 [0.91, 1.06]	1.00	1.25 [1.16, 1.35]
No Diabetes History (n=108,243)						
	Median value of owner-occupied housing units				**Insurance**	
PR, 95%CI	**High SES 4th Q (n=49,943)**	**3rd Q (n=35,938)**	**2nd Q (n=12,779)**	**Low SES 1st Q (n=9,560)**	**Other Insurance (n=104,009)**	**Medicaid (n=4,234)**
Model 1	1.00	1.08 [1.03, 1.13]	1.11 [1.04, 1.18]	1.15 [1.06, 1.26]	1.00	1.73 [1.61, 1.86]
Model 2	1.00	1.11 [1.05, 1.16]	1.14 [1.07, 1.21]	1.21 [1.11, 1.32]	1.00	1.88 [1.75, 2.03]
Model 3	1.00	1.05 [1.00, 1.11]	1.08 [1.01, 1.16]	1.13 [1.03, 1.24]	1.00	1.81 [1.00, 1.11]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract; Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Table S16. (continued)

%>25 years with a Bachelor's degree or more					Insurance	
PR, 95%CI	**High SES (n=34,534)**	**3rd Q (n=35,073)**	**2nd Q (n=27,042)**	**Low SES (n=11,575)**	**Other Insurance (n=104,009)**	**Medicaid (n=4,234)**
Model 1	1.00	1.13 [1.07, 1.19]	1.16 [1.09, 1.29]	1.18 [1.09, 1.29]	1.00	1.72 [1.60, 1.86]
Model 2	1.00	1.13 [1.08, 1.20]	1.17 [1.11, 1.24]	1.20 [1.11, 1.31]	1.00	1.88 [1.75, 2.03]
Model 3	1.00	1.09 [1.03, 1.15]	1.07 [1.01, 1.14]	1.10 [1.01, 1.20]	1.00	1.81 [1.67, 1.96]
Median household income					**Insurance**	
PR, 95%CI	**High SES (n=45,922)**	**3rd Q (n=27,131)**	**2nd Q (n=21,496)**	**Low SES (n=13,694)**	**Other Insurance (n=104,009)**	**Medicaid (n=4,234)**
Model 1	1.00	1.09 [1.04, 1.16]	1.08 [1.00, 1.16]	0.99 [0.92, 1.07]	1.00	1.74 [1.62, 1.88]
Model 2	1.00	1.12 [1.06, 1.18]	1.11 [1.03, 1.19]	1.02 [0.94, 1.09]	1.00	1.90 [1.76, 2.05]
Model 3	1.00	1.12 [1.06, 1.18]	1.11 [1.03, 1.19]	1.01 [0.92, 1.09]	1.00	1.82 [1.68, 1.98]

Table S17. Quantitative selection bias analysis for association of tract level socioeconomic status and insurance status with CKD prevalence for individuals <65 years

	Crude Poisson regression PR	**Selection bias adjusted crude PR**	**Fully Adjusted Poisson regression PR**	**Selection bias corrected fully adjusted* PR**
Insurance Status				
Other insurance	1.0	1.0	1.0	1.0
Medicaid (A)	1.7	1.7	1.5	1.5
Medicaid (B)		1.2		1.1
Medicaid (C)		1.2		1.1
Median value of owner-occupied housing units is the measure of SES and insurance status				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.4	1.3	1.2	1.1
Low SES tract (B)		0.9		0.8
Low SES tract (C)		0.9		0.8
%>25 years with a Bachelor's degree or more and insurance status				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.4	1.3	1.1	1.0
Low SES tract (B)		0.9		0.7
Low SES tract (C)		0.9		0.7
Median household income and insurance status				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.02	0.9	0.99	0.9
Low SES tract (B)		0.6		0.6
Low SES tract (C)		0.6		0.6

PR: prevalence ratio

Selection probabilities for tract SES used are as follows:
S_1(CKD+ & SES+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(CKD+ & SES-)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(CKD- & SES+)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(CKD- & SES-)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$

For example (under scenario A): for S_1=0.9, that means the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and having CKD and living in a low SES tract is 50%. For S_2=0.9, that means the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and having CKD and living in a high SES tract is 90%. We are assuming that $S_1 \leq S_2$. For S_3 =0.2, that means that the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and not having CKD and living in a low SES tract is 20%. We are assuming that $S_1 > S_3$.

Selection probabilities for insurance used are as follows:
S_1(CKD+ & Medicaid+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(CKD+ & Medicaid-)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(CKD- & Medicaid+)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(CKD- & Medicaid-)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$

For example (under scenario A): for S_1=0.5, that means the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and having CKD and on Medicaid is 50%. For S_2=0.9, that means the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and having CKD and have other other insurance is 0.9. We are assuming that $S_1 \leq S_2$. For S_3 =0.2, that means that the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and not having CKD and on Medicaid is 20%. We are assuming that $S_3 < S_4$.

* Selection bias corrected fully adjusted PR = crude selection bias adjusted PR * r
Where r = [Fully adjusted Poisson Regression PR/Crude Poisson Regression PR]. I am assuming this is a constant for each model

CKD+: have CKD; CKD-: don't have CKD; SES+: belong to low SES tract; SES-: belong to high SES tract

Table S18. Quantitative selection bias analysis for association of tract level socioeconomic status with CKD prevalence for individuals ≥ 65 years

	Crude Poisson regression PR	**Selection bias adjusted crude PR**	**Fully Adjusted Poisson regression PR**	**Selection bias corrected fully adjusted***
Insurance Status				
Supplemental Insurance	1.0	1.0	1.0	1.0
Medicaid (A)	1.0	1.0	1.0	1.0
Medicaid (B)		0.7		0.7
Medicaid (C)		0.8		0.8
Median value of owner-occupied housing units is the measure of SES				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.2	1.1	1.1	1.0
Low SES tract (B)		0.8		0.7
Low SES tract (C)		0.8		0.7
%>25 years with a Bachelor's degree or more				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.2	1.2	1.1	1.1
Low SES tract (B)		0.8		0.7
Low SES tract (C)		0.9		0.8
Median household income				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	0.99	0.9	0.96	0.9
Low SES tract (B)		0.6		0.6
Low SES tract (C)		0.7		0.7

PR: prevalence ratio

Selection probabilities for tract SES used are as follows:
S_1(CKD+ & SES+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(CKD+ & SES-)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(CKD- & SES+)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(CKD- & SES-)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$
Selection probabilities for insurance used are as follows:
S_1(CKD+ & Medicaid+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(CKD+ & Medicaid-)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(CKD- & Medicaid+)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(CKD- & Medicaid-)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$

* Selection bias corrected fully adjusted PR = crude selection bias adjusted PR * r
Where r = [Fully adjusted Poisson Regression PR/Crude Poisson Regression PR]. I am assuming this is a constant for each model

CKD+: have CKD; CKD-: don't have CKD; SES+: belong to low SES tract; SES-: belong to high SES tract

Table S19. Quantitative selection bias analysis for association of tract racial composition with CKD prevalence*

	Crude Poisson regression PR	Selection bias adjusted PR	Fully Adjusted Poisson regression	Selection bias corrected fully adjusted*
Blacks				
<2% blacks in tracts	1.0	1.0	1.0	1.0
>10% blacks in tracts (A)	1.2	1.1	0.96	0.9
>10% blacks in tracts (B)		0.8		0.6
>10% blacks in tracts (C)		0.8		0.6
Whites				
<2% blacks in tracts	1.0	1.0	1.0	1.0
>10% blacks in tracts (A)	0.99	0.9	0.98	0.9
>10% blacks in tracts (B)		0.6		0.6
>10% blacks in tracts (C)		0.6		0.6

***We choose the cutoffs of 2 and 10% as they represent the first and 4th quartile of the distribution of percent blacks in tracts in the 7 county St Paul/Minneapolis metropolitan area in Minnesota.**

PR: prevalence ratio
Selection probabilities used are as follows:
S_1(CKD+ & High_black_tract+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(CKD+ & High_black_tract -)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(CKD- & High_black_tract +)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(CKD- & High_black_tract -)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$

*Selection bias corrected fully adjusted PR= crude selection bias adjusted PR * r
Where r = [Fully adjusted Poisson Regression PR/Crude Poisson Regression PR]. I am assuming this is a constant for each model

CKD+: have CKD; CKD-: don't have CKD; High_black_tract +: belong to tract with high percent of blacks in cohort (>10%); High_black_tract -: belong to tract with low percent of blacks in cohort (<2%)

Table S20. Comparison of patients included in analyses vs. excluded from analyses

	Overall N=185,269	**Cohort of excluded adults (1 outpatient clinic visit between 6/1/2017-12/31/2018 & no inpatient/outpatient creatinine & have address available)** N= 104,860
Individual level characteristics		
Age, mean (SD)	55.0 ± 17.8	40.5 ± 17.0
Male, n(%)	84,116(45%)	44,447 (43%)
Black	16,130 (9%)	8,442 (8%)
Ever Smoker, n(%)	80603 (42%)	25173 (24%)
Medicaid (among patients <65 years), n(%)	5,259 (4%)	2,299 (3%)
Medicare (among patients ≥65 years), n(%)	11,719 (20%)	1,591 (14%)
Medical History		
Hypertension, n(%)	83,270 (45%)	2793 (3%)
Diabetes, n(%)	29,913 (16%)	1663 (2%)
Obese (BMI≥ 30 kg/m2), n(%)	67,467 (40%)	20306 (27%)
Cardiovascular disease, n(%)	26,789 (15%)	557 (0.5%)
Stroke, n(%)	7,447 (4%)	211 (0.2%)
Hyperlipidemia, n(%)	80,636 (44%)	3081 (3%)
Cancer, n(%)	14,609 (8%)	1291 (1%)
Median value of owner occupied housing units		
Q1: < $165,200	16,625 (9%)	10848 (10%)
Q2: $165,200 - $188,100	22,475 (12%)	13999 (13%)
Q3: $188,100 - $231,300	63,198 (34%)	31724 (30%)
Q4: ≥ $231,300	82,940 (45%)	48261 (46%)
% of Residents > 25 years with complete college education		
Q1: < 20.4%	19,825 (11%)	12109 (12%)
Q2: 20.4% - 34.1%	46,939 (25%)	25480 (24%)
Q3: 34.1% - 48.1%	61,027 (33%)	29915 (29%)
Q4: ≥ 48.1%	57,452 (31%)	37337 (36%)
Median household income		
Q1: <$35,935	21,363 (12%)	14,907 (14%)
Q2: $35,935 - $47,379	23,344 (13%)	14,510 (14%)
Q3: $47,379 - $62,343	40,829 (22%)	22,143 (21%)
Q4: ≥ $62,343	99,590 (52%)	53,192 (51%)

Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

CHAPTER 4 - NEIGHBORHOOD SOCIOECONOMIC STATUS AND PATTERNS OF KIDNEY CARE: DATA FROM ELECTRONIC HEALTH RECORDS

Synopsis Digest

Rationale and Objective

Electronic health records (EHR) can be leveraged to assess quality of care measures in patients with chronic kidney disease (CKD). Neighborhood socioeconomic status (SES) could be a potential barrier to receiving appropriate evidence-based therapy and follow up. Our goal is to examine whether neighborhood SES is independently associated with quality of care received by CKD patients.

Study Design

Cross sectional study (6/1/2017 – 12/31-2018)

Settings & Participants

EHR data for patients seen at a healthcare system in the 7-county Minneapolis/St Paul area and linked census tract data.

Exposures

Census tract SES measures [American Community Survey: 2008-2012] [median value of owner occupied housing units (wealth), percentage of residents >25 years with ≥ Bachelor's degree (education), and median household income (income)].

Outcomes

CKD quality of care indicators: 1) prescription for angiotensin converting enzyme inhibitor/angiotensin receptor blocker (ACEi/ARB) in patients with moderate to severe CKD or mild CKD with urine albumin to creatinine ratio (UACR) >300 mg/day; 2) UACR measurement, and 3) CKD identified on the problem list or coded for at an encounter among patients with CKD (estimated glomerular filtration rate <60 ml/min/1.73 m_2).

Analytic Approach

Multilevel Poisson regression with robust error variance with a random intercept at the census tract level was used to estimate the association between each quality of CKD care measure and neighborhood SES.

Results

Of the 16,776 patients who should be on ACEi/ARB, 65% were prescribed these medications. In patients with CKD (n=25,097), UACR was measured in 27% of patients and only 55% of patients with CKD had it identified in their EHRs. We found no independent association between neighborhood SES and CKD quality of care indicators.

Conclusions

Neighborhood SES is not associated with quality of CKD care received. However, adherence to CKD guidelines is low, indicating an opportunity to improve care for all patients, regardless of SES.

Introduction

CKD is a major public health problem in the US; 14.8% of the US adult population has CKD. The US Surgeon General's goal for public health for American's citizens, Healthy People 2020, has a section focused on CKD.[47] Goals of this policy include: increasing the proportion of people with CKD who are aware that they have impaired kidney function; increasing the proportion of individuals with CKD who receive appropriate medical evaluation including evaluation for microalbuminuria; and increasing the proportion of persons with diabetes and CKD who receive recommended medical treatment with ACEi or ARBs.

EHR systems are increasingly adopted in the US. 95% of all US hospitals currently have EHRs. Recent programs, such as the Medicare's Physician Quality Reporting System, seek to leverage EHR systems to assess providers' evidence-based disease management and support quality-based reimbursement strategies.[123,124] The criteria put forth by Healthy People 2020 can be used as performance measures for CKD care in healthcare systems to hold providers accountable for the care they provide to patients with CKD.[125]

There is strong evidence of the association between neighborhood SES and individuals' health. Individuals who live in disadvantaged neighborhoods have worse self-reported health, more comorbidities, higher morbidity and mortality rates, and even poorer dialysis outcomes than those who live in more advantaged neighborhoods.[114,115,126-128] A recent meta-analysis showed that low individual level SES (income and education) and low combined level SES (individual indicators or area level SES indicators) were associated with increase in CKD prevalence compared to high individual SES and combined level SES, respectively.[16] The linkage of neighborhood SES with kidney disease could be explained by contextual factors like neighborhood poverty, racial segregation, and/or individual level factors including access to healthcare, individual level SES, and overall health status among other factors.[112] One possible mechanism in which socioeconomic

disadvantage could influence kidney function is by increasing both psychological and physical stress. This could influence inflammatory markers and increase CVD complications, which in turn accelerate the decline in kidney function.[45,46]

Previous studies have found that low neighborhood SES is associated with worse quality of care for CVD and diabetes.[129-132] However, there is a paucity of data on the role of neighborhood SES on kidney disease care, specifically early stages of CKD. Recent literature in kidney disease has started to look at the role of geographic variation and SES on pre-ESKD care.[133-135] There has been conflicting evidence regarding the role of neighborhood SES and whether lower SES is associated with worse on pre-ESKD quality of care.[72,136,137]

Overall, low neighborhood SES could be a potential barrier for patients with CKD to receive appropriate evidence-based therapy and follow up. Our goal is to examine whether neighborhood SES is associated with quality of care among patients with CKD using EHR data from a healthcare system that serves the Minneapolis/St Paul metropolitan area in Minnesota.

Methods

Study Population

Patients were identified from the EHR database of Fairview Health Services, the primary affiliate of the University of Minnesota. The data includes demographics, clinic visits, labs, diagnostic codes, and geocoded addresses with latitude and longitude and census tracts of patients' residences.[81] The Institutional Review Board at the University of Minnesota approved this study. We included patients aged ≥ 18 years with at least one primary care physician (**Figure S2**) in the Fairview health system between July 1, 2017 till December 31, 2018 (18 months period), a geocoded home address in the 7-county Minneapolis/St Paul metropolitan area, and at least one measure of outpatient creatinine

during this time period. Creatinine is a blood test used to measure eGFR, which indicates how well the kidneys are functioning. We excluded patients who moved from 6/1/2017 to 12/31/2018 or who have opted out of using their clinical data for research purposes (~5%) (**Table 10**). We manually abstracted clinical and laboratory data for 100 random patient charts and compared it with data pulled directly from the EHR to assess the accuracy of our EHR based definitions *(data not shown)*.

Neighborhood Socioeconomic Status Measures

Our geographic unit of analysis was census tract, a small relatively stable area designed to include homogeneous populations. Census tracts include on average 4,000 residents (range: 2,500 to 8,000 people).[82] We included three measures to operationalize tract level SES: median value of owner-occupied housing units, percentage of residents over age 25 with a Bachelor's degree or more, and median household income as identified from the 2012 ACS 5-Year Data [2008-2012]. These measures reflect wealth, education, and income of the tract. Low and high SES census tract were defined as belonging to the first and fourth quartile of the distribution of each of the measures using census data of the 7-county metropolitan area. We linked each patients' residence to the appropriate census tract and tract characteristics. A patient was considered to be living in low census tract SES if tract median value of owner occupied housing units was <$165,200, tract percent of residents over 25 years of age with a Bachelor's degree or more was <20.4%, or tract median household income was <$35,935 (**APPENDIX – CENSUS DATA**).

Kidney care measures

All creatinine measures were traceable to an IDMS reference measurement. eGFR was calculated using the CKD-EPI creatinine equation. This equation incorporates patients' creatinine, age, sex (female vs. male), and race (black vs. other).[3] Last outpatient creatinine measured between 6/1/2017 to 12/31/2018 (index creatinine/eGFR) was used for all analyses.

We assessed three measures of kidney care: prescription of ACEi/ARB, UACR measurement, and identification of CKD in the EHR. ACEi/ARB prescription was assessed by querying the medication list (active orders, documented home or self-reported medications) between 6/1/2017 and 12/31/2018 and up to 90 days after the index creatinine. At each clinic visit, providers are encouraged to reconcile medications and document any changes in the EHR. We further excluded patients who had a contraindication for an ACEi/ARB (n=2,400): documented history of hyperkalemia, ACEi/ARB allergies, and women who were pregnant within 1 year before or after the index creatinine. We identified 16,776 patients who should be on an ACEi/ARB according to the 2017 American College of Cardiology/American Heart Association (ACC/AHA) *Guidelines for the Prevention, Detection, Evaluation and Management of High Blood Pressure in Adults* – presence of hypertension and CKD (stage 3 or higher [eGFR ≤ 45 ml/min/1.73m$_2$] or stage 1 or 2 [eGFR ≥60 ml/min/1.73m$_2$] with UACR >300 mg/day) with no documentation of a contraindication for an ACEi/ARB.[61] ACEi/ARB prescription compliance was defined as: [(number of patients on an ACEi/ARB)/ (number of patients ≥18 years who are eligible to be on ACEi/ARB according to the 2017 ACC/AHA guidelines)] x 100%.

UACR measurement, a test for albuminuria, was assessed by querying outpatient labs between 6/1/2017 and 12/31/2018 and up to 90 days after the index creatinine. We identified 25,097 patients with CKD, defined as having eGFR < 60 ml/min/1.73 m$_2$, where it is recommended to test for albuminuria using UACR.[1,138] UACR measurement adherence was defined as: [(number of patients who have UACR measured/ number of patients with lab based CKD [eGFR <60ml/min/1.73m$_2$])] x 100%.

We also assessed whether CKD was documented in the patients' EHR (problem list, medical history, diagnosis, or procedure code), which was defined as having at least two ICD9/10 code for CKD, ESKD, dialysis, or kidney transplant documented before and up until 90 days after the date of the index creatinine among patients with CKD (eGFR < 60

ml/min/1.73 m_2). Identification of CKD in the EHR was defined as: [(number of patients with CKD who have CKD documented in EHR/ number of patients with CKD)] x 100%. A diagnosis of CKD could reflect both physicians' awareness of CKD and in turn could be a proxy of patients' awareness of having impaired kidney function. For all models, kidney care measures were each considered separately as dichotomous outcomes.

Variables

All data were obtained from the EHR including sex, race, and insurance (**APPENDIX – CHAPTER 4**). Age, smoking status, BMI [obesity: BMI ≥ 30kg/m_2] were defined using the last value before or at the time of the index creatinine. Comorbidities were considered present if at least two ICD-9/10 codes for that condition were present at or before the date of the index creatinine.[85]

Statistical Analysis

We evaluated the data for positivity violations or the presence of off-support data by using stratified tabulation to assess the number of participants for each kidney care measure by tract SES overall and by race.[103] We described the characteristics of patients who are eligible to be on ACEi/ARB and who have CKD. Categorical variables were presented as frequencies and continuous variables as mean (SD) values. Additionally, we looked at the percentage of patients who received appropriate kidney care by quartile of neighborhood SES and additionally stratified by race. Pearson correlation was used to test the association among the census tract SES variables (as continuous measures) and different kidney function measures.

We used multilevel models with a random intercept at the census tract level to estimate the tract level SES association with kidney care measures. Since all kidney care measures were common outcomes, we estimated the PR and 95% CI using Poisson regression with robust error variance.[104-106] Random intercept accounts for any residual within tract correlation in outcomes. To study the association of neighborhood SES with ACEi/ARB

prescription compliance we fit these models: Model 1: crude; Model 2: Model 1 + age, sex, race, obesity, smoking, insurance status; Model 3: Model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes. Additionally, a test for effect modification (on the multiplicative and additive scale) was performed with neighborhood SES to examine effect modification by race and sex for the ACEi/ARB prescription compliance exposure [**Table S22**, **Table S23**]. We did not assess neighborhood SES interaction with hypertension and diabetes since these comorbidities are part of the eligibility criteria to be prescribed ACEi/ARB. [107,119] To study the association of neighborhood SES with UACR measurement and CKD identification in the EHR, we fit similar models to those described above and added index eGFR to model 3. We assessed if there was effect modification (on the multiplicative and additive scale) by sex, race, hypertension, and diabetes history for the UACR measurement and CKD identification in EHR exposures [**Table S26**, **Table S27**, **Table S28**, **Table S29**, **Table S30**, **Table S31**, **Table S32**, **Table S33**].

Since we only included patients who had their kidney function measured and fulfilled our inclusion criteria, we are subject to selection bias. We assessed the impact selection bias has on the observed PR by using different selection probabilities.[108] We estimated an adjusted crude PR by multiplying each cell in the two by two table (exposure: high vs. low neighborhood SES. outcome: ACEi/ARB prescription compliance vs. not/UACR measured vs. not/CKD identified in EHR vs. not) with a selection factor [probability of a patient being included in the cohort given kidney care measured received and tract characteristics]. A range of selection factors were subjectively used. We estimated the sensitivity corrected adjusted PR by multiplying the adjusted crude PR with an additional adjusted proportion [observed adjusted PR/observed crude PR].[108] This will allow us to estimate PRs that we would have observed if we had included a broader population without restricting our analysis to patients seen at Fairview who had their kidney function measured.

Preplanned sensitivity analysis included the following: using a restrictive definition of CKD (eGFR <45 ml/min per 1.73 m_2/year, as opposed to the cut point of eGFR<60 ml/min/1.73m_2) to assess UACR measurement performance and CKD identified in EHR; changing the 18 months study time period (6/1/2017 – 12/31/2018) to a 36 months study time period (12/31/2015 to 12/31/2018); stratifying the analysis by age (<65 vs. ≥65 years); assessing a broader eligibility criteria to be prescribed ACEi/ARBs i.e. eligibility will be based on the ACC/AHA guidelines and/or the ADA guidelines [recommended for patients with diabetes, hypertension and albuminuria (UACR>30mg/day)]; and we limited our analysis to creatinine obtained during routine clinic visits (i.e. within 2 weeks of primary care physician visit).[119] Statistical analyses were conducted using R and Stata.[87,109]

Results

Cohort Characteristics

We identified 531,145 patients in our query; 185,269 patients had creatinine measured and resided in the 7 county metro area. Of those, 16,776 were eligible to be on an ACEi/ARB and 25,097 had CKD (**Figure 3**). Baseline characteristics of these patient populations are shown in **Table 11, Table 12,** and **Table 13**. Fairview patients resided in 666 of the 704 census tracts in the Twin Cities metropolitan area. Compared to the population of the metropolitan area, our cohort had similar distribution of patients by county, and proportion of males, and share of patients on Medicaid, but consisted of an older population with lower share of blacks (5% vs. 8%) (**Table S21**). Tract income was weakly correlated with tract wealth and education (r=0.30 and 0.33 respectively). However, tract wealth was moderately correlated with tract education (r=0.68). We observed a moderate correlation between ACEi/ARB prescription compliance and CKD identified in the EHR (r=0.58). However, ACEi/ARB prescription compliance was weakly correlated (r=0.19) with UACR measurement and CKD identified in the EHR was weakly correlated with UACR measurement (r=0.24).

Kidney care measures and neighborhood SES

We have sufficient number of patients in each SES strata by kidney care measure overall and by race (**APPENDIX – CHAPTER 4**). Our analyses are therefore feasible and are not subject to structural confounding or positivity violations.[78]

Our analysis found that quality of kidney care was moderate to low depending on which of the 3 measures were examined. ACEi/ARB prescription compliance was 65% in the overall cohort. UACR measurement performance and CKD identification in the EHR in patients with CKD was 27% and 55%, respectively. The distribution of all kidney care measures was similar across quartiles of neighborhood SES – wealth, education and income – and by race (**APPENDIX – CHAPTER 4**). Characteristics of patients by kidney care measure are shown in **Table 11, Table 12, Table 13**. Patients who were prescribed ACEi/ARB had more comorbidities (diabetes, obesity, hyperlipidemia) than those who were not. Those who had UACR measured vs. not were older, more likely to be black, and had more comorbidities. As for patients who had CKD identified in the EHR vs. not, they were older, more likely to be male and black, and have more comorbidities.

Belonging to low neighborhood SES (first quartile) compared to high neighborhood SES (forth quartile) [wealth, education and income] was not associated with ACEi/ARB prescription compliance, UACR measurement or CKD identification in the EHR after adjusting for demographics and clinical characteristics (**Table 14, Table 15, Table 16**). However, belonging to the second quartile of wealth (median value of owner occupied housing unit: $165,200 - $188,100) was associated with 13% higher prevalence [95%CI: 1.04, 1.22] of UACR measurement than belonging to high SES neighborhood, wealth (fourth quartile of median value of owner occupied housing unit: ≥ $231,300). Similarly belonging to the second or third quartile of tract SES, education (percent of residents >25 years with a bachelor's degree or more in tract, second quartile: 20.4%-34.1% and third

quartile: 34.1%-48.1%) was associated with 10% greater prevalence of UACR measurement than living in high SES tracts (percent of residents >25 years with a bachelor's degree or more in tract ≥48.1%).

Results of the stratified analyses for the identified effect modifiers are shown in **Table S24, Table S25 and Table S34**. Hypertension and race modified the association between tract wealth SES and CKD identified in the EHR. Among those with no hypertension history, living in low SES tract, wealth (first quartile) was associated with 22% greater prevalence of CKD identification in the EHR compared to patients living in high SES tract, wealth (fourth quartile). Among whites, patients living in low wealth SES tracts had a 3% greater prevalence of CKD compared to those living in high SES tracts (fourth quartile). Conversely, we found no association between tract wealth and CKD prevalence in patients with hypertension or in black patients.

Bias and Sensitivity Analysis

In our bias analyses, over a range of selection probabilities, we found that the adjusted PR for the association of tract SES and kidney care measures were smaller than the observed PR (**Table 17**, **Table 18**, **Table 19**). For example, PR for the association of neighborhood wealth SES (low vs. high) with ACEi/ARB prescription compliance, UACR measurement and CKD identification in the EHR was 0.96, 1, and 1, respectively, in the fully adjusted model. After adjusting for selection bias, the PRs range between 0.7-0.9, 0.7-0.9 and 0.8-1, respectively.

With respect to the sensitivity analyses, we observed similar results to those in the primary analysis, when: 1) neighborhood SES and UACR measurement and CKD identified were assessed among patients with CKD, defined as <45 ml/min/1.73 m_2 rather than <60 ml/min/1.73m_2; 2) we changed cohort time period from 18 months to 36 months; 3) stratified by age, 4) when using the ADA and ACC/AHA to define ACEi/ARB prescription compliance, and 5) using creatinine obtained during routine clinic visits (**APPENDIX – CHAPTER 4**).

Discussion

We found that there is room to improve evidence-based quality of CKD care. Among eligible patients with hypertension and CKD, 35% were not prescribed ACEi/ARB. In patients with CKD, UACR was not measured in 73% of patients and 45% of patients did not have CKD documented in their EHRs. Low neighborhood SES (low-first quartile vs. high SES-fourth quartile) was not associated with ACEi/ARB prescription compliance, UACR measurement or CKD identification in the EHR after adjusting for demographics and clinical characteristics.

Low neighborhood SES has been associated with worse quality and delivery of care for several medical conditions, including ESKD.[129-131] There is conflicting data regarding the role of pre-ESKD nephrology care (patients seeing a nephrologist before initiation of dialysis) and neighborhood SES or county level SES (a non-generalizable measure of neighborhood level SES). Some studies reported lower pre-ESKD nephrology care in urban counties, counties with low educational attainment (<high school), and in areas (zip codes) with low levels of median household income.[72,136] On the other hand, Platinga et al. did not find an association between area (census tract) poverty level and pre-ESKD care.[137] Our study is the first to assess quality of care by neighborhood SES in all CKD patients using Healthy People 2020 relevant metrics. We hypothesized that CKD care would be worse in patients living in disadvantaged neighborhoods. Surprisingly, we found no independent association of neighborhood SES (low SES- first quartile vs. high SES- fourth quartile) with ACEi/ARB prescription compliance, UACR measurement or CKD identification in the EHR.

Paradoxically, we found that patients belonging to the second and third quartile of tract SES for education and wealth had a greater prevalence of UACR measurement compared to the fourth quartile (high SES tract). This was not observed when comparing the first (low SES tract) vs. fourth quartile (high SES) of tract SES for wealth or education. The reason behind this observation is unclear. We also observed that patients with no

hypertension history and white patients living in low wealth SES tracts had higher prevalence of CKD identified in the EHR than those living in high SES tracts. This association was not observed in patients with hypertension or in black patients. We can only speculate that these paradoxical observations might be attributable to the characteristics of patients seen at Fairview, physician characteristics, unmeasured confounders, or mediators related to healthcare that are patterned by neighborhood. Stronger study designs, such as recruiting a community based sample of patients and assessing their kidney function along with their individual level SES, are needed to further explain these associations. These future studies could leverage healthcare systems and clinics servicing different communities and areas to identify potential participants, minimizing selection bias.

Our results should be interpreted with caution as they are only applicable to patients who had their creatinine measured and received primary care from within the health system. Patients excluded from our cohort were healthier and younger than those included in the analysis (**Table S35**). However, the distribution of patients by tract SES was similar. To account for this selection, we estimated a range of selection bias adjusted PR. The adjusted PR reflect a more conservative estimate of the associations of kidney care received with neighborhood SES in the Fairview population than the observed PR.

Previous studies have looked at overall quality of care provided to patients with CKD. A study of 11,774 patients with CKD (eGFR: 15 - 60 ml/min/1.73m$_2$) with an average age of 73 years from a multi-specialty primary care group practice in Massachusetts found low rates of adherence to many CKD practice guidelines including: annual urine protein quantification (30%), receipt of appropriate ACEi/ARBs medications (75%), and documentation of CKD on their problem list (24%).[68] An analysis of Southern California Kaiser Permanente reported that over a 12 month period, primary care providers saw the majority of patients with CKD (85%) but only 79% had CKD coded in their EHR. They reported that in patients with prevalent CKD, 79% had proteinuria assessed and 84% had ACEi/ARB on their medication list.[69] Additionally, in a large managed care cohort of

10,000 patients with CKD, physician documentation of CKD with ICD codes was only 14%.[96] USRDS reports that only 26% of patients with CKD received medical evaluation with serum creatinine, lipids and microalbuminuria in 2007, and only 67% of individuals with diabetes and CKD received ACEi/ARBs.[47] Trends observed in these studies are consistent with our findings especially with very low rates of UACR measurement. Since CKD identification in the EHR in our study was only 55%, the higher rate of ACEi/ARB prescription compliance was likely due in part to management of CVD or diabetes in these patients.

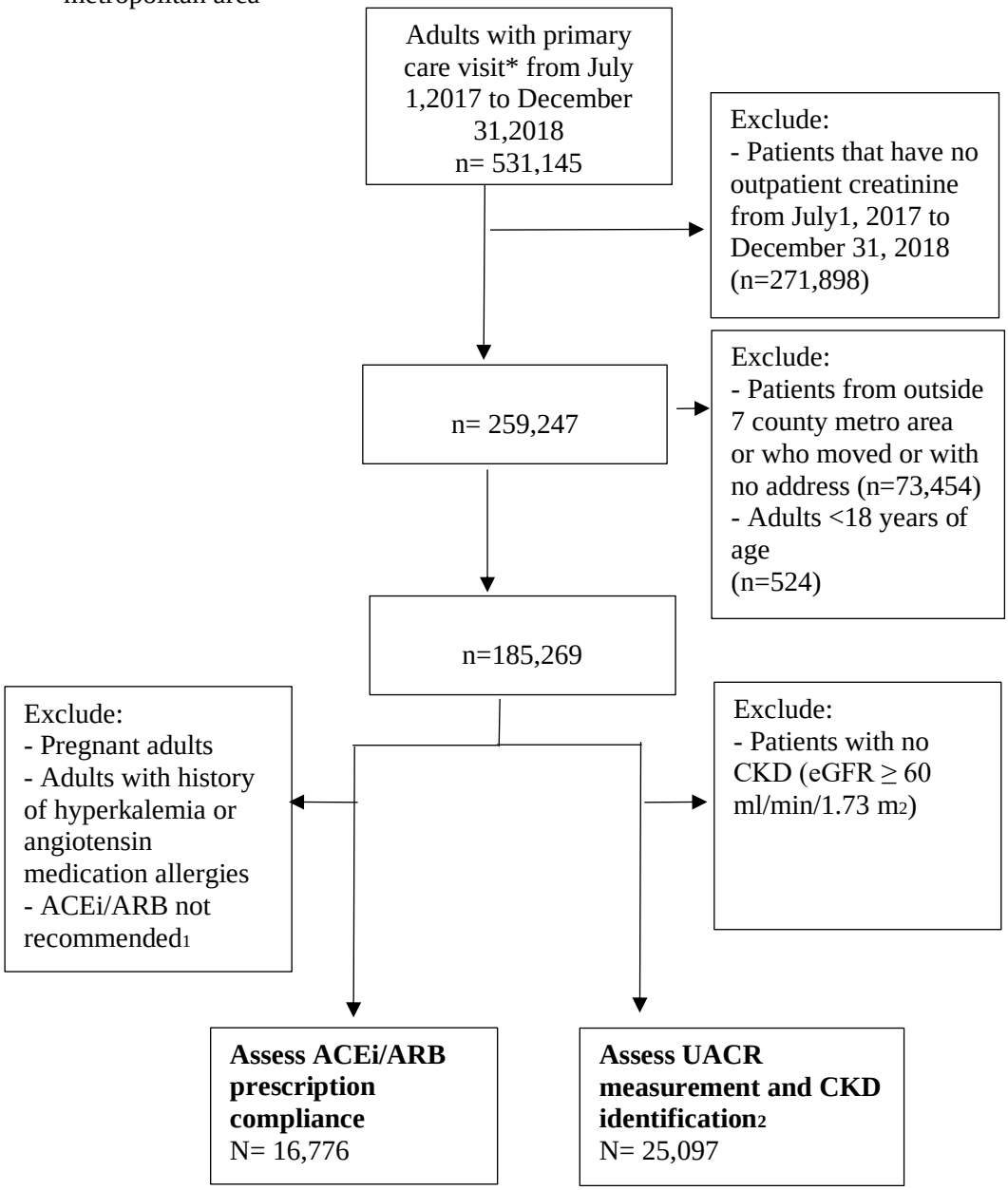
Our study has several limitations. First, we studied a single healthcare system in Minnesota which may not be representative of the general population and other states. However, we have shown that patients included in this analysis are similar to the population in the Twin Cities metro area. Second, there are limitations to the current EHR data quality including lack of individual level SES measures and coarse race measures. Improving data capture and improving quality of demographic data collected in EHRs will help overcome these limitations. Third, we used ICD codes to determine comorbidities and medications only from EHR queries and not clinic notes. In order to minimize misclassification bias by ICD codes we used at least two ICD codes to confirm diagnoses. We also adjudicated 100 patient charts and found that ICD code diagnoses and medications were consistent with clinic notes. Fourth, we did not evaluate patient adherence to ACEi/ARBs or assess their awareness of having CKD. Medication adherence is particularly important in the context of chronic diseases, especially since 50% of patients do not take their medications as prescribed.[139] Fifth, we used only a one-time eGFR measurement to determine CKD prevalence. Our findings, however, derived from sensitivity analyses were consistent when using a more restrictive definition of CKD and models assessing UACR measurement and CKD identification in the EHR were adjusted for eGFR. Finally, we did not look at other aspects of CKD care such as treatments to reduce patients' risk of cardiovascular disease and measures to address anemia, metabolic acidosis, bone-mineral disorders, and early referral to nephrologists.[71] This is an important direction for future examination.

Our study is the first to look at the association of neighborhood SES with quality of CKD care received. Major strengths of our study include: EHR data from routine clinical care, availability of geographic data, and using small geographic areas to determine neighborhood SES. Furthermore, our results were consistent across multiple sensitivity analysis.

In conclusion, overall quality of care in patients with CKD can be greatly improved. EHRs can be leveraged to assess adherence to evidence-based screening and treatment guidelines in the care of patients with CKD and can target providers, the healthcare system and patients.[77,140] Despite previous evidence that neighborhood SES influences quality of healthcare for conditions such as CVD and diabetes, we found no association of neighborhood SES with overall quality of care in CKD patients. Quality improvement initiatives focusing on prevention, screening and improved management of patients with a group of comorbid conditions (hypertension, diabetes, and CKD) are needed.

Tables and Figures

Table 10. Cohort flow chart of Fairview patients from the 7 county Minneapolis/St Paul metropolitan area



* Primary care physician visits were defined as a completed outpatient office visits to family practice, family practice-internal medicine, internal medicine, obstetrics/gynecology, gerontology or geriatrics clinic visit.
ACEi/ARB: angiotensin converting enzyme inhibitor/angiotensin receptor blocker; CKD: chronic kidney disease; eGFR: estimated glomerular filtration rate; UACR: urine albumin to creatinine ratio
1- ACEi/ARB recommended for adults with HTN and CKD [stage 3 or higher or stage 1 or 2 with UACR >300 mg/day]; 2- CKD identification: CKD documented in EHR, using ICD9/10 codes, among patients with CKD (≤60 ml/min/1.73m2)

Table 11. Characteristics of nonpregnant adults with hypertension and chronic kidney disease*

	Overall N=16,776	**Angiotensin medication prescription compliant** N=10,885	**Non-compliant with angiotensin medication prescription** N=5,891
eGFR (ml/min/1.73m2), mean(SD)	47.7 ± 15.3	49.4 ± 15.3	44.5 ± 14.7
Individual level demographic characteristics			
Age, mean (SD)	72.8 ± 13.4	72.6 ± 12.9	73.2 ± 14.3
Male, n(%)	7,108 (42%)	4,719 (43%)	2,389 (41%)
Black, n(%)	885 (5%)	583 (5%)	302 (5%)
Individual social characteristics (n%)			
Ever smokers, n(%)	8,489 (51%)	5,489 (50%)	2,996 (51%)
Medicaid (among adults <65yrs), n(%)	287 (7%)	163 (6%)	124 (8%)
Medicare (among adults ≥65yrs), n(%)	2,767 (22%)	1,882 (23%)	885 (20%)
Medical History			
Diabetes, n(%)	6,149 (37%)	4,423 (41%)	1,726 (29%)
Obese (BMI≥ 30 kg/m2), n(%)	7,088 (45%)	5,014 (48%)	2,074 (38%)
Cardiovascular disease, n(%)	7,277 (43%)	4,606 (42%)	2,671 (45%)
Stroke, n(%)	1,906 (11%)	1,222 (11%)	684 (12%)
Hyperlipidemia, n(%)	13,122 (78%)	9,047 (83%)	4,075 (69%)
Cancer, n(%)	2,651 (16%)	1,599 (15%)	1,052 (18%)
Median value of owner occupied housing units			
Q1: < $165,200	1,607 (10%)	1,022 (9%)	585 (10%)
Q2: $165,200 - $188,100	2,196 (13%)	1,482 (14%)	714 (12%)
Q3: $188,100 - $231,300	6,144 (37%)	3,952 (36%)	2,192 (37%)
Q4: ≥ $231,300	6,825 (41%)	4,426 (41%)	2,399 (41%)
Percent of residents > 25 years with a Bachelor's degree or more			
Q1: < 20.4%	1,945 (12%)	1,295 (12%)	650 (11%)
Q2: 20.4% - 34.1%	4,560 (27%)	3,011 (28%)	1,549 (26%)
Q3: 34.1% - 48.1%	5,668 (34%)	3,638 (33%)	2,030 (35%)
Q4: ≥ 48.1%	4,600 (27%)	2,939 (27%)	1,661 (28%)
Median household income			
Q1: <$35,935	1,807 (11%)	1,137 (11%)	670 (11%)
Q2: $35,935 - $47,379	2,334 (14%)	1,521 (14%)	813 (14%)
Q3: $47,379 - $62,343	3,956 (24%)	2,532 (23%)	1,424 (24%)
Q4: ≥ $62,343	8,664 (52%)	5,688 (52%)	2,976 (51%)

* Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking ACEi and ARB (angiotensin medications)

CKD: chronic kidney disease; cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 12. Overall characteristics of adults with chronic kidney disease* and of those who had UACR measured vs. not

	Overall N=25,097	**UACR measured** N= 6,863	**UACR not measured** N= 18,234
eGFR (ml/min/1.73m$_2$), mean(SD)	46.9 ± 12.31	44.9 ± 11.3	47.2 ± 12.7
Individual level demographic characteristics			
Age, mean (SD)	70.9 ± 14.1	71.9 ± 12.3	70.5 ± 14.7
Male, n(%)	10,323 (41%)	2,999 (44%)	7,324 (40%)
Black, n(%)	1,130 (5%)	368 (6%)	744 (4%)
Individual social characteristics (n%)			
Ever smokers, n(%)	12,254 (49%)	3,510 (51%)	8,744 (48%)
Medicaid (among adults <65yrs), n(%)	539 (7%)	115 (6%)	424 (7%)
Medicare (among adults ≥65yrs), n(%)	3,707 (21%)	1,258 (25%)	2,449 (20%)
Medical History			
Hypertension, n(%)	19,627 (78%)	6,389 (93%)	13,238 (73%)
Diabetes, n(%)	7,763 (31%)	4,271 (62%)	3,492 (19%)
Obese (BMI≥ 30 kg/m$_2$), n(%)	9,674 (42%)	3,424 (51%)	6,250 (38%)
Cardiovascular disease, n(%)	9,527 (38%)	2,813 (41%)	6,714 (37%)
Stroke, n(%)	2,512 (10%)	766 (11%)	1,746 (10%)
Hyperlipidemia, n(%)	17,334 (69%)	5,968 (87%)	11,366 (62%)
Cancer, n(%)	3,772 (15%)	1,018 (15%)	2,754 (15%)
Median value of owner occupied housing units			
Q1: < $165,200	2,375 (10%)	692 (10%)	1,683 (9%)
Q2: $165,200 - $188,100	3,164 (13%)	1,013 (15%)	2,151 (12%)
Q3: $188,100 - $231,300	8,940 (36%)	2,567 (37%)	6,373 (35%)
Q4: ≥ $231,300	10,611 (42%)	2,590 (38%)	8,021 (44%)
Percent of residents > 25 years with a Bachelor's degree or more			
Q1: < 20.4%	2,795 (11%)	865 (13%)	1,930 (11%)
Q2: 20.4% - 34.1%	6,673 (27%)	1,983 (29%)	4,690 (26%)
Q3: 34.1% - 48.1%	8,450 (34%)	2,347 (34%)	6,103 (34%)
Q4: ≥ 48.1%	7,173 (29%)	1,667 (24%)	5,506 (30%)
Median household income			
Q1: <$35,935	2,723 (11%)	733 (11%)	1,990 (11%)
Q2: $35,935 - $47,379	3,391 (14%)	928 (14%)	2,463 (14%)
Q3: $47,379 - $62,343	5,857 (23%)	1,608 (23%)	4,249 (23%)
Q4: ≥ $62,343	13,104 (52%)	3,590 (52%)	9,514 (52%)

*estimated glomerular filtration rate <60/mL/min per 1.73m$_2$ between 6/1/2017 and 12/31/2018; CKD: chronic kidney disease; cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 13. Characteristics of adults with chronic kidney disease* who had CKD identified in the electronic health records vs. not

	CKD identified N=13,811	**CKD not identified** N=11,286
eGFR (ml/min/1.73m2), mean(SD)	41.9 ± 13.6	52.9 ± 6.7
Individual level demographic characteristics		
Age, mean (SD)	72.5 ± 14.1	68.9 ± 13.9
Male, n(%)	6,405 (46%)	3,918 (35%)
Black, n(%)	906 (7%)	224 (2%)
Individual social characteristics (n%)		
Ever smokers, n(%)	7,158 (52%)	5,096 (45%)
Medicaid (among adults <65yrs), n(%)	361 (10%)	178 (4%)
Medicare (among adults ≥65yrs), n(%)	2,228 (22%)	1,479 (15%)
Medical History		
Hypertension, n(%)	12,561 (91%)	7,066 (63%)
Diabetes, n(%)	5,808 (42%)	1,955 (17%)
Obese (BMI≥ 30 kg/m2), n(%)	5,521 (42%)	4,153 (41%)
Cardiovascular disease, n(%)	6,742 (49%)	2,785 (25%)
Stroke, n(%)	1,789 (13%)	723 (6%)
Hyperlipidemia, n(%)	10,841 (79%)	6,493 (58%)
Cancer, n(%)	2,330 (17%)	1,442 (13%)
Median value of owner occupied housing units		
Q1: < $165,200	1,406 (10%)	969 (9%)
Q2: $165,200 - $188,100	1,863 (14%)	1,301 (12%)
Q3: $188,100 - $231,300	5,091 (37%)	3,849 (34%)
Q4: ≥ $231,300	5,448 (40%)	5,163 (46%)
Percent of residents > 25 years with a Bachelor's degree or more		
Q1: < 20.4%	1,652 (12%)	1,143 (10%)
Q2: 20.4% - 34.1%	3,820 (28%)	2,853 (25%)
Q3: 34.1% - 48.1%	4,671 (34%)	3,779 (34%)
Q4: ≥ 48.1%	3,666 (27%)	3,507 (31%)
Median household income		
Q1: <$35,935	1,542 (11%)	1,181 (11%)
Q2: $35,935 - $47,379	1,978 (14%)	1,413 (13%)
Q3: $47,379 - $62,343	3,323 (24%)	2,534 (23%)
Q4: ≥ $62,343	6,954 (50%)	6,150 (55%)

*estimated glomerular filtration rate <60/mL/min per 1.73m2 between 6/1/2017 and 12/31/2018; CKD: chronic kidney disease; cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 14. Multilevel regression model for the association of tract level socioeconomic status with angiotensin medication prescription *compliance* *

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=6,825)	1.00	1.00	1.00
3rd Q (n=6,144)	0.99 [0.96, 1.02]	0.99 [0.96, 1.02]	0.99 [0.96, 1.01]
2nd Q (n=2,196)	1.04 [1.00, 1.08]	1.03 [0.99, 1.07]	1.01 [0.98, 1.05]
Low SES tract – 1st Q (n=1,611)	0.98 [0.92, 1.05]	0.97 [0.91, 1.04]	0.96 [0.91, 1.03]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract– 4th Q (n=4,600)	1.00	1.00	1.00
3rd Q (n=5,668)	1.00 [0.97, 1.04]	1.02 [0.98, 1.07]	0.99 [0.96, 1.03]
2nd Q (n=4,560)	1.03 [0.99, 1.07]	1.03 [0.99, 1.06]	1.01 [0.98, 1.04]
Low SES tract – 1st Q (n=1,948)	1.04 [1.00, 1.09]	1.02 [0.98, 1.07]	1.01 [0.97, 1.05]
Median household income			
High SES tract – 4th Q (n=8,664)	1.00	1.00	1.00
3rd Q (n=3,956)	0.97 [0.94, 1.01]	0.98 [0.95, 1.02]	0.98 [0.95, 1.01]
2nd Q (n=2,334)	0.99 [0.95, 1.03]	0.99 [0.95, 1.03]	0.99 [0.95, 1.03]
Low SES tract – 1st Q (n=1,822)	0.96 [0.92, 1.00]	0.96 [0.93, 1.00]	0.97 [0.94, 1.02]

* Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking angiotensin converting enzyme inhibitor (ACEI) and angiotensin receptor blocker (ARB)
ACEI/ARB prescription compliance: yes if recommended ACEI/ARB prescribed

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Multiplicative interaction:
p-value for interaction of wealth with race (p=0.69), **with sex (p=0.01)**
p-value for interaction of education with race (**p=0.04**), with sex (p=0.11)
p-value for interaction of income with race (p=0.47), with sex (p=0.62)

Table 15. Multilevel regression model for the association of tract level socioeconomic status with urine albumin to creatinine measurement

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=10,611)	1.00	1.00	1.00
3rd Q (n=8,940)	1.19 [1.11, 1.28]	1.15 [1.07, 1.23]	1.07 [0.99, 1.13]
2nd Q (n=3,164)	1.35 [1.23, 1.48]	1.27 [1.16, 1.29]	1.13 [1.04, 1.22]
Low SES tract – 1st Q (n=2,382)	1.22 [1.09, 1.36]	1.16 [1.03, 1.30]	1.01 [0.91, 1.12]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q (n=7,173)	1.00	1.00	1.00
3rd Q (n=8,450)	1.21 [1.11, 1.31]	1.15 [1.06, 1.25]	1.10 [1.00, 1.17]
2nd Q (n=6,673)	1.30 [1.20, 1.42]	1.23 [1.14, 1.34]	1.10 [1.02, 1.19]
Low SES tract – 1st Q (n=2,801)	1.34 [1.22, 1.48]	1.25 [1.14, 1.38]	1.07 [0.98, 1.17]
Median household income			
High SES tract – 4th Q (n=13,104)	1.00	1.00	1.00
3rd Q (n=5,857)	1.02 [0.95, 1.08]	0.96 [0.92, 1.07]	0.98 [0.92, 1.05]
2nd Q (n=3,391)	0.98 [0.88, 1.09]	0.95 [0.86, 1.05]	0.92 [0.84, 1.00]
Low SES tract – 1st Q (n=2,745)	0.97 [0.87, 1.08]	0.96 [0.86, 1.07]	0.96 [0.87, 1.06]

*UACR measured: UACR measured in patients with CKD (eGFR <60 ml/min/1.73m2). UACR measurement performance was defined as: number of patients who have UACR measured/ number of patients with CKD x 100%

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Multiplicative interaction:
p-value for interaction of wealth with race (p=0.12), with sex (p=0.11), hypertension (0.05), diabetes (p=0.21)
p-value for interaction of education with race (p=0.52), with sex (p=0.33), hypertension (p=0.54), diabetes (p=0.17)
p-value for interaction of income with race (p=0.21), with sex (p=0.46), hypertension (p=0.23), diabetes (p=0.44)

Table 16. Multilevel regression model for the association of tract level socioeconomic status with chronic kidney disease (CKD) identification

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=10,611)	1.00	1.00	1.00
3rd Q (n=8,940)	1.11 [1.07, 1.14]	1.09 [1.06, 1.12]	1.03 [1.00, 1.06]
2nd Q (n=3,164)	1.14 [1.09, 1.21]	1.11 [1.06, 1.17]	1.03 [0.99, 1.08]
Low SES tract – 1st Q (n=2,382)	1.15 [1.11, 1.20]	1.11 [1.07, 1.16]	1.02 [0.98, 1.06]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q (n=7,173)	1.00	1.00	1.00
3rd Q (n=8,450)	1.08 [1.04, 1.12]	1.06 [1.03, 1.10]	1.02 [0.99, 1.05]
2nd Q (n=6,673)	1.12 [1.08, 1.16]	1.09 [1.06, 1.14]	1.02 [0.98, 1.05]
Low SES tract – 1st Q (n=2,801)	1.16 [1.10, 1.22]	1.13 [1.08, 1.19]	1.03 [0.98, 1.07]
Median household income			
High SES tract – 4th Q (n=13,104)	1.00	1.00	1.00
3rd Q (n=5,857)	1.07 [1.03, 1.13]	1.04 [1.00, 1.07]	1.01 [0.97, 1.04]
2nd Q (n=3,391)	1.09 [1.06, 1.14]	1.07 [1.03, 1.10]	1.02 [0.98, 1.05]
Low SES tract – 1st Q (n=2,745)	1.07 [1.01, 1.10]	1.03 [0.98, 1.08]	1.01 [0.97, 1.06]

* CKD identified in EHR was defined as: number of patients who have CKD (eGFR <60ml/min/1.73m$_2$) documented by ICD9/10 codes in EHR / number of patients with CKD x 100%

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Multiplicative interaction:
p-value for interaction of wealth with **race (p=0.02),** with sex (p=0.08), **hypertension (p=0.001), diabetes (p=0.04)**
p-value for interaction of education with race (p=0.24), with sex (p=0.14), **hypertension (p=0.03),** diabetes (p=0.22)
p-value for interaction of income with race (p=0.16), with sex (p=0.35), hypertension (p=0.36), **diabetes (p=0.03)**

Table 17. Quantitative selection bias analysis for association of tract level socioeconomic status with angiotensin prescription compliance

	Crude Poisson regression PR	Selection bias adjusted crude PR	Fully Adjusted Poisson regression PR	Selection bias corrected fully adjusted* PR
Median value of owner-occupied housing units is the measure of SES				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	0.98	0.9	0.96	0.9
Low SES tract (B)		0.7		0.7
Low SES tract (C)		0.8		0.8
%>25 years with a Bachelor's degree or more				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.0	1.1	1.0	1.1
Low SES tract (B)		0.8		0.8
Low SES tract (C)		0.8		0.8
Median household income and insurance status				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	0.96	0.9	0.97	0.9
Low SES tract (B)		0.7		0.7
Low SES tract (C)		0.7		0.7

PR: prevalence ratio

Selection probabilities for tract SES used are as follows:
S_1(Angiotensin prescription compliant + & SES+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(Angiotensin prescription compliant + & SES-)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(Angiotensin prescription compliant - & SES+)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(Angiotensin prescription compliant - & SES-)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$

For example (under scenario A): for S_1=0.5, that means the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and having angiotensin medications prescribed per guidelines and living in a low SES tract is 50%. For S_2=0.9, that means the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and having angiotensin medications prescribed per guidelines and living in a high SES tract is 90%. We are assuming

that $S_1 \leq S_2$. For S3 =0.2, that means that the probability of a patient coming to Fairview clinics (i.e. included in our cohort) and not having angiotensin medications prescribed per guidelines and living in a low SES tract is 20%. We are assuming that $S_1 > S_3$ (this is a less likely scenario i.e. we are assuming that a patient is more likely to come to Fairview and have appropriate medication prescribed knowing that patient already fulfills the AHA/ACC criteria to be on angiotensin medications – i.e. has hypertension).

*Selection bias adjusted PR= crude selection bias adjusted PR * r where r = [Fully adjusted Poisson Regression PR/Crude Poisson Regression PR]. I am assuming this is a constant for each model

Angiotensin prescription compliant +: compliant with angiotensin prescription; Angiotensin prescription compliant -: compliant with angiotensin prescription; SES+: belong to low SES tract; SES-: belong to high SES tract

Table 18. Quantitative selection bias analysis for association of tract level socioeconomic status with urine albumin to creatinine (UACR) measurement

	Crude Poisson regression PR	Selection bias adjusted crude PR	Fully Adjusted Poisson regression PR	Selection bias corrected fully adjusted* PR
Median value of owner-occupied housing units is the measure of SES				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.2	1.1	1.0	0.9
Low SES tract (B)		0.8		0.7
Low SES tract (C)		0.8		0.7
%>25 years with a Bachelor's degree or more				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.3	1.3	1.1	1.1
Low SES tract (B)		0.9		0.8
Low SES tract (C)		0.9		0.8
Median household income and insurance status				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	0.97	0.9	0.96	0.9
Low SES tract (B)		0.7		0.7
Low SES tract (C)		0.7		0.7

PR: prevalence ratio

S_1(UACR measured + & SES+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(UACR measured + & SES-)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(UACR measured - & SES+)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(UACR measured - & SES-)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$

*Selection bias adjusted PR= crude selection bias adjusted PR * r
Where r = [Fully adjusted Poisson Regression PR/Crude Poisson Regression PR]. I am assuming this is a constant for each model

UACR measured +: UACR measured in patients with chronic kidney disease; UACR measured -: UACR not measured in patients with chronic kidney disease; SES+: belong to low SES tract; SES-: belong to high SES tract

Table 19. Quantitative selection bias analysis for association of tract level socioeconomic status with chronic kidney disease (CKD) identified

	Crude Poisson regression PR	Selection bias adjusted crude PR	Fully Adjusted Poisson regression PR	Selection bias corrected fully adjusted* PR
Median value of owner-occupied housing units is the measure of SES				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.2	1.2	1.0	1.0
Low SES tract (B)		0.9		0.8
Low SES tract (C)		0.9		0.8
%>25 years with a Bachelor's degree or more				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.2	1.2	1.0	1.0
Low SES tract (B)		0.9		0.8
Low SES tract (C)		0.9		0.8
Median household income and insurance status				
High SES tract	1.0	1.0	1.0	1.0
Low SES tract (A)	1.1	1.0	1.0	0.9
Low SES tract (B)		0.8		0.7
Low SES tract (C)		0.8		0.7

PR: prevalence ratio

S_1(CKD identified + & SES+)= 0.5 (A), 0.4 (B), 0.6 (C)
S_2(CKD identified + & SES-)= 0.9 (A), 0.7 (B), 0.6 (C)
S_3(CKD identified - & SES+)= 0.2 (A), 0.1 (B), 0.3 (C)
S_4(CKD identified - & SES-)= 0.4 (A), 0.3 (B), 0.5 (C)

Assumptions: $S_1 \leq S_2$, $S_1 > S_3$, $S_2 > S_3$ and $S_3 < S_4$

*Selection bias adjusted PR= crude selection bias adjusted PR * r
Where r = [Fully adjusted Poisson Regression PR/Crude Poisson Regression PR]. I am assuming this is a constant for each model

CKD identified +: CKD identified in patients with chronic kidney disease; CKD identified -: CKD not identified in patients with chronic kidney disease; SES+: belong to low SES tract; SES-: belong to high SES tract

Table S21. Comparison of Fairview patients to the 7-county Minneapolis/St Paul metropolitan area

	Fairview population (included in our analysis) to assess ACEI/ARB prescription compliance n=16,776	Fairview population (included in our analysis) to assess UACR measurement performance and CKD identification n=25,095	Census data (7 county metro area)
Median Age[1]	55	56	36*
% Black	5%	5%	8%
% Male	42%	41%	49%
%Medicaid[2]	7%	7%	7%
Number of census tracts	666	666	704
Population by County, n(%)			
Anoka	2,677 (16%)	3,773 (15%)	331,649 (12%)
Carver	180 (1%)	275 (1%)	91,355 (3%)
Dakota	3,795 (22%)	5,807 (23%)	399,443 (14%)
Hennepin	7,120 (42%)	10,506 (42%)	1,158,039 (40%)
Ramsey	1,742 (10%)	2,718 (11%)	510,885 (18%)
Scott	699 (4%)	1,101 (4%)	130,689 (5%)
Washington	563 (3%)	917 (4%)	238,721 (8%)
Total population	*16,776*	*25,097*	*2,860,781*

[1]Median age in Fairview population before excluding patients <18 years

[2]Medicaid in Fairview population is calculated for those ≥ 18 years with Medicaid coverage

Medicaid coverage (Medicaid or other means-tested public coverage) for census data include individuals ≥18 years with coverage through Medicaid, Medical Assistance or any kind of government assistance plan for those with low incomes or a disability from 2012 American Community Survey: 5-Year Data [2008-2012].

*Census data is not restricted to adults >18 years. Median age here is of all the population.

ACEi/ARB: angiotensin converting enzyme inhibitor/angiotensin receptor blocker
UACR: urine albumin to creatinine ratio
CKD: chronic kidney disease

Table S22. Angiotensin medication prescription compliance: interaction of neighborhood SES with race (black vs. white)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q	0.69	0.99 [0.88, 1.11]	0.99 [0.87, 1.11]
2nd Q		0.97 [0.85, 1.13]	0.97 [0.82, 1.13]
Low SES tract – 1st Q		0.99 [0.85, 1.17]	0.99 [0.84, 1.15]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q	0.04	1.16 [1.00, 1.33]	1.15 [1.01, 1.29]
2nd Q		1.04 [0.90, 1.21]	1.04 [0.89, 1.19]
Low SES tract – 1st Q		0.96 [0.81, 1.14]	0.96 [0.82, 1.12]
Median household income			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q	0.47	1.05 [0.94, 1.17]	1.04 [0.94, 1.16]
2nd Q		1.06 [0.93, 1.21]	1.06 [0.93, 1.19]
Low SES tract – 1st Q		0.98 [0.86, 1.12]	1.06 [0.93, 1.19]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction

RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{black}) + \beta(\text{low tract SES*black})} - e^{(\beta(\text{low tract SES}) + \beta(\text{black}))} + 1 = RR_{(\text{low SES tract and black})} + RR_{(\text{low SES tract and white})} + RR_{(\text{high SES tract and black})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{black}) + \beta(\text{low tract SES*black})} / e^{(\beta(\text{low tract SES}) * e^{\beta(\text{black}))} = RR_{(\text{low SES tract and black})} / RR_{(\text{low SES tract and white})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Table S23. Angiotensin medication prescription compliance: interaction of neighborhood SES with sex (male vs. female)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.01	1.00	1.00
3rd Q		1.00 [0.95, 1.06]	1.00 [0.95, 1.05]
2nd Q		1.09 [1.02, 1.15]	1.08 [1.02, 1.14]
Low SES tract – 1st Q		1.09 [1.01, 1.19]	1.08 [1.00, 1.17]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**	0.11	1.00	1.00
3rd Q		1.03 [0.97, 1.09]	1.03 [0.97, 1.09]
2nd Q		1.01 [0.95, 1.07]	1.00 [0.94, 1.07]
Low SES tract – 1st Q		1.08 [1.00, 1.15]	1.07 [1.01, 1.14]
Median household income			
High SES tract – 4th Q **(reference)**	0.62	1.00	1.00
3rd Q		0.99 [0.93, 1.04]	1.05 [0.93, 1.17]
2nd Q		1.03 [0.96, 1.10]	1.00 [0.96, 1.10]
Low SES tract – 1st Q		0.97 [0.90, 1.04]	0.96 [0.90, 1.04]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{male}) + \beta(\text{low tract SES*male})} - e^{(\beta(\text{low tract SES}) + \beta(\text{male}))} + 1 = RR_{(\text{low SES tract and black})} + RR_{(\text{low SES tract and white})} + RR_{(\text{high SES tract and black})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{male}) + \beta(\text{low tract SES*male})} / e^{(\beta(\text{low tract SES}) * e^{\beta(\text{male}))} = RR_{(\text{low SES tract and black})} / RR_{(\text{low SES tract and white})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Table S24. Multilevel regression model for the association of tract level socioeconomic status with angiotensin medication prescription compliance[1] by sex

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
SEX			
Males (n=7,108)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=3,126)	1.00	1.00	1.00
3rd Q (n=2,492)	0.99 [0.95, 1.04]	0.99 [0.95, 1.03]	0.99 [0.95, 1.03]
2nd Q (n=871)	1.08 [1.03, 1.14]	1.07 [1.03, 1.12]	1.05 [1.01, 1.10]
Low SES tract – 1st Q (n=619)	1.03 [0.94, 1.13]	1.01 [0.92, 1.11]	1.01 [0.92, 1.11]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q (n=3,126)	1.00	1.00	1.00
3rd Q (n=2,492)	1.02 [0.97, 1.07]	1.01 [0.96, 1.07]	1.01 [0.96, 1.06]
2nd Q (n=871)	1.03 [0.98, 1.09]	1.02 [0.97, 1.07]	1.01 [0.96, 1.06]
Low SES tract – 1st Q (n=619)	1.08 [1.02, 1.14]	1.05 [0.99, 1.11]	1.04 [0.98, 1.09]
Females (n=9,668)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4TH Q (n=3,699)	1.00	1.00	1.00
3rd Q (n=3,652)	0.99 [0.96, 1.03]	0.99 [0.95, 1.02]	0.99 [0.94, 1.03]
2nd Q (n=1,325)	1.01 [0.89, 1.02]	0.99 [0.94, 1.04]	0.98 [0.94, 1.03]
Low SES tract – 1st Q (n=992)	0.95 [0.89, 1.02]	0.94 [0.88, 1.02]	0.93 [0.87, 0.99]
***Percent of >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=3,126)	1.00	1.00	1.00
3rd Q (n=2,492)	0.99 [0.95, 1.04]	0.98 [0.94, 1.03]	0.98 [0.94, 1.02]
2nd Q (n=871)	1.03 [0.98, 1.07]	1.03 [0.99, 1.07]	1.01 [0.97, 1.06]
Low SES tract – 1st Q (n=619)	1.02 [0.97, 1.07]	0.99 [0.95, 1.05]	0.98 [0.93, 1.03]

1-Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking ACEi/ARB. ACEI/ARB prescription compliance: yes if recommended ACEI/ARB prescribed;

PR: prevalence ratio; Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4; **Model 1:** crude; **Model 2:** age, race, obesity, smoking, insurance status; **Model 3:** model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes/ **We removed variables we stratified by from models**

Table S25. Multilevel regression model for the association of tract level socioeconomic status with angiotensin medication prescription compliance by race

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
RACE			
***Percent of >25 years with* a Bachelor's degree or more**			
Black (n=885)			
High SES tract – 4th Q (n=153)	1.00	1.00	1.00
3rd Q (n=247)	1.14 [0.99, 1.31]	1.15 [1.00, 1.33]	1.14 [1.00, 1.31]
2nd Q (n=276)	1.05 [0.91, 1.21]	1.06 [0.91, 1.24]	1.05 [0.91, 1.22]
Low SES tract – 1st Q (n=209)	0.98 [0.82, 1.15]	0.99 [0.84, 1.18]	0.97 [0.82, 1.14]
White (n=14,504)			
Percent of >25 years with a Bachelor's degree or more			
High SES tract – 4TH Q (n=4,112)	1.00	1.00	1.00
3rd Q (n=5,004)	0.99 [0.96, 1.04]	0.99 [0.95, 1.03]	0.98 [0.95, 1.02]
2nd Q (n=3,901)	1.03 [0.99, 1.07]	1.02 [0.99, 1.06]	1.01 [0.98, 1.05]
Low SES tract – 1st Q (n=1,447)	1.05 [1.00, 1.10]	1.03 [0.99, 1.08]	1.02 [0.97, 1.06]

1-Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking ACEi/ARB. ACEI/ARB prescription compliance: yes if recommended ACEI/ARB prescribed;
PR: prevalence ratio; Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4; **Model 1:** crude; **Model 2:** age, race, obesity, smoking, insurance status; **Model 3:** model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes/ **We removed variables we stratified by from models**

Table S26. Urine albumin to creatinine measurement: interaction of neighborhood SES with race (black vs. white)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.12	1.00	1.00
3rd Q		0.89 [0.72, 1.10]	0.87 [0.62, 1.12]
2nd Q		0.88 [0.69, 1.12]	0.85 [0.56, 1.15]
Low SES tract – 1st Q		0.90 [0.71, 1.14]	0.89 [0.62, 1.15]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**	0.52	1.00	1.00
3rd Q		1.01 [0.79, 1.28]	1.02 [0.75, 1.29]
2nd Q		0.99 [0.79, 1.24]	0.99 [0.73, 1.26]
Low SES tract – 1st Q		0.86 [0.67, 1.11]	0.86 [0.67, 1.11]
Median household income			
High SES tract – 4th Q **(reference)**	0.21	1.00	1.00
3rd Q		0.82 [0.66, 1.01]	0.79 [0.59, 1.01]
2nd Q		1.01 [0.81, 1.26]	1.01 [0.78, 1.24]
Low SES tract – 1st Q		0.90 [0.72, 1.09]	0.90 [0.72, 1.09]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{black}) + \beta(\text{low tract SES*black})} - e^{(\beta(\text{low tract SES}) + \beta(\text{black}))} + 1 = RR_{(\text{low SES tract and black})} + RR_{(\text{low SES tract and white})} + RR_{(\text{high SES tract and black})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{black}) + \beta(\text{low tract SES*black})} / e^{(\beta(\text{low tract SES}) * e^{\beta(\text{black}))} = RR_{(\text{low SES tract and black})} / RR_{(\text{low SES tract and white})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S27. Urine albumin to creatinine measurement: interaction of neighborhood SES with sex (male vs. female)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		0.99 [0.91, 1.09]	1.00 [0.91, 1.10]
2nd Q	0.11	0.99 [0.89, 1.11]	0.99 [0.87, 1.12]
Low SES tract – 1st Q		0.95 [0.84, 1.08]	0.94 [0.81, 1.08]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		1.07 [0.97, 1.19]	1.09 [0.96, 1.22]
2nd Q	0.33	1.07 [0.97, 1.17]	1.07 [0.98, 1.18]
Low SES tract – 1st Q		1.09 [0.94, 1.22]	1.08 [0.96, 1.22]
Median household income			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		1.04 [0.94, 1.15]	0.82 [0.65, 0.99]
2nd Q	0.46	1.03 [0.93, 1.16]	1.03 [0.94, 1.14]
Low SES tract – 1st Q		1.08 [0.97, 1.19]	1.08 [0.97, 1.19]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{male}) + \beta(\text{low tract SES*male})} - e^{(\beta(\text{low tract SES}) + \beta(\text{male}))} + 1 = RR_{(\text{low SES tract and black})} + RR_{(\text{low SES tract and white})} + RR_{(\text{high SES tract and black})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{male}) + \beta(\text{low tract SES*male})} / e^{(\beta(\text{low tract SES}) * e^{\beta(\text{male}))} = RR_{(\text{low SES tract and black})} / RR_{(\text{low SES tract and white})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S28. Urine albumin to creatinine measurement: interaction of neighborhood SES with hypertension history (yes vs. no)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.50	1.00	1.00
3rd Q		1.01 [0.83, 1.24]	1.03 [0.56, 1.50]
2nd Q		0.84 [0.65, 1.10]	0.55 [-0.26, 1.35]
Low SES tract – 1st Q		1.04 [0.75, 1.43]	1.08 [0.42, 1.74]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**	0.54	1.00	1.00
3rd Q		0.85 [0.68, 1.06]	0.57 [-0.15, 1.30]
2nd Q		0.89 [0.70, 1.15]	0.70 [-0.03, 1.44]
Low SES tract – 1st Q		0.96 [0.70, 1.32]	0.89 [0.08, 1.71]
Median household income			
High SES tract – 4th Q **(reference)**	0.23	1.00	1.00
3rd Q		0.81 [0.67, 0.99]	0.48 [-0.11, 1.07]
2nd Q		0.91 [0.69, 1.19]	0.78 [0.15, 1.41]
Low SES tract – 1st Q		0.96 [0.70, 1.31]	0.89 [0.08, 1.71]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{history of hypertension}) + \beta(\text{low tract SES*male})} - e^{(\beta(\text{low tract SES}) + \beta(\text{male}))} + 1 = RR_{(\text{low SES tract and history of hypertension})} + RR_{(\text{low SES tract and no history of hypertension})} + RR_{(\text{high SES tract and history of hypertension})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{history of hypertension}) + \beta(\text{low tract SES*history of hypertension})} / e^{(\beta(\text{low tract SES})} * e^{\beta(\text{history of hypertension}))} = RR_{(\text{low SES tract and history of hypertension})} / RR_{(\text{low SES tract and no history of hypertension})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S29. Urine albumin to creatinine measurement: interaction of neighborhood SES with diabetes history (yes vs. no)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		0.91 [0.80, 1.03]	0.66 [0.18, 1.14]
2nd Q	0.21	0.80 [0.68, 0.93]	0.14 [-0.56, 0.84]
Low SES tract – 1st Q		1.04 [0.82, 1.30]	1.10 [0.41, 1.79]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		0.86 [0.75, 1.00]	-0.59 [-1.47, 0.30]
2nd Q	0.17	0.89 [0.78, 1.02]	0.59 [0.06, 1.12]
Low SES tract – 1st Q		0.96 [0.79, 1.16]	0.85 [0.16, 1.54]
Median household income			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		1.07 [0.93, 1.22]	1.18 [0.80, 1.57]
2nd Q	0.44	1.05 [0.89, 1.25]	1.13 [0.69, 1.58]
Low SES tract – 1st Q		0.91 [0.76, 1.09]	0.91 [0.76, 1.09]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{history of diabetes}) + \beta(\text{low tract SES*male})} - e^{(\beta(\text{low tract SES}) + \beta(\text{male}))} + 1 = RR_{(\text{low SES tract and history of diabetes})} + RR_{(\text{low SES tract and no history of diabetes})} + RR_{(\text{high SES tract and history of diabetes})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{history of diabetes}) + \beta(\text{low tract SES*history of diabetes})} / e^{(\beta(\text{low tract SES})} * e^{\beta(\text{history of hypertension}))} = RR_{(\text{low SES tract and history of diabetes})} / RR_{(\text{low SES tract and no history of diabetes})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S30. CKD identification in the EHR: interaction of neighborhood SES with race (black vs. white)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.02	1.00	1.00
3rd Q		0.96 [0.88, 1.05]	0.95 [0.94, 1.06]
2nd Q		0.90 [0.91, 1.00]	0.89 [0.76, 1.02]
Low SES tract – 1st Q		0.91 [0.83, 1.01]	0.90 [0.78, 1.02]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**	0.24	1.00	1.00
3rd Q		0.97 [0.87, 1.08]	0.97 [0.84, 1.09]
2nd Q		0.96 [0.87, 1.06]	0.95 [0.83, 1.06]
Low SES tract – 1st Q		0.90 [0.81, 1.00]	0.90 [0.81, 1.00]
Median household income			
High SES tract – 4th Q **(reference)**	0.16	1.00	1.00
3rd Q		0.94 [0.87, 1.02]	0.93 [0.84, 1.02]
2nd Q		0.90 [0.82, 0.99]	0.89 [0.78, 0.99]
Low SES tract – 1st Q		0.95 [0.86, 1.05]	0.95 [0.86, 1.05]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{black}) + \beta(\text{low tract SES*black})} - e^{(\beta(\text{low tract SES}) + \beta(\text{black}))} + 1 = RR_{(\text{low SES tract and black})} + RR_{(\text{low SES tract and white})} + RR_{(\text{high SES tract and black})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{black}) + \beta(\text{low tract SES*black})} / e^{(\beta(\text{low tract SES}) * e^{\beta(\text{black}))} = RR_{(\text{low SES tract and black})} / RR_{(\text{low SES tract and white})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S31. CKD identification in the EHR: interaction of neighborhood SES with sex (male vs. female)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		0.99 [0.95, 1.04]	0.99 [0.94, 1.05]
2nd Q	0.08	0.98 [0.92, 1.05]	0.98 [0.90, 1.07]
Low SES tract – 1st Q		0.92 [0.86, 0.99]	0.90 [0.81, 0.99]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		1.01 [0.95, 1.06]	1.01 [0.94, 1.07]
2nd Q	0.14	0.96 [0.91, 1.02]	0.96 [0.99, 1.03]
Low SES tract – 1st Q		0.94 [0.86, 1.01]	0.92 [0.82, 1.02]
Median household income			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		1.06 [1.00, 1.11]	0.93 [0.84, 1.02]
2nd Q	0.35	0.99 [0.93, 1.05]	0.99 [0.92, 1.06]
Low SES tract – 1st Q		1.00 [0.93, 1.08]	1.00 [0.93, 1.08]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{male}) + \beta(\text{low tract SES*male})} - e^{(\beta(\text{low tract SES}) + \beta(\text{male}))} + 1 = RR_{(\text{low SES tract and black})} + RR_{(\text{low SES tract and white})} + RR_{(\text{high SES tract and black})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{male}) + \beta(\text{low tract SES*male})} / e^{(\beta(\text{low tract SES}) * e^{\beta(\text{male}))} = RR_{(\text{low SES tract and black})} / RR_{(\text{low SES tract and white})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S32. CKD identification in the EHR: interaction of neighborhood SES with hypertension history (yes vs. no)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		0.89 [0.79, 0.99]	0.74 [0.46, 1.02]
2nd Q	0.001	0.84 [0.72, 0.95]	0.61 [0.23, 0.99]
Low SES tract – 1st Q		0.79 [0.66, 0.95]	0.44 [-0.43, 0.93]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		0.92 [0.81, 1.05]	0.83 [0.53, 1.12]
2nd Q	0.03	0.83 [0.72, 0.94]	0.56 [0.20, 0.93]
Low SES tract – 1st Q		0.93 [0.69, 0.99]	0.55 [0.05, 1.04]
Median household income			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q		0.91 [0.80, 1.03]	0.80 [0.53, 1.07]
2nd Q	0.36	0.92 [0.80, 1.07]	0.83 [0.52, 1,15]
Low SES tract – 1st Q		0.91 [0.77, 1.07]	0.91 [0.77, 1.07]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{history of hypertension}) + \beta(\text{low tract SES*male})} - e^{(\beta(\text{low tract SES}) + \beta(\text{male}))} + 1 = RR_{(\text{low SES tract and history of hypertension})} + RR_{(\text{low SES tract and no history of hypertension})} + RR_{(\text{high SES tract and history of hypertension})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{history of hypertension}) + \beta(\text{low tract SES*history of hypertension})} / e^{(\beta(\text{low tract SES})} * e^{\beta(\text{history of hypertension}))} = RR_{(\text{low SES tract and history of hypertension})} / RR_{(\text{low SES tract and no history of hypertension})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S33. CKD identification in the EHR: interaction of neighborhood SES with diabetes history (yes vs. no)

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.04	1.00	1.00
3rd Q		0.97 [0.93, 1.01]	0.96 [0.91, 1.02]
2nd Q		0.98 [0.91, 1.04]	0.97 [0.89, 1.05]
Low SES tract – 1st Q		0.92 [0.86, 0.99]	0.90 [0.81, 1.00]
Percent of residents >25 years with a Bachelor's degree or more			
High SES tract – 4th Q **(reference)**	0.22	1.00	1.00
3rd Q		0.97 [0.92, 1.02]	1.73 [1.55, 1.92]
2nd Q		0.96 [0.91, 1.01]	0.95 [0.89, 1.01]
Low SES tract – 1st Q		0.93 [0.86, 1.01]	0.92 [0.82, 1.02]
Median household income			
High SES tract – 4th Q **(reference)**	0.03	1.00	1.00
3rd Q		0.96 [0.91, 1.01]	0.95 [0.89, 1.01]
2nd Q		0.95 [0.89, 1.00]	0.93 [0.87, 1.00]
Low SES tract – 1st Q		0.92 [0.86, 0.97]	0.92 [0.82, 1.02]

RR: relative risk (equivalent to prevalence ratio); RERI: relative excess risk due to interaction
RERI is calculated as follows: $e^{\beta(\text{low tract SES}) + \beta(\text{history of diabetes}) + \beta(\text{low tract SES*male})} - e^{(\beta(\text{low tract SES}) + \beta(\text{male}))} + 1 = RR_{(\text{low SES tract and history of diabetes})} + RR_{(\text{low SES tract and no history of diabetes})} + RR_{(\text{high SES tract and history of diabetes})} + 1$

Ratio of PR (interaction on multiplicative scale): $e^{\beta(\text{low tract SES}) + \beta(\text{history of diabetes}) + \beta(\text{low tract SES*history of diabetes})} / e^{(\beta(\text{low tract SES})} * e^{\beta(\text{history of hypertension}))} = RR_{(\text{low SES tract and history of diabetes})} / RR_{(\text{low SES tract and no history of diabetes})} * RR_{(\text{high SES tract and black})}$

Interaction obtained using the fully adjusted model:
Model: age, sex, race, obesity, smoking, insurance status, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table S34. Multilevel regression model for the association of tract level socioeconomic status with CKD identified in the EHR[1] for the identified effect modifiers

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Hypertension			
HAVE HYPERTENSION (n= 19,627)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=7,938)	1.00	1.00	1.00
3rd Q (n= 7,203)	1.05 [1.02, 1.08]	1.05 [1.02, 1.07]	1.02 [0.97, 1.05]
2nd Q (n=2,557)	1.08 [1.03, 1.13]	1.06 [1.02, 1.11]	1.02 [0.98, 1.06]
Low SES tract – 1st Q (n=1,929)	1.08 [1.04, 1.13]	1.05 [1.01, 1.09]	1.00 [0.97, 1.03]
Percent of >25 years with a Bachelor's degree or more			
High SES tract – 4th Q (n=5,335)	1.00	1.00	1.00
3rd Q (n=6,658)	1.04 [1.01, 1.07]	1.04 [1.00, 1.12]	1.01 [0.98, 1.06]
2nd Q (n=5,371)	1.05 [1.02, 1.08]	1.04 [1.01, 1.08]	1.00 [0.97, 1.03]
Low SES tract – 1st Q (n=2,263)	1.08 [1.04, 1.14]	1.07 [1.02, 1.12]	1.02 [0.98, 1.06]
HAVE NO HYPERTENSION (n=5,470)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=2,673)	1.00	1.00	1.00
3rd Q (n=1,737)	1.19 [1.06, 1.33]	1.19 [1.06, 1.34]	1.11 [0.99, 1.25]
2nd Q (n=607)	1.31 [1.12, 1.54]	1.31 [1.11, 1.54]	1.14 [0.98, 1.32]
Low SES tract – 1st Q (n=453)	1.30 [1.08, 1.56]	1.34 [1.11, 1.62]	1.22 [1.01, 1.46]
***Percent of >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=1,838)	1.00	1.00	1.00
3rd Q (n=1,792)	1.11 [0.98, 1.26]	1.14 [0.99, 1.30]	1.07 [0.95, 1.22]
2nd Q (n=1,302)	1.28 [1.11, 1.46]	1.27 [1.10, 1.46]	1.15 [1.00, 1.31]
Low SES tract – 1st Q (n=538)	1.28 [1.06, 1.53]	1.24 [1.10, 1.63]	1.17 0.96, 1.42]

1-CKD identified in EHR was defined as: number of patients who have CKD (eGFR <60ml/min/1.73m2) documented by ICD9/10 codes in EHR / number of patients with CKD x 100%
SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935
Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

- We removed variables we stratified by from models

Table S34. (continued)

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Diabetes			
HAVE DIABETES (n=7,763)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=2,842)	1.00	1.00	1.00
3rd Q (n=2,895)	1.03 [0.99, 1.06]	1.02 [0.99, 1.05]	1.01 [0.98, 1.04]
2nd Q (n=1,121)	1.06 [1.02, 1.11]	1.05 [1.00, 1.09]	1.03 [0.99, 1.07]
Low SES tract – 1st Q (n=905)	1.00 [0.95, 1.06]	0.98 [0.93, 1.04]	0.98 [0.93, 1.04]
Median household income			
High SES tract – 4th Q (n=3,859)	1.00	1.00	1.00
3rd Q (n=1,868)	1.01 [0.98, 1.05]	1.01 [0.97, 1.05]	0.99 [0.96, 1.03]
2nd Q (n=1,159)	1.01 [0.97, 1.05]	1.00 [0.96, 1.04]	0.99 [0.95, 1.03]
Low SES tract – 1st Q (n=877)	1.01 [0.96, 1.06]	0.97 [0.93, 1.02]	0.97 [0.93, 1.02]
HAVE NO DIABETES (n=17,334)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=7,769)	1.00	1.00	1.00
3rd Q (n=6,045)	1.11 [1.07, 1.16]	1.09 [1.05, 1.13]	1.04 [1.00, 1.08]
2nd Q (n=2,043)	1.12 [1.04, 1.21]	1.09 [1.02, 1.17]	1.04 [0.98, 1.10]
Low SES tract – 1st Q (n=1,477)	1.16 [1.09, 1.24]	1.13 [1.07, 1.19]	1.03 [0.98, 1.09]
Median household income			
High SES tract – 4th Q (n=9,245)	1.00	1.00	1.00
3rd Q (n=3,989)	1.09 [1.04, 1.14]	1.05 [1.01, 1.09]	0.98 [0.98, 1.06]
2nd Q (n=2,232)	1.12 [1.07, 1.19]	1.08 [1.03, 1.13]	0.97 [0.97, 1.07]
Low SES tract – 1st Q (n=1,868)	1.09 [1.02, 1.17]	1.06 [0.99, 1.13]	1.04 [0.98, 1.06]

Table S34 (continued)

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Race			
BLACKS (n=1,130)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=245)	1.00	1.00	1.00
3rd Q (n=383)	1.06 [0.98, 1.14]	1.07 [0.99, 1.15]	1.01 [0.94, 1.07]
2nd Q (n=210)	1.01 [0.92, 1.11]	1.00 [0.90, 1.12]	0.96 [0.88, 1.06]
Low SES tract – 1st Q (n=292)	0.97 [0.89, 1.06]	0.97 [0.89, 1.06]	0.94 [0.87, 1.02]
WHITES (n=21,789)			
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=9,635)	1.00	1.00	1.00
3rd Q (n=7,915)	1.10 [1.06, 1.14]	1.07 [1.04, 1.10]	1.03 [1.00, 1.05]
2nd Q (n=2,624)	1.13 [1.07, 1.20]	1.09 [1.04, 1.14]	1.04 [0.99, 1.09]
Low SES tract – 1st Q (n=1,615)	1.12 [1.06, 1.19]	1.09 [1.04, 1.14]	1.03 [1.00, 1.08]

Table S35. Description of cohort excluded from analyses (Chapter 4)

	Cohort of excluded adults (1 outpatient clinic visit between 6/1/2017-12/31/2018 & no inpatient/outpatient creatinine & have address available) N= 104,860
Individual level characteristics	
Age, mean (SD)	40.5 ± 17.0
Male, n(%)	44,447 (43%)
Black	8,442 (8%)
Ever Smoker, n(%)	25173 (24%)
Vitals	
Systolic BP, mmHg	121.4 ± 14.0
Diastolic BP, mmHg	75.4 ± 9.8
Medical History	
Hypertension, n(%)	2793 (3%)
Diabetes, n(%)	1663 (2%)
Obese (BMI≥ 30 kg/m2), n(%)	20306 (27%)
Cardiovascular disease, n(%)	557 (0.5%)
Stroke, n(%)	211 (0.2%)
Hyperlipidemia, n(%)	3081 (3%)
Cancer, n(%)	1291 (1%)
Median value of owner occupied housing units	
Q1: < $165,200	10848 (10%)
Q2: $165,200 - $188,100	13999 (13%)
Q3: $188,100 - $231,300	31724 (30%)
Q4: ≥ $231,300	48261 (46%)
% of Residents > 25 years with complete college education	
Q1: < 20.4%	12109 (12%)
Q2: 20.4% - 34.1%	25480 (24%)
Q3: 34.1% - 48.1%	29915 (29%)
Q4: ≥ 48.1%	37337 (36%)
Median household income	
Q1: <$35,935	14,907 (14%)
Q2: $35,935 - $47,379	14,510 (14%)
Q3: $47,379 - $62,343	22,143 (21%)
Q4: ≥ $62,343	53,192 (51%)

Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

CHAPTER 5 – SYNTHESIS

This dissertation documents our efforts to understand the role of neighborhood SES on CKD using EHR data from the Fairview health services system. In the first study we observed that adding neighborhood (census tract) SES status to traditional risk factors of CKD (hypertension and/or diabetes) improved the sensitivity of detecting patients with CKD but at a cost of decreased specificity. Similarly, screening patients who live in areas with high prevalence of CKD in addition to screening patients with hypertension and/or diabetes, improves sensitivity and decreases specificity. In the second study, we found that patients from low SES tracts, Medicaid recipients (among patients <65 years) have greater prevalence rates of CKD compared to patients from high SES tracts and patients with other insurance. However, we found no association between tract racial composition (percent of blacks living in census tract) and CKD prevalence in both blacks and whites. In the last study, we found that evidence-based quality of care recommendations for CKD patients can still be improved. Among eligible patients with hypertension and CKD, 35% are not prescribed ACEi/ARB, the recommended treatment. In patients with CKD, UACR was measured in 27% of patients and only 55% of patients with CKD had it identified in their EHRs. However, low neighborhood SES (first quartile) vs. high SES (fourth quartile) was not associated with ACEi/ARB prescription compliance, UACR measurement or CKD identification in the EHR after adjusting for patient characteristics.

Significance and Implications

My thesis work offers contribution in the field of public health and clinical medicine through 1) looking at the role of neighborhood SES on all stages of CKD, expanding beyond the current literature focused on ESKD and dialysis patients, 2) leveraging EHR data to understand CKD prevalence among patients seen at the Fairview health system, and 3) the translational potential of the findings to detect potential targets to improve identifying patients with CKD and providing evidence-based care. Our analyses provided insight into the association of health disparities, at an area level, with CKD prevalence. Furthermore, unlike the extensive and well organized large national data systems for

ESKD and kidney transplants, there are fewer studies and poorer tracking of pre-ESKD, particularly for the early stages of CKD. These studies show that EHR can be leveraged to understand characteristics of patients with CKD. In accordance with the American College of Physicians and National Academy of Medicine, we strongly advocate to collect individual level SES data in the EHR and incorporate social data in clinical care.[94,141] This will allow us to understand the nuances in which SES impacts patients with CKD and identify possible ways to improve their health and prevent CKD from progressing to ESKD.

Furthermore, this study is of particular importance for Minnesota. Minnesota Department of Health (MDH) recognizes that despite the state being ranked as one of the healthiest states in the nation, Minnesota has some of the worst health disparities in the US.[142] MDH reports that significant inequities exist by race and ethnicity for certain conditions such as diabetes, smoking, and cancer.[142] These disparities are mainly driven by inequities in social and economic factors. For example, adults with lower level of educational attainment are more likely to be diagnosed with diabetes and American Indians are four times as likely to die of diabetes than white Minnesotans. The Center for Health Equity at MDH's mission is to find solutions to alleviate health disparities in MN and the results from this research can help advance their mission by addressing disparities affecting patients with CKD. This research aligns with the University of Minnesota's mission to eliminate health disparities by conducting research to determine gaps in care and further inform health care policies.

An initiative that incorporates healthcare systems that incorporates all Minnesotans would allow us to verify our findings and study a more diverse and inclusive population (including immigrants, minority groups and uninsured patients). We would be able to leverage that data to further understand the population we want to target to screen for CKD, and have a more nuanced understanding of how social factors influence CKD prevalence and progression. Furthermore, quality improvement measures for CKD

management and care could be instituted across healthcare systems, improving CKD screening and management for all.

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APPENDIX – CENSUS DATA

Below definitions of the three census variables we used for our analysis according to the American Community Survey:

Median value of owner occupied housing units (wealth): This includes only specified owner-occupied housing units: one-family houses on less than 10 acres without a business or medical office on the property. These data exclude mobile homes, houses with a business or medical office, houses on 10 or more acres, and housing units in multi-unit structures.

"Owner-Occupied - A housing unit is owner-occupied if the owner or co-owner lives in the unit, even if it is mortgaged or not fully paid for. The owner or co-owner must live in the unit and usually is Person 1 on the questionnaire. The unit is "Owned by you or someone in this household with a mortgage or loan" if it is being purchased with a mortgage or some other debt arrangement such as a deed of trust, trust deed, contract to purchase, land contract, or purchase agreement. The unit also is considered owned with a mortgage if it is built on leased land and there is a mortgage on the unit. Mobile homes occupied by owners with installment loan balances also are included in this category."

Variable name: QZ6E001 (median value [dollars])

Educational attainment for the population 25 years and over (education):
"Respondents are classified according to the highest degree or the highest level of school completed. The question included instructions for persons currently enrolled in school to report the level of the previous grade attended or the highest degree received.

Respondents who received a regular high school diploma and did not attend college were instructed to report "Regular high school diploma." Respondents who received the equivalent of a high school diploma (for example, passed the test of General Educational Development (G.E.D.)), and did not attend college, were instructed to report "GED or alternative credential." "Some college" is in two categories: "Some college credit, but less than 1 year of college credit" and "1 or more years of college credit, no degree." The category "Associate's degree" included people whose highest degree is an associate's degree, which generally requires 2 years of college level work and is either in an occupational program that prepares them for a specific occupation, or an academic program primarily in the arts and sciences. The course work may or may not be transferable to a bachelor's degree. Master's degrees include the traditional MA and MS degrees and field-specific degrees, such as MSW, MEd, MBA, MLS, and MEng. Instructions included in the respondent instruction guide for mailout/mailback respondents only provided the following examples of professional school degrees: medicine, dentistry, chiropractic, optometry, osteopathic medicine, pharmacy, podiatry, veterinary medicine, law, and theology. The order in which degrees were listed suggested

that doctorate degrees were “higher” than professional school degrees, which were “higher” than master's degrees. If more than one box was filled, the response was edited to the highest level or degree reported. The instructions further specified that schooling completed in foreign or ungraded school systems should be reported as the equivalent level of schooling in the regular American system. The instructions specified that certificates or diplomas for training in specific trades or from vocational, technical or business schools were not to be reported. Honorary degrees awarded for a respondent's accomplishments were not to be reported.”

Variable calculated as:QUSE022 (Bachelor’s degree) +QUSE023 (Master’s degree) +QUSE024 (Professional school degree) + QUSE025 (Doctorate degree)/ QUSE001 (total population number)

Median household income (income): “Income in the Past 12 Months - Income of Households: This includes the income of the householder and all other individuals 15 years old and over in the household, whether they are related to the householder or not. Because many households consist of only one person, average household income is usually less than average family income. Although the household income statistics cover the past 12 months, the characteristics of individuals and the composition of households refer to the time of interview. Thus, the income of the household does not include amounts received by individuals who were members of the household during all or part of the past 12 months if these individuals no longer resided in the household at the time of interview. Similarly, income amounts reported by individuals who did not reside in the household during the past 12 months but who were members of the household at the time of interview are included. However, the composition of most households was the same during the past 12 months as at the time of interview.

For households and families, the median income is based on the distribution of the total number of households and families including those with no income. The median income for individuals is based on individuals 15 years old and over with income. Median income for households, families, and individuals is computed on the basis of a standard distribution.”

Variable name: QU1E001 (median household income in the past 12 months [in 2012 inflation-adjusted dollars)

- We used the distribution of these variables in the 7 county metro area to create quartiles for wealth, education and income.

Percent blacks in census tracts:
Variable calculated as: QSQE003 (Black or African American Alone or in Combination with One or More Other Races) /QSQE001 (total population number)

Source: https://www2.census.gov/programs-surveys/acs/tech_docs/subject_definitions/2012_ACSSubjectDefinitions.pdf

Summary data:

Median value of owner occupied housing units 2008-2012 ACS:
In the US: $181,400
In Minnesota: $194,300
In Wisconsin: $169,000
In Alabama: $122,300

In our analyses- 7 county Minneapolis/St Paul area [data from 2008-2012 American Community Survey]:
Quartile 1: <$165,200; Quartile 2: $165,200 - $188,100; Quartile 3: $188,100 – $231,300; and Quartile 4: ≥$231,300

Percent of people >25 years with Bachelor's degree or high 2008-2012 ACS:
In the US: 28.5%
In Minnesota: 32.2%
In Wisconsin: 26.4%
In Alabama: 22.3%

In our analyses- 7 county Minneapolis/St Paul area [data from 2008-2012 American Community Survey]:
Quartile 1: <20.4%; Quartile 2: 20.4% - 34.1%; Quartile 3: 34.1% - 48.1%; and Quartile 4: ≥48.1%

Median household income (in 2012 dollars) 2008-2012 ACS:
In the US: $53,046
In Minnesota: $59,126
In Wisconsin: $52,627
In Alabama: $43,160

In our analyses- 7 county Minneapolis/St Paul area [data from 2008-2012 American Community Survey]:
Quartile 1: <$35,935; Quartile 2: $35,935 - $47,379; Quartile 3: $47,379 - $62,343; and Quartile 4: ≥$62,434

Census data from: https://www.census.gov/quickfacts/fact/table/US/PST045219

APPENDIX – ICD CODES

ICD9- ICD10 codes for each diagnosis

Cancer

Breast Cancer

174.0, 174.1, 174.2, 174.3, 174.4, 174.5, 174.6, 174.8, 174.9, 175.0, 175.9, 233.0, V10.3 C50.011, C50.012, C50.019, C50.021, C50.022, C50.029, C50.111, C50.112, C50.119, C50.121, C50.122, C50.129, C50.211, C50.212, C50.219, C50.221, C50.222, C50.229, C50.311, C50.312, C50.319, C50.321, C50.322, C50.329, C50.411, C50.412, C50.419, C40.421, C50.422, C50.429, C50.511, C50.512, C50.519, C50.521, C50.522, C50.529, C50.611, C50.612, C50.619, C50.621, C50.622, C50.629, C50.811, C50.812, C50.819, C50.821, C50.822, C50.829, C50.911, C50.912, C50.919, C50.921, C50.922, C50.929, D05.00, D05.01, D05.02, D05.10, D05.11, D05.12, D05.80, D05.81, D05.82, D05.90, D05.91, D05.92, Z85.3

Colorectal Cancer

153.0, 153.1, 153.2, 153.3, 153.4, 153.5, 153.6, 153.7, 153.8, 153.9,154.0,154.1, 230.3, 230.4, V10.05, V10.06, C18.0, C18.1, C18.2, C18.3, C18.4, C18.5, C18.6, C18.7, C18.8, C18.9, C19, C20, D01.0, D01.1, D01.2, Z85.038, Z85.048

Endometrial Cancer

182.0, 233.2, V10.42, C54.1, C54.2, C54.3, C54.9, D07.0, Z85.42

Leukemia or Lymphoma

200.0, 200.00, 200.01, 200.02, 200.03, 200.04, 200.05, 200.06, 200.07, 200.08, 200.1, 200.10, 200.11, 200.12, 200.13, 200.14, 200.15, 200.16, 200.17, 200.18, 200.2, 200.20, 200.21, 200.22, 200.23, 200.24, 200.25, 200.26, 200.27, 200.28, 200.3, 200.30, 200.31, 200.32, 200.33, 200.34, 200.35, 200.36, 200.37, 200.38, 200.4, 200.40, 200.41, 200.42, 200.43, 200.44, 200.45, 200.46, 200.47, 200.48, 200.5, 200.50, 200.51, 200.52, 200.53, 200.54, 200.55, 200.56, 200.57, 200.58, 200.6, 200.60, 200.61, 200.62, 200.63, 200.64, 200.65, 200.66, 200.67, 200.68, 200.7, 200.70, 200.71, 200.72, 200.73, 200.74, 200.75, 200.76, 200.77, 200.78, 200.8, 200.80, 200.81, 200.82, 200.83, 200.84, 200.85, 200.86, 200.87, 200.88, 201.0, 201.00, 201.01, 201.02, 201.03, 201.04, 201.05, 201.06, 201.07, 201.08, 201.1, 201.10, 201.11, 201.12, 201.13, 201.14, 201.15, 201.16, 201.17, 201.18, 201.2, 201.20, 201.21, 201.22, 201.23, 201.24, 201.25, 201.26, 201.27, 201.28, 201.4, 201.40, 201.41, 201.42, 201.43, 201.44, 201.45, 201.46, 201.47, 201.48, 201.5, 201.50, 201.51, 201.52, 201.53, 201.54, 201.55, 201.56, 201.57, 201.58, 201.6, 201.60, 201.61, 201.62, 201.63, 201.64, 201.65, 201.66, 201.67, 201.68, 201.7, 201.70, 201.71, 201.72, 201.73, 201.74, 201.75, 201.76, 201.77, 201.78, 201.9, 201.90, 201.91, 201.92, 201.93, 201.94, 201.95, 201.96, 201.97, 201.98, 202.0, 202.00, 202.01, 202.02, 202.03, 202.04, 202.05, 202.06, 202.07, 202.08, 202.1, 202.10, 202.11, 202.12, 202.13, 202.14, 202.15, 202.16, 202.17, 202.18, 202.2, 202.20, 202.21, 202.22, 202.23, 202.24, 202.25, 202.26, 202.27, 202.28, 202.4, 202.40, 202.41, 202.42, 202.43, 202.44, 202.45, 202.46, 202.47,

202.48, 202.7, 202.70, 202.71, 202.72, 202.73, 202.74, 202.75, 202.76, 202.77, 202.78, 202.8, 202.80, 202.81, 202.82, 202.83, 202.84, 202.85, 202.86, 202.87, 202.88, 202.9, 202.90, 202.91, 202.92, 202.93, 202.94, 202.95, 202.96, 202.97, 202.98, 203.1, 203.10, 203.11, 203.12, 204.0, 204.00, 204.01, 204.02, 204.1, 204.10, 204.11, 204.12, 204.2, 204.20, 204.21, 204.22, 204.8, 204.80, 204.81, 204.82, 204.9, 204.90, 204.91, 204.92, 205.0, 205.00, 205.01, 205.02, 205.1, 205.10, 205.11, 205.12, 205.2, 205.20, 205.21, 205.22, 205.3, 205.30, 205.31, 205.32, 205.8, 205.80, 205.81, 205.82, 205.9, 205.90, 205.91, 205.92, 206.0, 206.00, 206.01, 206.02, 206.1, 206.10, 206.11, 206.12, 206.2, 206.20, 206.21, 206.22, 206.2, 206.20, 206.21, 206.22, 206.8, 206.80, 206.81, 206.82, 206.9, 206.90, 206.91, 206.92, 207.0, 207.00, 207.01, 207.02, 207.1, 207.10, 207.11, 207.12, 207.2, 207.20, 207.21, 207.22, 207.8, 207.80, 207.81, 207.82, 208.0, 208.00, 208.01, 208.02, 208.1, 208.10, 208.11, 208.12, 208.2, 208.20, 208.21, 208.22, 208.8, 208.80, 208.81, 208.82, 208.9, 208.90, 208.91, 208.92, V10.6, V10.60, V10.61, V10.62, V 10.63, V10.69, V10.7, V10.71, V10.72, V10.79, C81.00, C81.01, C81.02, C81.03, C81.04, C81.05, C81.06, C81.07, C81.08, C81.09, C81.10, C81.11, C81.12, C81.13, C81.14, C81.15, C81.16, C81.17, C81.18, C81.19, C81.20, C81.21, C81.22, C82.23, C81.24, C81.25, C81.26, C81.27, C81.28, C81.29, C81.30, C81.31, C81.32, C82.33, C81.34, C81.35, C81.36, C81.37, C81.38, C81.39, C81.40, C81.41, C81.42, C82.43, C81.44, C81.45, C81.46, C81.47, C81.48, C81.49, C81.70, C81.71, C81.72, C82.73, C81.74, C81.75, C81.76, C81.77, C81.78, C81.79, C81.90, C81.91, C81.92, C82.93, C81.94, C81.95, C81.96, C81.97, C81.98, C81.99, C82.00, C82.01, C82.02, C82.03, C82.04, C82.05, C82.06, C82.07, C82.08, C82.09, C82.10, C82.11, C82.12, C82.13, C82.14, C82.15, C82.16, C82.17, C82.18, C82.19, C82.20, C82.21, C82.22, C82.23, C82.24, C82.25, C82.26, C82.27, C82.28, C82.29, C82.30, C82.31, C82.32, C82.33, C82.34, C82.35, C82.36, C82.37, C82.38, C82.39, C82.40, C82.41, C82.42, C82.43, C82.44, C82.45, C82.46, C82.47, C82.48, C82.49, C82.50, C82.51, C82.52, C82.53, C82.54, C82.55, C82.56, C82.57, C82.58, C82.59, C82.60, C82.61, C82.62, C82.63, C82.64, C82.65, C82.66, C82.67, C82.68, C82.69, C82.80, C82.81, C82.82, C82.83, C82.84, C82.85, C82.86, C82.87, C82.88, C82.89, C82.90, C82.91, C82.92, C82.93, C82.94, C82.95, C82.96, C82.97, C82.98, C82.99, C83.00, C83.01, C83.02, C83.03, C83.04, C83.05, C83.06, C83.07, C83.08, C83.09, C83.10, C83.11, C83.12, C83.13, C83.14, C83.15, C83.16, C83.17, C83.18, C83.19, C83.30, C83.31, C83.32, C83.33, C83.34, C83.35, C83.36, C83.37, C83.38, C83.39, C83.50, C83.51, C83.52, C83.53, C83.54, C83.55, C83.56, C83.57, C83.58, C83.59, C83.70, C83.71, C83.72, C83.73, C83.74, C83.75, C83.76, C83.77, C83.78, C83.79, C83.80, C83.81, C83.82, C83.83, C83.84, C83.85, C83.86, C83.87, C83.88, C83.89, C83.90, C83.91, C83.92, C83.93, C83.94, C83.95, C83.96, C83.97 C83.98, C83.99, C84.00, C84.01, C84.02, C84.03, C84.04, C84.05, C84.06, C84.07, C84.08, C84.09, C84.10, C84.11, C84.12, C84.13, C84.14, C84.15, C84.16, C84.17, C84.18, C84.19, C84.40, C84.41, C84.42, C84.43, C84.44, C84.45, C84.46, C84.47, C84.48, C84.49, C84.60, C84.61, C84.62, C84.63, C84.64, C84.65, C84.66, C84.67, C84.68, C84.69, C84.70, C84.71, C84.72, C84.73, C84.74, C84.75, C84.76, C84.77, C84.78, C84.79, C84.90, C84.91, C84.92, C84.93, C84.94, C84.95, C84.96, C84.97, C84.98, C84.99, C84.A0, C84.A1, C84.A2, C84.A3, C84.A4, C84.A5, C84.A6, C84.A7, C84.A8, C84.A9, C84.Z0, C84.Z1, C84.Z2, C84.Z3,

C84.Z4, C84.Z5, C84.Z6, C84.Z7, C84.Z8, C84.Z9, C85.10, C85.11, C85.12, C85.13, C85.14, C85.15, C85.16, C85.17, C85.18, C85.19, C85.20, C85.21, C85.22, C85.23, C85.24, C85.25, C85.26, C85.27, C85.28, C85.29, C85.80, C85.81, C85.82, C85.83, C85.84, C85.85, C85.86, C85.87, C85.88, C85.89, C85.90, C85.91, C85.92, C85.93, C85.94, C85.95, C85.96, C85.97, C85.98, C85.99, C86.0, C86.1, C86.2, C86.3, C86.4, C86.5, C86.6, C88.4, C90.10, C90.11, C90.12, C91.00, C91.01, C91.02, C91.10, C91.11, C91.12, C91.30, C91.31, C91.32, C91.40, C91.41, C91.42, C91.50, C91.51, C91.52, C91.60, C91.61, C91.62, C91.A0, C91.A1, C91.A2, C91.Z0, C91.Z1, C91.Z2, C91.90, C91.91, C91.92, C92.00, C92.01, C92.02, C92.10, C92.11, C92.12, C92.20, C92.21, C92.22, C92.30, C92.31, C92.32, C92.40, C92.41, C92.42, C92.50, C92.51, C92.52, C92.60, C92.61, C92.62, C92.90, C92.91, C92.92, C92.A0, C92.A1, C92.A2, C92.Z0, C92.Z1, C92.Z2, C93.00, C93.01, C93.02, C93.10, C93.11, C93.12, C93.30, C93.31, C93.32, C93.Z0, C93.Z1, C93.Z2, C93.90, C93.91, C93.92, C94.00, C94.01, C94.02, C94.20, C94.21, C94.22, C94.30, C94.31, C94.32, C94.80, C94.81, C94.82, C95.00, C95.01, C95.02, C95.10, C95.11, C95.12, C95.90, C95.91, C95.92, C96.4, C96.9, C96.Z, D45, Z85.6, Z85.71, Z85.72, Z85.79

Lung Cancer
162.2, 162.3, 162.4, 162.5, 162.8, 162.9, 231.2, V10.11, C34.00, C34.01, C34.02, C34.10, C34.11, C34.12, C34.2, C34.30, C34.31, C34.32, C34.80, C34.81, C34.82, C34.90, C34.91, C34.92, D02.20, D02.21, D02.22, Z85.118

Prostate Cancer
185, 233.4, V10.46, C61, D07.5, Z85.46

Cardiovascular disease
Acute Myocardial Infarction
410.01, 410.11, 410.21, 410.31, 410.41, 410.51, 410.61, 410.71, 410.81, 410.91, I21.01, I21.02, I21.09, I21.11, I21.19, I21.21, I21.29, I21.3, I21.4, I22.0, I22.1, I22.2, I22.8, I22.9

Heart Failure
398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.20, 428.21, 428.22, 428.23, 428.30, 428.31, 428.32, 428.33, 428.40, 428.41, 428.42, 428.43, 428.9, I09.81, I11.0, I13.0, I13.2, I50.1, I50.20, I50.21, I50.22, I50.23, I50.30, I50.31, I50.32, I50.33, I50.40. I50.41, I50.42, I50.43, I50.9

Ischemic Heart Disease
410.00, 410.01, 410.02, 410.10, 410.11, 410.12, 410.20, 410.21, 410.22, 410.30, 410.31, 410.32, 410.40, 410.41, 410.42, 410.50, 410.51, 410.52, 410.60, 410.61, 410.62, 410.70, 410.71, 410.72, 410.80, 410.81, 410.82, 410.90, 410.91, 410.92, 411.0, 411.1, 411.81, 411.89, 412, 413.0, 413.1, 413.9, 414.00, 414.01, 414.02, 414.03, 414.04, 414.05, 414.06, 414.07, 414.12, 414.2, 414.3, 414.4, 414.8, 414.9, I20.0, I20.1, I20.8, I20.9, I21.01, I21.02, I21.09, I21.11, I21.19, I21.21, I21.29, I21.3, I21.4, I22.0, I22.1, I22.2, I22.8,

I22.9, I24.0, I24.1, I24.8, I24.9, I25.10, I25.110, I25.111, I25.118, I25.119, I25.2, I25.42, I25.5, I25.6, I25.700, I25.701, I25.708, I25.709, I25.710, I25.711, I25.718, I25.719, I25.720, I25.721, I25.728, I25.729, I25.730, I25.731, I25.738, I25.739, I25.750, I25.751, I25.758, I25.759, I25.760, I26.761, I25.768, I25.769, I25.790, I25.791, I25.798, I25.799, I25.810, I25.811, I25.812, I25.82, I25.83, I25.84, I25.89, I25.9

Peripheral Vascular Disease
440.0, 440.1, 440.2, 440.20, 440.21, 440.22, 440.23, 440.29, 440.4, 443.8, 443.81, 443.82, 443.89, 443.9, E08.51, E08.52, E09.51, E09.52, E10.51, E10.52, E11.51, E11.52, E13.51, E13.52, I70.0, I70.1, I70.201, I70.202, I70.203, I70.208, I70.209, I70.211, I70.212, I70.213, I70.218, I70.219, I70.221, I70.222, I70.223, I70.228, I70.229, I70.231, I70.232, I70.233, I70.234, I70.235, I70.238, I70.239, I70.241, I70.242, I70.243, I70.244, I70.245, I70.248, I70.249, I70.25, I70.291, I70.292, I70.293, I70.298, I70.299, I70.92, I73.81, I73.89, I73.9, I79.1, I79.8

Stroke or Transient Ischemic Attack
430, 431, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.00, 434.01, 434.10, 434.11, 434.90, 434.91, 435.0, 435.1, 435.3, 435.8, 435.9, 436, 997.02, G45.0, G45.1, G45.2, G45.8, G45.9, G46.0, G46.1, G46.2, G97.31, G97.32, I60.00, I60.01, I60.02, I60.10, I60.11, I60.12, I60.20, I60.21, I60.22, I60.30, I60.31, I60.32, I60.4, I60.50, I60.51, I60.52, I60.6, I60.7, I60.8, I60.9, I61.0, I61.1, I61.2, I61.3, I61.4, I61.5, I61.6, I61.8, I61.9, I63.00, I63.02, I63.011, I63.012, I63.019, I63.031, I63.032, I63.039, I63.09, I63.10, I63.111, I63.112, I63.119, I63.12, I63.131, I63.132, I63.139, I63.19, I63.20, I63.211, I63.212, I63.219, I63.22, I63.231, I63.232, I63.239, I63.29, I63.30, I63.311, I63.312, I63.319, I63.321, I63.322, I63.329, I63.331, I63.332, I63.339, I63.341, I63.342, I63.349, I63.39, I63.40, I63.411, I63.412, I63.419, I63.421, I63.422, I63.429, I63.431, I63.432, I63.439, I63.441, I63.442, I63.449, I63.49, I63.50, I63.511, I63.512, I63.519, I63.521, I63.522, I63.529, I63.531, I63.532, I63.539, I63.541, I63.542, I63.549, I63.59, I63.6, I63.8, I63.9, I66.01, I66.02, I66.03, I66.09, I66.11, I66.12, I66.13, I66.19, I66.21, I66.22, I66.23, I66.29, I66.3, I66.8, I66.9, I67.841, I67.848, I67.89, I97.810, I97.811, I97.820, I97.821

Diabetes Mellitus
249.00, 249.01, 249.10, 249.11, 249.20, 249.21, 249.30, 249.31, 249.40, 249.41, 249.50, 249.51, 249.60, 249.61, 249.70, 249.71, 249.80, 249.81, 249.90, 249.91, 250.00, 250.01, 250.02, 250.03, 250.10, 250.11, 250.12, 250.13, 250.20, 250.21, 250.22, 250.23, 250.30, 250.31, 250.32, 250.33, 250.40, 250.41, 250.42, 250.43, 250.50, 250.51, 250.52, 250.53, 250.60, 250.61, 250.62, 250.63, 250.70, 250.71, 250.72, 250.73, 250.80, 250.81, 250.82, 250.83, 250.90, 250.91, 250.92, 250.93, 357.2, 362.01, 362.02, 362.03, 362.04, 362.05, 362.06, 366.41, E08.00, E08.01, E08.10, E08.11, E08.21, E08.22, E08.29, E08.311, E08.319, E08.321, E08.329, E08.331, E08.339, E08.341, E08.349, E08.351, E08.359, E08.36, E08.39, E08.40, E08.41, E08.42, E08.43, E08.44, E08.49, E08.51, E08.52, E08.59, E08.610, E08.618, E08.620, E08.621, E08.622, E08.628, E08.630, E08.638, E08.641, E08.649, E08.65, E08.69, E08.8, E08.9, E09.00, E09.01, E09.10, E09.11,

E09.21, E09.22, E09.29, E09.311, E09.319, E09.321, E09.329, E09.331, E09.339, E09.341, E09.349, E09.351, E09.359, E09.36, E09.39, E09.40, E09.41, E09.42, E09.43, E09.44, E09.49, E09.51, E09.52, E09.59, E09.610, E09.618, E09.620, E09.621, E09.622, E09.628, E09.630, E09.638, E09.641, E09.649, E09.65, E09.69, E09.8, E09.9, E10.10, E10.11, E10.21, E10.22, E10.29, E10.311, E10.319, E10.321, E10.329, E10.331, E10.339, E10.341, E10.349, E10.351, E10.359, E10.36, E10.39, E10.40, E10.41, E10.42, E10.43, E10.44, E10.49, E10.51, E10.52, E10.59, E10.610, E10.618, E10.620, E10.621, E10.622, E10.628, E10.630, E10.638, E10.641, E10.649, E10.65, E10.69, E10.8, E10.9, E11.00, E11.01, E11.21, E11.22, E11.29, E11.311, E11.319, E11.321, E11.329, E11.331, E11.339, E11.341, E11.349, E11.351, E11.359, E11.36, E11.39, E11.40, E11.41, E11.42, E11.43, E11.44, E11.49, E11.51, E11.52, E11.59, E11.610, E11.618, E11.620, E11.621, E11.622, E11.628, E11.630, E11.638, E11.641, E11.649, E11.65, E11.69, E11.8, E11.9, E13.00, E13.01, E13.10, E13.11, E13.21, E13.22, E13.29, E13.311, E13.319, E13.321, E13.329, E13.331, E13.339, E13.341, E13.349, E13.351, E13.359, E13.36, E13.39, E13.40, E13.41, E13.42, E13.43, E13.44, E13.49, E13.51, E13.52, E13.59, E13.610, E13.618, E13.620, E13.621, E13.622, E13.628, E13.630, E13.638, E13.641, E13.649, E13.65, E13.69, E13.8, E13.9

Hypertension
362.11, 401.0, 401.1, 401.9, 402.00, 402.01, 402.10, 402.11, 402.90, 402.91, 403.00, 403.01, 403.10, 403.11, 403.90, 403.91, 404.00, 404.01, 404.02, 404.03, 404.10, 404.11, 404.12,
404.13, 404.90, 404.91, 404.92, 404.93, 405.01, 405.09, 405.11, 405.19, 405.91, 405.99, 437.2
H35.031, H35.032, H35.033, H35.039, I10, I11.0, I11.9, I12.0, I12.9, I13.0, I13.10, I13.11, I13.2, I15.0, I15.1, I15.2, I15.8, I15.9, I67.4, N26.2

Hyperlipidemia
272.0, 272.1, 272.3, 272.4, 272.5, 272.6, 272.7, 272.8, 272.9, 277.7, 759.89, E75.21, E75.22, E77.0, E77.1, E78.0, E78.1, E78.2, E78.3, E78.4, E78.5, E78.6, E78.7, E78.81, E78.89, E78.9, E88.1, E88.81

Hyperkalemia
276.7, E87.5

Pregnancy
V22.0, V23.81, V23.82, V23.86, V23.89, V22.1, Z34.90, Z34.91, Z34.92, Z34.93, Z34.01, Z34.02, Z34.03, Z36, Z34.00, O09.511, O09.512, O09.512, O09.521, O09.522, O09.523, O09.529, O09.811, O09.812, O09.813, O09.819, O09.892, O09.893, O09.899

Allergy to angiotensin converting enzyme inhibitor or angiotensin receptor blocker
995.3, T46.4X5A, T46.4X5S, T46.4X6D

Chronic Kidney Disease
585.1, 585.2, 585.2, 585.3, 585.4, 585.5, 585.9, 285.21, 403.10, 403.00, 403.11, 403.91, 404.01, 404.12, 404.92, 404.93,N18.1, N18.2, N18.3, N18.4M N18.5, N18.9, E08.22, E09.22, E10.22, E11.22, E13.22, I12.0, I12.9, I13.0, I13.2

End Stage Kidney Disease
585.6, N18.6

Dialysis
90918, 90919, 90920, 90921, 90925, 90935, 90937, 90945, 90947, 90951, 90952, 90953, 90954, 90955, 90956, 90957, 90958, 90959, 90960, 90961, 90962, 90963, 90964, 90965, 90966, 90967, 90968, 90969, 90970, 90989, 90993, 90999, 99512, 38.95, 39.95, 54.98, 585.6
G0257, G0308, G0309, G0310, G0310, G0311, G0312, G0323, G0314, G0315, G0316, G0317, G0318, G0319, G0320, G0321, G0322, G0323, G0324, G0325, G0326, G0327, V45.11, V45.12, V56.0, V56.31, V56.32, V56.8, N18.6, Z49, Z91.15, Z99.2

Transplant
50340, 50360, 50365, 50380, 55.53, 55.69, 996.81, 00.91, 00.93, V42.0, Z94.0, T86.10, T86.13, T86.11, T86.19, T86.12, Z48.22

APPENDIX – CHAPTER 2

NOTES ON DATA ANALYSIS:

- 2-4% of all Fairview patients opt out of research

- 1% of all Fairview patients have no geocoded address

- I adjudicated 50 patient charts:
  1) I randomly selected 50 patients from my original cohort.
  2) For these patients, I used their electronic health records and manually extracted all information that I used for my analyses.
  3) I compared the information manually collected to the information I obtained from the data shelter (i.e. the data that I received from the academic health center that I used to code patients' demographic and clinical characteristics)
  4) Information obtained from the data shelter matched that manually abstracted

- There are 676 tracts included. There are 704 tracts in 7-county metro area. This is a good representation. (Coverage = 96%)
  I have a minimum of 5 patients in 1 tract. 2 tracts have less than 20 patients (total number of patients = 18)
  Maximum number of patients per tract is 2544
  For approach 4, we include 406 tracts in the 7 county metro area.

- Defining race:
  We used electronic health record data. Race data is usually inputted at first visit to Fairview clinic by an administrator or nurse after asking the patient. A patients' race was considered black if at any time patient has identified as belonging to black race; of the remaining participants we identified sequentially "Asian", "American Indian or Alaska Native or Native Hawaiian or other", "white", and missing/not recorded race.

  For our analysis: 20,651 (8%) were black; 172,290 (67%) were white; 13,141 (5%) were Asian; 1,733 (0.7%) were American Indian or Alaska Native or Native Hawaiian or other Pacific Islander ; 26 (0.01%) were other race; and 23,771 (9%) had race as a missing variable. We only stratified by white and black race (the two most common races included). We did not impute missing race. We considered it missing at random.

  Please note, for eGFR calculation using CKD-EPI, if race was not documented as black in the EHR, we considered it as other

Table 1. Characteristics of patients with and without chronic kidney disease

	Have CKD n= 34,437 (13%)	**No CKD** n= 221,725 (87%)	**p-value**
Individual level characteristics			
Age, mean (SD)	65 ± 17	47 ± 16	<0.001
Black, n(%)	1,834 (5%)	20,677 (9%)	<0.001
Male, n(%)	13,411 (39%)	105,483 (48%)	<0.001
Ever smoker, n(%)	13,609 (40%)	81,577 (37%)	0.304
Baseline characteristics			
Systolic BP, mmHg	127 ± 19	123 ± 17	<0.001
Diastolic BP, mmHg	74 ± 12	76 ± 11	<0.001
Medical history			
Hypertension , n(%)	18,656 (54%)	53,088 (24%)	<0.001
Diabetes, n(%)	7,400 (22%)	17,373 (8%)	<0.001
Obesity (BMI ≥ 30 kg/m2), n(%)	9,467 (40%)	63,895 (35%)	<0.001
Cardiovascular Disease, n(%)	5,984 (17%)	8,720 (4%)	<0.001
Stroke, n(%)	1,421 (4%)	2,312 (1%)	<0.001
Hyperlipidemia, n(%)	13,896 (40%)	46,895 (21%)	<0.001
Cancer, n(%)	2,137 (6%)	6,067 (3%)	<0.001

CKD: chronic kidney disease, BP: blood pressure, BMI: body mass index; Cardiovascular disease includes: congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 2. Characteristics of patients with CKD and with no CKD among those to be screened using Approach 1 (standard screening approach)*

Approach 1 (n=81,497 have history of hypertension and/or diabetes)			
	Have CKD n= 20,636 (25%)	**No CKD** n= 60,861 (75%)	**p-value**
Individual level characteristics			
Age, mean (SD)	69 ± 15	57 ± 15	<0.001
Black, n(%)	1,134 (6%)	5,536 (9%)	<0.001
Male, n(%)	8,576 (42%)	32,104 (53%)	0.038
Ever smoker, n(%)	9,145 (44%)	27,479 (45%)	<0.001
Baseline characteristics			
Systolic BP, mmHg	130 ± 20	132 ± 19	<0.001
Diastolic BP, mmHg	74 ± 13	79 ± 12	<0.001
Medical history			
Hypertension, n(%)	18,656 (90%)	53,088 (87%)	<0.001
Diabetes, n(%)	7,400 (36%)	17,373 (29%)	<0.001
Obesity (BMI ≥ 30 kg/m_2), n(%)	6,525 (44%)	23,901 (50%)	<0.001
Cardiovascular Disease, n(%)	5,094 (25%)	6,337 (10%)	<0.001
Stroke, n(%)	1,235 (6%)	1,689 (3%)	<0.001
Hyperlipidemia, n(%)	11,412 (5%)	28,027 (46%)	<0.001
Cancer, n(%)	1,538 (7%)	2,603 (4%)	0.282

CKD: chronic kidney disease, BP: blood pressure, BMI: body mass index; Cardiovascular disease includes: congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

*Approach1 (standard screening approach): to screen patients who have history of hypertension and/or diabetes

Table 3. Characteristics of patients with CKD and with no CKD among those to be screened using Approach 2 (hypertension and/or diabetes and/or low census tract socioeconomic status-wealth) and Approach 7 (low census tract socioeconomic status – wealth)*

	Approach 2A			Approach 7A		
	Have CKD n= 22,078 (22%)	**No CKD** n= 76,621 (78%)	**p-value**	**Have CKD** n= 3,526 (14%)	**No CKD** n= 21,699 (86%)	**p-value**
Individual level characteristics						
Age, mean (SD)	68 ± 15	54 ± 16	<0.001	64 ± 18	46 ± 17	<0.001
Black, n(%)	1,291(6%)	8,761 (11%)	<0.001	427 (12%)	4,583 (21%)	<0.001
Male, n(%)	9,059 (41%)	39,377 (51%)	<0.001	1,298 (37%)	10,161 (47%)	<0.001
Smoker, n(%)	9,586 (43%)	33,025 (43%)	0.406	1,300 (37%)	8,287 (38%)	0.139
Baseline characteristics						
Systolic BP, mmHg	130 ± 20	130 ± 19	0.628	130 ± 22	125 ± 18	<0.001
Diastolic BP, mmHg	74 ± 13	79 ± 12	<0.001	76 ± 14	77 ± 12	<0.001
Medical History						
Hypertension, n(%)	18,656 (85%)	53,088 (69%)	<0.001	1,801 (51%)	4,871 (22%)	<0.001
Diabetes, n(%)	7,400 (34%)	17,373 (23%)	<0.001	859 (24%)	2,096 (10%)	<0.001
Obesity (BMI ≥ 30 kg/m2), n(%)	6,823 (44%)	27,968 (47%)	0.001	951 (43%)	6,395 (38%)	<0.001
Cardiovascular disease, n(%)	5,188 (24%)	6,544 (9%)	<0.001	541 (15%)	799 (4%)	<0.001
Stroke, n(%)	1,252 (6%)	1,737 (2%)	<0.001	123 (4%)	177 (0.8%)	<0.001
Hyperlipidemia, n(%)	11,590 (52%)	29,152 (38%)	<0.001	1,141 (32%)	3,322 (15%)	<0.001
Cancer, n(%)	1,579 (7%)	2,831 (4%)	0.17	162 (5%)	427 (2%)	0.01

CKD: chronic kidney disease, BP: blood pressure, BMI: body mass index; Cardiovascular disease includes: congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

*Approach2A: to screen patients who have a history of hypertension and/or diabetes plus live in census tracts where median value of owner occupied housing units is in the first quartile *Approach 7A: to screen patients who live in census tracts where median value of owner occupied housing units is in the first quartile

Table 4. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD (**CKD defined as: index eGFR< 45ml/min/1.73m$_2$ (i.e stage 3A, 3B and 4) or UACR > 300mg/g or UPCR > 500mg/g or UA≥100 mg/g within 18 months from PCP visit**)

	All patients (n= 256,162; 10,800 have CKD)					
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or low census tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low census tract SES, education)**	**Approach 2C (HTN and/or DM and/or low census tract SES, income)**	**Approach 3 (HTN and/or DM, and/or 1 of 3 low census tract SES variables, 1st Q)**	**Approach 4 (HTN and/or DM, and/or 1 of 3 low census tract SES variables, median)**
Number screened	81,497	98,699	99,933	102,171	124,371	174,006
CKD detected	7,441	7,851	7,925	7,831	8,368	9,437
Sensitivity	69 [68.0, 69.8]	73 [71.9, 73.5]	74 [72.5, 74.2]	73 [71.7, 73.4]	77 [76.7, 78.2]	87 [86.7, 88.0]
Specificity	70 [69.6, 69.9]	63 [62.8, 63.2]	62 [62.3, 62.4]	62 [61.3, 61.7]	53 [52.5, 52.9]	33 [32.7, 33.1]
PPV	9 [8.9, 9.3]	8 [7.8, 8.1]	8 [7.8, 8.1]	8 [7.5, 7.8]	7 [6.6, 6.9]	5 [5.3, 5.5]
NPV	98 [98.0, 98.1]	98 [98.1, 98.2]	98 [98.1, 98.2]	98 [98.0, 98.1]	98 [98.1, 98.2]	98 [98.3, 98.4]
Number needed to screen	11	13	13	13	15	18

PCP: primary care physician visit; CKD: chronic kidney disease; eGFR: estimated glomerular filtration rate; UACR: urine albumin to creatinine ratio; UPCR: urine protein to creatinine ratio; UA: urinalysis; HTN: hypertension; DM: diabetes; SES: socioeconomic status; PPV: positive predictive values, NPV: negative predictive values; 1st Q: first quartile

*Unable to assess Approach 5 as there are no tracts with CKD prevalence ≥14.8% using this restrictive definition of CKD

Table 5. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD **where time between PCP and index creatinine is 12 months rather than 18 months**

	All patients (n= 231,612; 31,908 have CKD)						**Tracts with >200 patients** (n= 199,134; 27,717 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or low census tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low census tract SES, education)**	**Approach 2C (HTN and/or DM and/or low census tract SES, income)**	**Approach 3 (HTN, DM, or 1 of 3 low census tract SES variables, 1st Q)**	**Approach 4 (HTN, DM, or 1 of 3 low census tract SES variables, median)**	**Approach 1 (HTN or DM)**	**Approach 5 (HTN, DM, or census tract prevalence of CKD)**
Number screened	75,497	91,198	92,162	75,497	114,029	158,501	65,564	109,621
CKD detected	19,446	20,780	20,984	19,446	22,674	26,340	17,062	21,446
Sensitivity	61 [60.4, 61.5]	65 [64.6, 65.6]	66 [65.2, 66.3]	61 [60.4, 61.5]	71 [70.6, 71.6]	83 [82.1, 82.9]	62 [60.9, 62.1]	77 [76.8, 77.9]
Specificity	72 [71.7, 72.1]	65 [64.5, 64.9]	64 [64.1, 64.5]	72 [71.7, 72.1]	54 [54.0, 54.4]	34 [33.6, 34.0]	72 [71.5, 71.9]	49 [48.3, 48.8]
PPV	26 [25.4, 26.1]	23 [22.5, 23.1]	23 [22.4, 23.0]	26 [25.4, 26.0]	20 [19.7, 20.1]	17 [16.4, 16.8]	26 [25.7, 26.4]	20 [19.4, 19.8]
NPV	912 [91.9, 92.2]	92 [91.9, 92.2]	92 [92.0, 92.3]	92 [91.9, 92.2]	92 [91.9, 92.3]	92 [92.2, 92.6]	92 [91.9, 92.1]	93 [92.8, 93.2]
Number needed to screen	4	4	4	4	5	6	4	5

CKD: chronic kidney disease; PCP: primary care physician; HTN: hypertension; DM: diabetes; SES: socioeconomic status; 1st Q: first quartile; PPV: positive predictive values, NPV: negative predictive values.

Table 6. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD **where time between PCP and index creatinine is 24 months rather than 18 months**

	All patients (n= 275,183; 35,841 have CKD)						**Tracts with >200 patients** (n= 242,588; 32,310 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or low census tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low census tract SES, education)**	**Approach 2C (HTN and/or DM and/or low census tract SES, income)**	**Approach 3 (HTN and/or DM, and/or 1 of 3 low census tract SES variables, 1st Q)**	**Approach 4 (HTN and/or DM, and/or 1 of 3 low census tract SES variables, median)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM, and/or census tract prevalence of CKD)**
Number screened	84,210	102,553	103,981	106,431	130,214	175,113	75,718	98,317
CKD detected	21,120	22,619	22,872	22,814	24,858	28,619	19,175	23,54
Sensitivity	59 [58.4, 59.4]	63 [62.6, 63.6]	64 [63.3, 64.3]	64 [63.1, 64.2]	69 [68.9, 69.8]	80 [79.4, 80.3]	60 [58.8, 59.9]	73 [72.5, 73.4]
Specificity	73 [73.1, 73.4]	66 [65.9, 66.2]	66 [65.3, 65.8]	65 [64.3, 64.7]	55 [55.1, 55.5]	38 [37.6, 38.0]	97 [96.5, 96.6]	54 [54.2, 54.6]
PPV	25 [24.8, 25.4]	22 [21.8, 22.3]	22 [21.7, 22.2]	21 [21.2, 21.7]	19 [18.9, 19.3]	16 [16.2, 16.5]	25 [25.0, 25.6]	20 [19.5, 19.9]
NPV	92 [92.0, 92.2]	92 [92.0, 92.3]	92 [92.1, 92.3]	92 [91.9, 92.2]	92 [92.1, 92.4]	93 [92.3, 92.7]	99 [99.2, 99.2]	93 [92.8, 93.0]
Number needed to screen	4	5	5	5	5	6	4	4

CKD: chronic kidney disease; PCP: primary care physician; HTN: hypertension; DM: diabetes; SES: socioeconomic status; 1st Q: first quartile; PPV: positive predictive values, NPV: negative predictive values.

Table 7. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD
Using the median of the distribution of census tract socioeconomic status

	All patients (n= 256,162; 34,437 have CKD)						
	Approach 1 (HTN and/or DM)	**Approach 8A (HTN and/or DM and/or low CT SES, wealth)**	**Approach 8B (HTN and/or DM and/or low CT SES, education)**	**Approach 8C (HTN and/or DM and/or low CT SES, income)**	**Approach 9A (low CT SES, wealth)**	**Approach 9B (low CT SES, education)**	**Approach 9C (low CT SES, income)**
Number screened	81,497	120,534	142,893	125,154	58,026	93,407	63,840
CKD detected	20,636	23,989	25,990	24,180	8,174	13,423	8,805
Sensitivity	60 [59.4, 60.4]	70 [69.2, 70.2]	75 [75.0, 75.9]	70 [69.7, 70.7]	24 [23.3, 24.2]	39 [38.5, 39.5]	26 [25.1, 26.0]
Specificity	73 [72.4, 72.7]	56 [56.2, 56.7]	47 [47.1, 47.5]	54 [54.2, 54.6]	78 [77.3, 77.7]	64 [63.7, 64.1]	75 [74.9, 75.3]
PPV	25 [25.0, 25.6]	20 [19.7, 20.1]	18 [17.9, 18.4]	19 [19.1, 19.5]	14 [13.8, 14.4]	14 [14.1, 14.6]	14 [13.5, 14.1]
NPV	92 [91.9, 92.2]	92 [92.2, 92.4]	93 [92.4, 92.7]	92 [92.0, 92.3]	87 [86.6, 86.9]	87 [86.9, 87.2]	87 [86.5, 86.8]
Number needed to screen	4	5	6	5	7	7	7

CKD: chronic kidney disease; PCP: primary care physician; HTN: hypertension; DM: diabetes; SES: socioeconomic status; 1st Q: first quartile; PPV: positive predictive values, NPV: negative predictive values.

Approach 8A: screen patients who have a history of HTN or DM or live in census tracts where median value of owner occupied housing units is < median (< $188,100)

Approach 8B: screen patients who have a history of HTN or DM or live in census tracts where % or residents >25 years with complete education is < median (<20.4%)
Approach 8C: screen patients who have a history of HTN or DM or live in census tracts where tract median household income is < median (<$47,379)
Approach 9A: screen patients who live in census tracts where median value of owner occupied housing units is < median (< $188,100)
Approach 9B: screen patients who live in census tracts where % or residents >25 years with complete education is < median (<20.4%)
Approach 9C: screen patients who have live in census tracts where tract median household income is < median (<$47,379)

Table 8. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD **(AND)**

	All patients (n= 257,156; 34,362 have CKD)			
	Approach 10 (HTN and DM only)	**Approach 11A (HTN and DM and low CT SES, wealth)**	**Approach 11B (HTN and DM and low CT SES, education)**	**Approach 11C (HTN and DM and low CT SES, income)**
Number screened	15,020	1,604	1,967	1,506
CKD detected	5,420	576	687	552
Sensitivity	16	2	2	2
	[15.4, 16.1]	[1.5, 1.8]	[1.8, 2.1]	[1.5, 1.7]
Specificity	96	99	99	99
	[95.6, 95.7]	[99.6, 99.6]	[99.5, 99.6]	[99.5, 99.6]
PPV	36	36	35	37
	[35.3, 37.1]	[33.4, 38.3]	[32.8, 37.1]	[34.2, 39.1]
NPV	88	87	87	87
	[87.7, 88.4]	[86.6, 86.8]	[86.6, 86.8]	[86.6, 86.8]
Number needed to screen	3	3	3	3

CKD: chronic kidney disease; PCP: primary care physician; HTN: hypertension; DM: diabetes; SES: socioeconomic status; 1st Q: first quartile; PPV: positive predictive values, NPV: negative predictive values.

Approach 10: screen patients who have a history of HTN and DM
Approach 11A: screen patients who have a history of HTN and DM and live in census tracts where median value of owner occupied housing units is in the first quartile in the 7-county metro area
Approach 11B: screen patients who have a history of HTN and DM and live in census tracts where % or residents >25 years with complete education is in the first quartile in the 7-county metro area
Approach 11C: screen patients who have a history of HTN and DM and live in census tracts where tract median household income is in the first quartile in the 7-county metro area

Table 9. The sensitivity, specificity, PPV, NPV, and number needed to screen for each screening approach to detect CKD (including only patients who had their index creatinine measured during a primary physician visit)

	All patients (n= 192,711 ; 26,859 have CKD)						**Tracts with >200 patients** (n= 147,262; 87,019 have CKD)	
	Approach 1 (HTN and/or DM)	**Approach 2A (HTN and/or DM and/or low census tract SES, wealth)**	**Approach 2B (HTN and/or DM and/or low census tract SES, education)**	**Approach 2C (HTN and/or DM and/or low census tract SES, income)**	**Approach 3 (HTN and/ DM and/ or 1 of 3 low census tract SES variables, 1st Q)**	**Approach 4 (HTN and/or DM, and/or 1 of 3 low census tract SES variables, median)**	**Approach 1 (HTN and/or DM)**	**Approach 5 (HTN and/or DM, and/or census tract prevalence of CKD)**
Number screened	69,405	76,346	76,935	75,854	80,875	90,423	53,683	104,549
CKD detected	18,097	18,742	18,773	18,519	19,026	19,795	14,266	17,530
Sensitivity	67 [66.8, 67.9]	94 [93.6, 94.3]	94 [93.8, 94.4]	93 [92.4, 93.1]	95 [94.1, 95.7]	99 [99.1,99.3]	68 [66.8, 68.1]	83 [82.4, 83.4]
Specificity	69 [68.8, 69.3]	22 [21.4, 21.9]	20 [20.6, 21.2]	22 [21.7, 22.3]	16 [15.6, 16.1]	4 [3.8, 4.1]	69 [68.4, 69.0]	45 [44.6, 45.2]
PPV	26 [25.7, 26.4]	25 [24.2, 24.9]	24 [24.1, 24.7]	24 [24.1, 24.7]	24 [23.2, 23.8]	22 [21.6, 22.2]	27 [26.2, 26.9]	20 [19.9, 20.4]
NPV	93 [92.7, 93.0]	93 [92.6, 93.3]	93 [92.4, 93.3]	92 [91.5, 92.2]	93 [92.2, 93.1]	95 [94.1, 95.7]	93 [92.5, 92.8]	94 [93.8, 94.2]
Number needed to screen	4	4	4	4	4	5	4	6

CKD: chronic kidney disease; PCP: primary care physician; HTN: hypertension; DM: diabetes; SES: socioeconomic status; 1st Q: first quartile; PPV: positive predictive values, NPV: negative predictive values.

APPENDIX – CHAPTER 3

NOTES ON DATA ANALYSIS:

- On support data: data based on actual data observations.

- Positivity violations\off support data: certain groups or subgroups never receive "treatments of interest"

- Structural confounding is the confounding resulting from social stratification or another selection process.

- **Defining primary care physician visit:**
  It is a completed outpatient office visits to family practice, family practice-internal medicine, internal medicine, obstetrics/gynecology, gerontology or geriatrics clinic visit.

- **Defining race:**
  We used electronic health record data. Race data is usually inputted at first visit to Fairview clinic by an administrator or nurse after asking the patient. A patients' race was considered black if at any time patient has identified as belonging to black race; of the remaining participants we identified sequentially "Asian", "American Indian or Alaska Native or Native Hawaiian or other", "white", and missing/not recorded race.

  Only 1% of our cohort are American Indian or Alaska native or Native Hawaiian and 5% Asian and 6% with missing race. Given the scarcity of data for the other races, we looked at the association of racial composition and chronic kidney disease stratified as black vs. white. When assessing the association of neighborhood socioeconomic status and insurance status with chronic kidney disease, we adjusted for race (4 categorical variables: black, white, other, and we including missingness as a covariate).

  Please note, for eGFR calculation using CKD-EPI, if race was not documented as black in the EHR, we considered it as other

- **Defining insurance status (main analysis)**

< 65 years:

  - Patient considered to be on Medicaid if most recent insurance was reported as Medicaid (end date is not reported or on or after time of index eGFR and start date is before or at time of index eGFR).
  - Patient considered to have "other insurance" if most recent insurance was reported as "other"/private insurance (end date is not reported or on or after time of index eGFR and start date is before or at time of index eGFR).
  - Otherwise we considered patient to be uninsured (i.e. at most recent time, patient had no Medicaid or other insurance coverage)

≥ 65 years:

- Patients considered to be on Medicare (Part A, B or C*) if that was the only last insurance reported (end date is not reported or on or after time of index eGFR and start date is before or at time of index eGFR).
- Otherwise patients considered to have supplemental insurance plan

*These include:
MEDICARE PT B ONLY
MEDICARE PT A
RR MEDICARE PT A ONLY
MEDICARE RAILROAD PART B ONLY
MEDICARE
MEDICARE HOMECARE & HOSPICE
ACO MEDICARE
UCARE MEDICARE [Medicare advantage plans]
MEDICARE ADVANTAGE
HEALTHPARTNERS MEDICARE ADVANTAGE
HUMANA MEDICARE ADVANTAGE
UNITED HEALTHCARE MEDICARE ADVANTAGE
ATENA MEDICARE ADVANTAGE
OSF MEDICARE ADVANTAGE
BCBS MEDICARE ADVANTAGE

- **Defining insurance status (sensitivity analysis)**

< 65 years:

- Patient considered to be on Medicaid if they had only Medicaid coverage from 6/1/2017 to 12/31/2018 (not other insurance). Patient considered to have "other insurance" if most recent insurance was reported as "other"/private insurance (if they only had other insurance coverage 100% of the time from 6/1/2017 to 12/31/2018)
- Otherwise we considered patient to be uninsured

≥ 65 years:

- Patients considered to be on Medicare (Part A, B or C) if that was the only insurance reported from 6/1/2017 to 12/31/2018
- Patients considered to have supplemental insurance if they were covered by supplemental insurance plans 100% of the time from 6/1/2017 to 12/31/2018 and no coverage by Medicare plan A, B or C

Details on insurance coverage:

- **Part A** covers inpatient hospital stays, skilled nursing facility (SNF) stays, some home health visits, and hospice care. Part A benefits are subject to a deductible ($1,364 per benefit period in 2019). Part A also requires coinsurance for extended inpatient hospital and SNF stays.

- **Part B** covers physician visits, outpatient services, preventive services, and some home health visits. Many Part B benefits are subject to a deductible ($185 in 2019), and, typically, coinsurance of 20 percent.
- **Part C** refers to the Medicare Advantage program, through which beneficiaries can enroll in a private health plan, such as a health maintenance organization (HMO) or preferred provider organization (PPO), and receive all Medicare-covered Part A and Part B benefits and typically also Part D benefits.
- **Part D** covers through private plans that contract with Medicare, including stand-alone prescription drug plans (PDPs) and Medicare Advantage plans with prescription drug coverage (MA-PDs). Enrollment in Part D is voluntary

Medicare supplemental insurance plans vs. Medicare Advantage plans

	Medicare supplement insurance plans	Medicare Advantage plans
Doctors and hospitals	You can select your doctors and hospitals as long as they accept Medicare patients.	You may be required to use doctors and hospitals in the plan network.
Referrals	You can see specialists without referrals.	You may need referrals and may be required to use network specialists.
Network	No network restrictions. Coverage goes with you across the United States.	You may have network restrictions. Emergency care is covered for travel within the United States and sometimes abroad.
Enrolling	You can apply to buy a Medicare supplement insurance plan any time after you turn 65 and join Medicare Part B.	Generally, there are specific periods during the year when you can enroll or switch to another Medicare Advantage plan.
Costs	You pay a monthly plan premium in addition to your Part B premium. When you use services, your out-of-pocket costs are limited.	Generally, you pay a low or $0 monthly plan premium in addition to your Part B premium. When you use services, you pay co-pays, co-insurance and deductibles.
Prescription drug coverage	Prescription drug coverage is not included. Consider also purchasing a Medicare Part D plan.	Prescription drug coverage is included with most plans.

Medicare supplemental insurance or Medigap is a coverage that can be added to original Medicare Part A and B. Medicare Advantage (Part C) is an alternative to Original Medicare Parts A and B.

Reference: https://www.medicaremadeclear.com/choosing-plan/coverage/medicare-supplement-vs-medicare-advantage

Comparing difference Medicare programs:

Original Medicare & Medicare Advantage Plans At-a-Glance

	Original Medicare (Parts A+B)	Original Medicare plus Medigap	HMO (Part C/Medicare Advantage)	PPO (Part C/Medicare Advantage)
What do I pay?	Part B premiums, deductibles and coinsurances	Medigap premiums, Part B premiums, generally no copayment	Medicare premiums and plan premium; your plan sets its own deductibles and copays	Medicare premiums and plan premium; your plan sets its own deductibles and copays
Can I go to any doctor?	Yes, if they accept Medicare	Yes, if they accept Medicare	No, you must go to in-network providers	Yes, though PPOs have provider networks, you may go out of network for a higher copay
Where can I get routine, non-emergency care?	Anywhere in the country	Anywhere in the country	For most plans, in your local geographic area	For most plans, in your local geographic area
Where can I get emergency care?	Anywhere in the country	Anywhere in the country	Anywhere in the country	Anywhere in the country
How do I get prescription drug coverage?	Part D	Part D	You must join a plan that includes drug coverage, also called MA-PD	You must join a plan that includes drug coverage, also called MA-PD
Will I need a referral to see a specialist?	No	No, unless you have a Medicare SELECT plan	Usually	No, but you may pay more out of pocket if you go to a provider who is out of network
Is there a limit to my out-of-pocket spending?	No	No	Yes, all Medicare Advantage plans must have limits on out-of-pocket spending	Yes, all Medicare Advantage plans must have limits on out-of-pocket spending
Will it pay for extras, like vision and hearing aids?	No, Medicare does not cover dental, hearing or vision	No	Maybe; some plans offer these additional benefits	Maybe; some plans offer these additional benefits

HMO: health maintenance organization (medical insurance group); PPO: preferred provider organization

Reference: https://www.mymedicarematters.org/coverage/compare/

Table 1. Distribution of participants by insurance status for each tract socioeconomic measurement for patients < and ≥ 65 years

	< 65 years		
	Quartiles for median value of owner occupied housing units (tract level SES) & n with CKD in each		
	Medicaid	**Uninsured**	**Other insurance**
Q1: < $165,200	881 (205)	523 (60)	10,754 (1,553)
Q2: $165,200 to <$188,100	966 (191)	613 (84)	14,179 (1,857)
Q3: $188,100 to <$231,300	1,956 (415)	1,511 (172)	39,606 (4,744)
Q4: ≥ $231,300	1,454 (291)	1,641 (57)	53,878(5,641)
	Quartiles for % >25 years with Bachelor's degree or more (tract level SES) & n with CKD in each		
	Medicaid	**Uninsured**	**Other insurance**
Q1: < 20.4%	1,013 (230)	572 (78)	13,052 (1,803)
Q2: 20.4% - 34.1%	1,718 (344)	1,226 (135)	29,887 (3,817)
Q3: 34.1% - 48.1%	1,588 (338)	1,279 (161)	38,294 (4,473)
Q4: ≥ 48.1%	938 (190)	1,111 (99)	37,180 (3,703)
	Quartiles for median household income (tract level SES) & n with CKD in each		
	Medicaid	**Uninsured**	**Other insurance**
Q1: <$35,935	706 (147)	497 (45)	13,822 (1,539)
Q2: $35,935 - $47,379	951 (207)	623 (74)	14,883 (1,847)
Q3: $47,379 - $62,343	1,374 (286)	1,048 (125)	25,226 (3,165)
Q4: ≥ $62,343	2,219 (461)	2,112 (227)	64,810 (7,238)

Table 1 (continued)

≥ 65 years		
Quartiles for median value of owner occupied housing units (tract level SES) & n with CKD in each		
	Medicare	**Supplemental insurance plan**
Q1: < $165,200	1,091 (478)	3,385 (1,290)
Q2: $165,200 to <$188,100	1,596 (726)	5,121 (1,933)
Q3: $188,100 to <$231,300	4,289 (1,725)	15,836 (6,283)
Q4: ≥ $231,300	4,743 (1,791)	21,224 (7,394)
Quartiles for % >25 years with Bachelor's degree or more (tract level SES) & % with CKD in each		
	Medicare	**Supplemental insurance plan**
Q1: < 20.4%	1,271 (568)	3,917 (1,587)
Q2: 20.4% - 34.1%	3,169 (1,337)	10,939 (4,329)
Q3: 34.1% - 48.1%	3,995 (1,605)	15,771 (5,970)
Q4: ≥ 48.1%	3,284 (1,210)	14,939 (5,114)
Quartiles for median household income (tract level SES) & % with CKD in each		
	Medicare	**Supplemental insurance plan**
Q1: <$35,935	1,219 (458)	5,119 (1,869)
Q2: $35,935 - $47,379	1,693 (707)	5,594 (2,213)
Q3: $47,379 - $62,343	2,723 (1,113)	10,458 (4,009)
Q4: ≥ $62,343	6,076 (2,439)	24,373 (8,901)

Table 2. Distribution of participants by insurance status by race for patients < and 65 years

For Individuals <65 years			
	Medicaid	**Uninsured**	**Other insurance**
Overall (n & n,% with CKD)			
Black	1,298 (248)	664 (71)	11,698 (1,476)
White	3,961 (854)	3,624 (402)	106,732 (12,323)

For Individuals ≥65 years		
	Medicare	**Supplemental Insurance plan**
Overall (n & n with CKD)		
Black	375 (134)	2,095 (675)
White	11,344 (4,586)	43,478 (16,329)

Table 3. Distribution of participants by insurance status for each 5% increment of percent black in census tracts

%Blacks in tracts	Blacks	Whites	Total #	# CKD	% CKD	# Blacks with CKD	% Blacks with CKD	# Whites with CKD	% Whites with CKD
< 5%	3,664	91,543	95,207	18,351	19.3	535	14.6	17,816	19.5
5 - 10%	3,474	41,620	45,094	9,107	20.1	551	15.9	8,556	20.6
10 - 15%	2,212	15,606	17,818	3,918	22.0	363	16.4	3,555	22.8
15 - 20%	1,967	9,703	11,670	2,583	22.1	310	15.8	2,273	23.4
20 - 25%	4,519	1,137	5,656	1,147	20.3	207	18.2	940	20.8
25 - 30%	584	1,791	2,375	489	20.6	86	14.7	403	22.5
30 - 35%	464	1,346	1,810	403	22.3	82	17.7	321	23.8
35 - 40%	725	1,219	1,944	405	20.8	131	18.1	274	22.4
40 - 45%	1,060	1,012	2,072	371	17.9	176	16.6	195	19.3
45 - 50%	261	252	513	114	22.2	55	21.1	59	23.4
50 - 55%	76	76	159	34	21.4	19	22.9	15	19.7
55 - 60%	211	211	392	87	22.2	38	21.0	49	23.2
>60%+	315	218	533	82	15.4	51	16.1	31	14.2

Table 4A. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for individuals <65 years

	High SES (4th quartile of median value of owner occupied housing units[≥ $231,300]) N= 56,973	**Low SES (1st quartile of median value of owner occupied housing units [< $165,200])** N=12,149	**p-value**
CKD, n(%)	6,089 (11%)	1,818 (15%)	<0.001
Individual level demographic characteristics			
Age, mean (SD)	46.7 ± 12.6	44.4 ± 12.7	<0.001
Male, n(%)	26,961 (47%)	5,332 (44%)	<0.001
Black	3,301 (6%)	2958 (24%)	<0.001
Individual social characteristics (n%)			
Smoker, n(%)	18,545 (33%)	5,469 (45%)	<0.001
Medicaid, n(%)	1,454 (3%)	881 (7%)	<0.001
Vitals			
Systolic BP, mmHg	124.4 ± 16.7	126.0 ± 17.8	<0.001
Diastolic BP, mmHg	77.9 ± 11.1	78.8 ± 11.7	<0.001
Medical History			
Hypertension, n(%)	17,080 (30%)	4,332 (36%)	<0.001
Diabetes, n(%)	5,510 (10%)	2,139 (18%)	<0.001
Obese (BMI≥ 30 kg/m_2), n(%)	19,452 (38%)	5,117 (47%)	<0.001
Cardiovascular disease, n(%)	3,355 (6%)	990 (8%)	0.031
Stroke, n(%)	915 (2%)	258 (2%)	0.273
Hyperlipidemia, n(%)	18,087 (32%)	3,464 (29%)	<0.001
Cancer, n(%)	2,461 (4%)	389 (3%)	<0.001

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 4B. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for individuals < 65 years

	High SES (4th quartile of %>25 years with complete college education[≥ $48.1%]) N=39,229	**Low SES (1st quartile of %>25 years with complete college education [<20.4%])** N=14,637	**p-value**
CKD, n(%)	3,992 (10%)	2,111 (14%)	<0.001
Individual level demographic characteristics			
Age, mean (SD)	46.2 ± 12.8	45.5 ± 12.8	<0.001
Male, n(%)	18,412 (47%)	6,636 (45%)	<0.001
Black	2,628 (7%)	2,596 (18%)	<0.001
Individual social characteristics			
Smoker, n(%)	11,894 (30%)	7,200 (49%)	<0.001
Medicaid, n(%)	938 (2%)	1,013 (7%)	<0.001
Vitals			
Systolic BP, mmHg	123.9 ± 16.6	127.3 ± 17.5	<0.001
Diastolic BP, mmHg	77.6 ± 11.0	79.2 ± 11.5	<0.001
Medical History			
Hypertension, n(%)	10,890 (28%)	5,709 (39%)	<0.001
Diabetes, n(%)	3,664 (9%)	2,569 (18%)	<0.001
Obese (BMI≥ 30 kg/m_2), n(%)	12,164 (35%)	6,565 (50%)	<0.001
Cardiovascular disease, n(%)	2,195 (6%)	1,252 (9%)	0.001
Stroke, n(%)	597 (2%)	313 (2%)	0.158
Hyperlipidemia, n(%)	11,688 (30%)	4,748 (32%)	0.344
Cancer, n(%)	1,734 (4%)	514 (4%)	<0.001

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 4C. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for individuals <65years

	High SES (4th quartile of household income [≥ $62,343]) N=69,141	**Low SES (1st quartile of of household income [<$35,935])** N=15,025	**p-value**
CKD, n(%)	7,926 (12%)	1,731 (12%)	0.853
Individual level demographic characteristics			
Age, mean (SD)	46.5 ± 12.5	45.2 ± 13.0	<0.001
Male, n(%)	31,981 (46%)	6,952 (46%)	0.981
Black	5,142 (7%)	2,442 (16%)	<0.001
Individual social characteristics			
Smoker, n(%)	25,193 (36%)	5,844 (39%)	<0.001
Medicaid, n(%)	2,219 (3%)	706 (5%)	<0.001
Vitals			
Systolic BP, mmHg	125.2 ± 16.8	125.0 ± 16.8	0.034
Diastolic BP, mmHg	78.3 ± 11.1	78.3 ± 10.9	<0.001
Medical History			
Hypertension, n(%)	22,684 (33%)	4,640 (31%)	<0.001
Diabetes, n(%)	7,964 (12%)	1,910 (13%)	0.001
Obese (BMI≥ 30 kg/m_2), n(%)	26,262 (42%)	5,364 (40%)	<0.001
Cardiovascular disease, n(%)	4,428 (7%)	1,007 (7%)	0.184
Stroke, n(%)	1,171 (2%)	260 (2%)	0.778
Hyperlipidemia, n(%)	22,740(33%)	4,196 (28%)	<0.001
Cancer, n(%)	2,901 (4%)	591 (4%)	0.150

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 5A. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for individuals ≥65 years

	High SES (4th quartile of median value of owner occupied housing units[≥ $231,300]) N= 25,967	**Low SES (1st quartile of median value of owner occupied housing units [< $165,200])** N=4,476	**p-value**
CKD, n(%)	9,185 (35%)	1868 (42%)	<0.001
Individual level demographic characteristics			
Age, mean (SD)	75.0 ± 7.6	76.0 ± 8.3	<0.001
Male, n(%)	12,167 (47%)	1,773 (40%)	<0.001
Black	612 (3%)	512 (21%)	<0.001
Individual social characteristics (n%)			
Smoker, n(%)	12,536 (48%)	2,294 (51%)	<0.001
Medicare, n(%)	8,151 (31%)	1,381 (31%)	0.486
Vitals			
Systolic BP, mmHg	131.0 ± 18.6	132.4 ± 19.4	<0.001
Diastolic BP, mmHg	74.3 ± 10.8	74.2 ± 10.8	0.464
Medical History			
Hypertension, n(%)	18,133 (70%)	3,379 (76%)	<0.001
Diabetes, n(%)	5,531 (21%)	1,355 (30%)	<0.001
Obese (BMI≥ 30 kg/m2), n(%)	7,851 (33%)	1,558 (37%)	<0.001
Cardiovascular disease, n(%)	7,951 (31%)	1,388 (31%)	0.613
Stroke, n(%)	2,266 (9%)	418 (9%)	0.192
Hyperlipidemia, n(%)	18,084 (70%)	3,039 (68%)	0.02
Cancer, n(%)	4,402 (17%)	1668 (15%)	0.001

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 5B. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for individuals ≥65 years

	High SES (4th quartile of %>25 years with complete college education[≥ $48.1%]) N=18,223	**Low SES (1st quartile of %>25 years with complete college education [<20.4%])** N=5,188	**p-value**
CKD, n(%)	6,324 (35%)	2,155 (42%)	<0.001
Individual level demographic characteristics			
Age, mean (SD)	75.0 ± 7.6	75.2 ± 7.7	0.023
Male, n(%)	8,556 (47%)	2,217 (43%)	<0.001
Black	425 (2%)	445 (9%)	<0.001
Individual social characteristics			
Smoker, n(%)	8,684 (48%)	2,754 (53%)	<0.001
Medicare, n(%)	5,851 (32%)	1,417 (27%)	<0.001
Vitals			
Systolic BP, mmHg	131.2 ± 18.7	132.1 ± 18.9	0.002
Diastolic BP, mmHg	74.5 ± 10.7	74.1 ± 10.5	0.008
Medical History			
Hypertension, n(%)	12,461 (68%)	3,985 (77%)	<0.001
Diabetes, n(%)	3,664 (20%)	1,631 (31%)	<0.001
Obese (BMI≥ 30 kg/m_2), n(%)	5,053 (30%)	2,054 (42%)	<0.001
Cardiovascular disease, n(%)	5,502 (30%)	1,591 (31%)	0.523
Stroke, n(%)	1,490 (8%)	460 (9%)	0.119
Hyperlipidemia, n(%)	12,510 (69%)	3,698 (71%)	<0.001
Cancer, n(%)	3,110 (17%)	748 (14%)	<0.001

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 5C. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for individuals ≥65years

	High SES (4th quartile of household income [≥ $62,343]) N=30,449	**Low SES (1st quartile of of household income [<$35,935])** N=6,337	**p-value**
CKD, n(%)	11,340 (37%)	2,327 (37%)	0.437
Individual level demographic characteristics			
Age, mean (SD)	75.1 ± 7.6	75.3 ± 7.6	0.062
Male, n(%)	13,917 (46%)	2,847 (45%)	0.259
Black	806 (3%)	706 (11%)	<0.001
Individual social characteristics			
Smoker, n(%)	15,178 (50%)	3,070 (48%)	0.043
Medicare, n(%)	6,076 (20%)	1,219 (19%)	0.196
Vitals			
Systolic BP, mmHg	131.3 ± 18.8	131.8 ± 18.6	0.113
Diastolic BP, mmHg	74.3 ± 10.9	74.6 ± 10.6	0.109
Medical History			
Hypertension, n(%)	21,945 (72%)	4,485 (71%)	0.037
Diabetes, n(%)	7,266 (24%)	1,545 (24%)	0.392
Obese (BMI≥ 30 kg/m_2), n(%)	10,005 (36%)	1,927 (33%)	<0.001
Cardiovascular disease, n(%)	9,596 (32%)	1,895 (30%)	0.012
Stroke, n(%)	2,652 (9%)	548 (9%)	0.0890
Hyperlipidemia, n(%)	21,565 (71%)	4,251 (67%)	<0.001
Cancer, n(%)	5,034 (17%)	1,008 (16%)	0.226

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 6. Characteristics of population by race in the Twin Cities metro area

	White N=169,139	**Black** N=16,130	**p-value**
CKD, n(%)	34,494 (20%)	2,604 (16%)	<0.001
Individual level demographic characteristics			
Age, mean (SD)	55.8 ± 17.7	47.0 ± 16.5	<0.001
Male, n(%)	77,435 (46%)	6,681 (41%)	<0.001
Individual social characteristics			
Smoker, n(%)	72,345 (43%)	5,522 (34%)	<0.001
Medicaid, n(%)	3,961 (2%)	1,298 (8%)	<0.001
Medicare, n(%)	11,344 (7%)	375 (2%)	<0.001
Median value of owner occupied housing units			
Q1: < $165,200	13,155 (8%)	3,470 (22%)	<0.001
Q2: $165,200 - $188,100	19,348 (11%)	3,127 (19%)	
Q3: $188,100 - $231,300	57,581 (34%)	5,617 (35%)	
Q4: ≥ $231,300	79,027 (47%)	3,913 (24%)	
% of Residents > 25 years with a Bachelor's degree or more			
Q1: < 20.4%	16,784 (10%)	3,041 (19%)	<0.001
Q2: 20.4% - 34.1%	41,679 (25%)	5,260 (33%)	
Q3: 34.1% - 48.1%	56,254 (33%)	4,773 (30%)	
Q4: ≥ 48.1%	54,399 (32%)	3,053 (19%)	
Median household income			
Q1: <$35,935	18,215 (11%)	3,148 (20%)	<0.001
Q2: $35,935 - $47,379	20,564 (12%)	2,780 (17%)	
Q3: $47,379 - $62,343	36,598 (22%)	4,231 (26%)	
Q4: ≥ $62,343	93,642 (55%)	5,948 (37%)	
Vitals			
Systolic BP, mmHg	127.2 ± 17.7	127.4 ± 19.3	0.225
Diastolic BP, mmHg	77.0 ± 11.2	78.0 ± 12.5	<0.001
Medical History			
Hypertension, n(%)	76,782 (45%)	6,448 (40%)	<0.001
Diabetes, n(%)	26,483 (16%)	3,430 (21%)	<0.001
Obese (BMI≥ 30 kg/m_2), n(%)	60,974 (39%)	6,493 (45%)	<0.001
Cardiovascular disease, n(%)	25,070 (15%)	1,719 (11%)	0.036
Stroke, n(%)	6,930 (4%)	517 (3%)	<0.001
Hyperlipidemia, n(%)	75,892 (44%)	4,744 (29%)	<0.001
Cancer, n(%)	13,961 (8%)	648 (4%)	<0.001

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 7A. Characteristics of population by insurance status in the Twin Cities metro area (<65 years)

	Other Insurance N= 118,430	**Medicaid** N= 5,259	**p-value**
CKD, n(%)	13,799 (12%)	1,102 (21%)	<0.001
Individual level demographic characteristics			
Age, mean (SD)	46.2 ± 12.4	42.7 ± 13.9	<0.001
Male, n(%)	54,241 (46%)	2,239 (43%)	<0.001
Black, n(%)	11,698 (10%)	1,298 (25%)	<0.001
Individual social characteristics			
Smoker, n(%)	44,885 (38%)	2,537 (48%)	<0.001
Median value of owner occupied housing units			
Q1: < $165,200	10,745 (9%)	881 (17%)	<0.001
Q2: $165,200 - $188,100	14,179 (12%)	966 (18%)	
Q3: $188,100 - $231,300	39,606 (33%)	1,956 (37%)	
Q4: ≥ $231,300	53,878 (46%)	1,454 (27%)	
% of Residents > 25 years with a Bachelor's degree or more			
Q1: < 20.4%	13,052 (11%)	1,013 (19%)	<0.001
Q2: 20.4% - 34.1%	29,887 (25%)	1,718 (33%)	
Q3: 34.1% - 48.1%	38,294 (32%)	1,588 (30%)	
Q4: ≥ 48.1%	37,180 (31%)	938 (18%)	
Median household income			
Q1: <$35,935	13,822 (12%)	706 (13%)	<0.001
Q2: $35,935 - $47,379	14,483 (12%)	951 (18%)	
Q3: $47,379 - $62,343	25,226 (21%)	1,374 (26%)	
Q4: ≥ $62,343	64,810 (55%)	2,219 (42%)	
Medical History			
Hypertension, n(%)	38,945 (33%)	1,816 (35%)	0.013
Diabetes, n(%)	14,421 (12%)	1,025 (20%)	<0.001
Obese (BMI≥ 30 kg/m_2), n(%)	45,431 (42%)	1,962 (43%)	0.138
Cardiovascular disease, n(%)	7,788 (7%)	634 (12%)	<0.001
Stroke, n(%)	2,022 (2%)	217 (4%)	<0.001
Hyperlipidemia, n(%)	37,889 (32%)	1,615 (31%)	0.053
Cancer, n(%)	4,842 (4%)	219 (4%)	0.813

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 7B. Characteristics of population by insurance status in the Twin Cities metro area (≥65 years)

	Supplemental Insurance Plan N= 45,573	**Medicare** N=11,719	**p-value**
CKD, n(%)	17,004 (37%)	4,720 (40%)	<0.001
Individual level demographic characteristics			
Age, mean (SD)	75.1 ± 7.7	76.7 ± 7.7	<0.001
Male, n(%)	20,300 (45%)	5,149 (44%)	0.243
Black, n(%)	2,095 (5%)	375 (3%)	<0.001
Individual social characteristics			
Smoker, n(%)	22,529 (49%)	6,262 (53%)	<0.001
Median value of owner occupied housing units			
Q1: < $165,200	3,385 (7%)	1,091 (9%)	<0.001
Q2: $165,200 - $188,100	5,121 (11%)	1,596 (14%)	
Q3: $188,100 - $231,300	15,836 (37%)	4,289 (37%)	
Q4: ≥ $231,300	21,224 (47%)	4,743 (41%)	
% of Residents > 25 years with a Bachelor's degree or more			
Q1: < 20.4%	3,917 (9%)	1,271 (11%)	<0.001
Q2: 20.4% - 34.1%	10,939 (24%)	3,169 (27%)	
Q3: 34.1% - 48.1%	15,771 (35%)	3,995 (34%)	
Q4: ≥ 48.1%	14,939 (33%)	3,284 (28%)	
Median household income			
Q1: <$35,935	5,119 (11%)	1,219 (10%)	0.002
Q2: $35,935 - $47,379	5,594 (12%)	1,693 (15%)	
Q3: $47,379 - $62,343	10,458 (23%)	2,723 (23%)	
Q4: ≥ $62,343	24,373 (54%)	6,076 (52%)	
Medical History			
Hypertension, n(%)	32,754 (72%)	8,770 (75%)	<0.001
Diabetes, n(%)	11,250 (25%)	2,816 (24%)	0.144
Obese (BMI≥ 30 kg/m_2), n(%)	15,120 (36%)	3,696 (34%)	0.001
Cardiovascular disease, n(%)	14,554 (32%)	3,596 (31%)	0.01
Stroke, n(%)	4,152 (9%)	1,010 (9%)	<0.001
Hyperlipidemia, n(%)	31,874 (70%)	8,481 (72%)	<0.001
Cancer, n(%)	7,579 (17%)	1,903 (6%)	0.315

CKD: chronic kidney disease; Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease; BP: blood pressure

Table 8A. Interaction between neighborhood SES and insurance status with race (black vs. white) for patients < 65 years

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.17	1.00	1.00
3rd Q		0.96 [0.85, 1.08]	0.74 [0.49, 1.00]
2nd Q		0.88 [0.76, 1.02]	0.56 [0.25, 0.86]
Low SES tract – 1st Q		0.91 [0.80, 1.05]	0.88 [0.72, 1.05]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q **(reference)**	0.45	1.00	1.00
3rd Q		0.91 [0.80, 1.04]	0.89 [0.75, 1.04]
2nd Q		0.95 [0.84, 1.09]	0.94 [0.80, 1.08]
Low SES tract – 1st Q		0.93 [0.82, 1.06]	0.93 [0.82, 1.06]
Median household income			
High SES tract – 4th Q **(reference)**	0.39	1.00	1.00
3rd Q		0.97 [0.86, 1.10]	0.97 [0.83, 1.09]
2nd Q		0.94 [0.83, 1.06]	0.93 [0.79, 2.06]
Low SES tract – 1st Q		0.99 [0.88, 1.14]	0.99 [0.88, 1.14]
Insurance (Medicaid vs. other insurance)	0.20	0.84 [0.75, 1.01]	0.80 [0.50, 1.09]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model
Model: tract SES, insurance status, race, sex, age, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension

Table 8B. Interaction between neighborhood SES and insurance status with hypertension history (yes vs. no) for patients < 65 years

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.46	1.00	1.00
3rd Q		0.91 [0.84, 1.00]	0.79 [0.62, 0.97]
2nd Q		0.95 [0.86, 1.06]	0.86 [0.65, 1.08]
Low SES tract – 1st Q		0.98 [0.87, 1.10]	0.89 [0.62, 1.16]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q **(reference)**	0.01	1.00	1.00
3rd Q		0.86 [0.79, 1.03]	0.67 [0.47, 0.87]
2nd Q		0.94 [0.86, 1.03]	0.83 [0.62, 1.05]
Low SES tract – 1st Q		0.84 [0.74, 0.95]	0.55 [0.24, 0.87]
Median household income			
High SES tract – 4th Q **(reference)**	0.01	1.00	1.00
3rd Q		1.01 [0.93, 1.10]	1.00 [0.84, 1.17]
2nd Q		1.01 [0.92, 1.12]	0.99 [0.80, 1.19]
Low SES tract – 1st Q		1.16 [1.04, 1.29]	1.16 [1.04, 1.29]
Insurance (Medicaid vs. other insurance)	<0.001	0.74 [0.65, 0.84]	0.48 [0.17, 0.79]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model:
Model: tract SES, insurance status, race, sex, age, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Table 8C. Interaction between neighborhood SES and insurance status with diabetes (yes vs. no) for patients < 65 years

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.56	1.00	1.00
3rd Q		0.94 [0.87, 1.05]	0.93 [0.67, 1.19]
2nd Q		0.96 [0.87, 1.05]	1.01 [0.61, 1.41]
Low SES tract – 1st Q		1.06 [0.93, 1.19]	1.07 [0.72, 1.40]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q **(reference)**	0.85	1.00	1.00
3rd Q		0.95 [0.87, 1.03]	0.88 [0.56, 1.19]
2nd Q		1.00 [0.91, 1.10]	0.96 [0.61, 1.24]
Low SES tract – 1st Q		0.99 [0.88, 1.12]	0.87 [0.43, 1.31]
Median household income			
High SES tract – 4th Q **(reference)**	0.41	1.00	1.00
3rd Q		0.92 [0.86, 1.00]	0.79 [0.47, 1.11]
2nd Q		0.96 [0.87, 1.06]	0.64 [0.26, 1.01]
Low SES tract – 1st Q		0.98 [0.89, 1.09]	0.98 [0.89, 1.09]
Insurance (Medicaid vs. other insurance)	<0.001	0.66 [0.59, 0.74]	0.29 [0.05, 0.54]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model:
Model: tract SES, insurance status, race, sex, age, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension

Table 9A. Interaction between neighborhood SES and insurance status with race (black vs. white) for patients ≥ 65 years

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.71	1.00	1.00
3rd Q		1.05 [0.90, 1.23]	0.94 [0.70, 1.19]
2nd Q		0.92 [0.78, 1.10]	0.56 [0.32, 0.85]
Low SES tract – 1st Q		1.03 [0.86, 1.22]	1.03 [0.87, 1.18]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q **(reference)**	0.69	1.00	1.00
3rd Q		1.04 [0.87, 1.25]	1.00 [0.85, 1.16]
2nd Q		0.95 [0.80, 1.12]	0.95 [0.80, 1.10]
Low SES tract – 1st Q		1.03 [0.85, 120]	1.03 [0.85, 1.20]
Median household income			
High SES tract – 4th Q **(reference)**	0.23	1.00	1.00
3rd Q		0.99 [0.84, 1.15]	0.98 [0.85, 1.12]
2nd Q		0.97 [0.81, 1.16]	0.97 [0.81, 1.13]
Low SES tract – 1st Q		0.92 [0.79, 1.06]	0.92 [0.79, 1.06]
Insurance (Medicaid vs. other insurance)	0.35	1.07 [0.93, 1.24]	1.02 [0.94, 1.12]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model:
Model: tract SES, insurance status, race, sex, age, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension

Table 9B. Interaction between neighborhood SES and insurance status with hypertension history (yes vs. no) for patients ≥ 65 years

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q	0.37	1.05 [0.98, 1.14]	1.08 [0.97, 1.19]
2nd Q		1.03 [0.93, 1.14]	1.05 [0.88, 1.20]
Low SES tract – 1st Q		1.05 [0.89, 1.23]	1.08 [0.85, 1.32]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q	0.67	1.01 [0.94, 1.10]	1.02 [0.90, 1.14]
2nd Q		0.98 [0.89, 1.07]	0.97 [0.82, 1.12]
Low SES tract – 1st Q		1.03 [0.91, 1.16]	1.06 [0.87, 1.25]
Median household income			
High SES tract – 4th Q **(reference)**		1.00	1.00
3rd Q	0.87	0.99 [0.91, 1.09]	0.99[0.86, 1.13]
2nd Q		1.05 [0.94, 1.18]	1.08 [0.91, 1.24]
Low SES tract – 1st Q		0.98 [0.89, 1.09]	0.98 [0.89, 1.09]
Insurance (Medicaid vs. other insurance)	0.61	1.02 [0.95, 1.10]	0.99 [0.94, 1.04]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model:
Model: tract SES, insurance status, race, sex, age, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Table 9C. Interaction between neighborhood SES and insurance status with diabetes (yes vs. no) for patients ≥ 65 years

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q **(reference)**	0.78	1.00	1.00
3rd Q		0.97 [0.94, 1.02]	0.92 [0.81, 1.04]
2nd Q		0.98 [0.91, 1.04]	0.98 [0.77, 1.19]
Low SES tract – 1st Q		1.04 [0.97, 1.11]	1.07 [0.96, 1.18]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q **(reference)**	0.88	1.00	1.00
3rd Q		0.96 [0.92, 1.01]	0.96 [0.83, 1.09]
2nd Q		0.97 [0.92, 1.03]	0.94 [0.78, 1.10]
Low SES tract – 1st Q		1.03 [0.95, 1.11]	0.95 [0.77, 1.13]
Median household income			
High SES tract – 4th Q **(reference)**	0.36	1.00	1.00
3rd Q		1.02 [0.98, 1.07]	0.94 [0.81, 1.07]
2nd Q		1.02 [0.96, 1.08]	0.98 [0.85, 1.11]
Low SES tract – 1st Q		1.02 [0.95, 1.09]	1.02 [0.95, 1.09]
Insurance (Medicaid vs. other insurance)	0.59	0.98 [0.94, 1.03]	0.99 [0.97, 1.02]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model:
Model: tract SES, insurance status, race, sex, age, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension

Table 10A. Interaction between percent blacks in tracts with hypertension history

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Blacks	0.63	1.01 [0.99, 1.03]	1.01 [0.97, 1.06]
Whites	0.45	0.99 [0.98, 1.01]	0.99 [0.97, 1.01]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model:
Model: tract racial composition, insurance (Medicaid or Medicare vs. other insurance or supplemental insurance plan), age, sex, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, tract median value of owner occupied housing units, tract % >25 years with a Bachelor's degree or more (quartiles, tract household income

Table 10B. Interaction between percent blacks in tracts with diabetes history

	Overall multiplicative interaction	Interaction on the multiplicative scale (ratio of PR)	Interaction on the additive scale (RERI)
Blacks	0.59	0.99 [0.97, 1.02]	0.99 [0.95, 1.03]
Whites	0.36	0.99 [0.98, 1.01]	0.99 [0.97, 1.01]

Q1: first quartile; Q2: second quartile; Q3: third quartile; Q4: fourth quartile
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Interaction obtained using the fully adjusted model:
Model: tract racial composition, insurance (Medicaid or Medicare vs. other insurance or supplemental insurance plan), age, sex, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, tract median value of owner occupied housing units, tract % >25 years with a Bachelor's degree or more, tract household income

Note: CKD (using more restrictive definition) is prevalent in 7% of the overall population, 4% in patients <65 years (4,541/127,977) and 14% in patients ≥65 years (7,924/57,292), 7% in blacks (1,134/16,696) and 7% in whites (11,383/169,139). Therefore, we will use multilevel logistic regression and estimate OR and 95%CI for patients <65 and for blacks and whites. However, we will use multilevel Poisson regression with robust error variance for patients ≥65 years.

Table 11A. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence (more restrictive definition) in individuals <65 years*

Median value of owner-occupied housing units					**Insurance**	
OR, 95%CI	**High SES 4th Q (n=55,332)**	**3rd Q (n=41,562)**	**2nd Q (n=15,145)**	**Low SES 1st Q (n=11,650)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.17 [1.12, 1.23]	1.32 [1.24, 1.41]	1.49 [1.38, 1.62]	1.00	1,06 [1.03, 1.09]
Model 2	1.00	1.20 [1.14, 1.26]	1.36 [1.27, 1.45]	1.57 [1.45, 1.70]	1.00	1.11 [1.08, 1.14]
Model 3	1.00	1.06 [1.01, 1.11]	1.13 [1.06, 1.20]	1.25 [1.15, 1.36]	1.00	1.12 [1.08, 1.15]
%>25 years with a Bachelor's degree or more					**Insurance**	
OR, 95%CI	**High SES (n=38,118)**	**3rd Q (n=39,882)**	**2nd Q (n=31,605)**	**Low SES (n=14,084)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.23 [1.17, 1.30]	1.36 [1.28, 1.44]	1.52 [1.41, 1.65]	1.00	1.06 [1.03, 1.09]
Model 2	1.00	1.23 [1.08, 1.14]	1.37 [1.29, 1.45]	1.54 [1.42, 1.67]	1.00	2.33 [2.12, 2.57]
Model 3	1.00	1.11 [1.06, 1.18]	1.12 [1.06, 1.19]	1.19 [1.10, 1.29]	1.00	1.12 [1.08, 1.15]

Table 11A. (continued)

	Median household income				Insurance	
OR, 95%CI	**High SES (n=67,029)**	**3rd Q (n=26,600)**	**2nd Q (n=15,434)**	**Low SES (n=14,626)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.17 [1.10, 1.24]	1.18 [1.09, 1.28]	1.03 [0.95, 1.12]	1.00	1.06 [1.04,1.09]
Model 2	1.00	1.19 [1.13, 1.27]	1.22 [1.13, 1.32]	1.07 [0.98, 1.16]	1.00	1.11 1.09, 1.15]
Model 3	1.00	1.13 [1.07, 1.19]	1.12 [1.05, 1.20]	1.01 [0.94, 1.08]	1.00	1.11 [1.08, 1.16]

*Using a more restrictive definition of chronic kidney disease (CKD): eGFR <45 ml/min per 1.73 m_2/year or UACR ≥ 300mg/g or UPCR ≥ 500mg/g or UA ≥ 100mg/g

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

No interaction between tract SES (any of the three measures) and race, hypertension or diabetes
No interaction between insurance (any of the three measures) and race, hypertension or diabetes

Table 11B. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence (more restrictive definition) in individuals ≥ 65 years*

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=25,967)**	**3rd Q (n=20,125)**	**2nd Q (n=6,717)**	**Low SES 1st Q (n=4,476)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.19 [1.12, 1.27]	1.29 [1.18, 1.40]	1.36 [1.25, 1.49]	1.00	1.02 [0.99, 1.05]
Model 2	1.00	1.14 [1.08, 1.20]	1.22 [1.13, 1.33]	1.26 [1.14, 1.41]	1.00	0.98 [0.96, 1.01]
Model 3	1.00	1.06 [1.01, 1.11]	1.12 [1.04, 1.21]	1.14 [1.06, 1.24]	1.00	0.99 [0.97, 1.02]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=18,223)**	**3rd Q (n=19,766)**	**2nd Q (n=14,108)**	**Low SES (n=5,188)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.15 [1.08, 1.23]	1.28 [1.20, 1.38]	1.35 [1.23, 1.48]	1.00	1.02 [0.99, 1.05]
Model 2	1.00	1.11 [1.05, 1.18]	1.22 [1.15, 1.30]	1.30 [1.19, 1.42]	1.00	0.98 [0.96, 1.00]
Model 3	1.00	1.03 [0.98, 1.09]	1.09 [1.03, 1.16]	1.13 [1.05, 1.23]	1.00	0.99 [0.97, 1.02]

Table 11B. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=22,160)**	**3rd Q (n=15,538)**	**2nd Q (n=12,113)**	**Low SES (n=7,481)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.14 [1.00, 1.05]	1.21 [1.13, 1.31]	1.06 [0.97, 1.16]	1.00	1.02 [1.00, 1.05]
Model 2	1.00	1.07 [1.01, 1.14]	1.15 [1.07, 1.23]	1.02 [0.93, 1.11]	1.00	0.99 [0.96, 1.01]
Model 3	1.00	1.04 [0.96, 1.12]	1.09 [1.03, 1.17]	1.04 [0.96, 1.12]	1.00	1.00 [0.98, 1.03]

* Using a more restrictive definition of chronic kidney disease (CKD): eGFR <45 ml/min per 1.73 m_2/year or UACR ≥ 300mg/g or UPCR ≥ 500mg/g or UA ≥ 100mg/g

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

No interaction between tract SES (any of the three measures) and race, hypertension or diabetes
No interaction between insurance (any of the three measures) and race, hypertension or diabetes

Table 11C. Multilevel regression model for the association of tract racial composition with CKD prevalence (more restrictive definition) by race

	Model 1 (PR, 95% CI)	**Model 2 (PR, 95% CI)**	**Model 3 (PR, 95% CI)**	P-value for interaction of tract % black with race
Blacks (n=16,130)				0.02
OR per 5% increase in blacks in census tract	1.02 [1.01, 1.04]	1.01 [0.99, 1.03]	1.00 [0.98, 1.02]	
Whites (n=151,168)				
OR per 5% increase in blacks in census tract	1.04 [1.02, 1.06]	1.04 [1.03, 1.06]	1.01 [1.00, 1.03]	

SES: socioeconomic status, PR: prevalence ratio of CKD

*Using a more restrictive definition of chronic kidney disease (CKD): eGFR <45 ml/min per 1.73 m_2/year or UACR ≥ 300mg/g or UPCR ≥ 500mg/g or UA ≥ 100mg/g

Model 1: tract racial composition, insurance (Medicaid or Medicare vs. other insurance or supplemental insurance plan), age, sex, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, and diabetes
Model 2: model 1 + tract median value of owner occupied housing units (quartiles) + tract % >25 years with a Bachelor's degree or more (quartiles) + tract household income (quartiles)

There is no interaction between percent black in tracts and hypertension or diabete

Analyses using only creatinine measured during routine clinical visits (Tables 12A, 12B, and 12C)

Table 12A Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals <65 years

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=34,659)**	**3rd Q (n=24,378)**	**2nd Q (n=8,729)**	**Low SES 1st Q (n=6,642)**	**Other Insurance (n=71,899**	**Medicaid (n=2,509)**
Model 1	1.00	1.18 [1.12, 1.25]	1.34 [1.24, 1.45]	1.45 [1.32, 1.60]	1.00	1.78 [1.65, 1.93]
Model 2	1.00	1.21 [1.14, 1.27]	1.36 [1.26, 1.47]	1.51 [1.37, 1.65]	1.00	1.89 [1.14, 2.04]
Model 3	1.00	1.04 [1.00, 1.09]	1.11 [1.04, 1.18]	1.17 [1.08, 1.27]	1.00	1.48 [1.38, 1.59]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=24,001)**	**3rd Q (n=24,397)**	**2nd Q (n=18,106)**	**Low SES (n=7,904)**	**Other Insurance (n=71,899**	**Medicaid (n=2,509)**
Model 1	1.00	1.22 [1.14, 1.30]	1.36 [1.27, 1.46]	1.55 [1.42, 1.70]	1.00	1.78 [1.65, 1.92]
Model 2	1.00	1.22 [1.15, 1.29]	1.36 [1.27, 1.45]	1.55 [1.42, 1.69]	1.00	1.89 [1.75, 2.05]
Model 3	1.00	1.08 [1.02, 1.14]	1.11 [1.05, 1.18]	1.17 [1.08, 1.26]	1.00	1.48 [1.38, 1.60]

Table 12A. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=41,449)**	**3rd Q (n=15,514)**	**2nd Q (n=8,873)**	**Low SES (n=8,572)**	**Other Insurance (n=71,899**	**Medicaid (n=2,509)**
Model 1	1.00	1.11 [1.04, 1.19]	1.16 [1.07, 1.26]	1.01 [0.92, 1.11]	1.00	1.84 [1.70, 1.98]
Model 2	1.00	1.13 [1.06, 1.21]	1.19 [1.09, 1.29]	1.03 [0.94, 1.13]	1.00	1.94 [1.80, 2.10]
Model 3	1.00	1.06 [1.00, 1.11]	1.08 [1.01, 1.15]	0.99 [0.92, 1.06]	1.00	1.50 [1.39, 1.60]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

Table 12B. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals ≥ 65 years

Median value of owner-occupied housing units					Insurance	
PR, 95%CI	**High SES 4th Q (n=16,302)**	**3rd Q (n=12,450)**	**2nd Q (n=4,289)**	**Low SES 1st Q (n=2,914)**	**Supplemental Insurance Plan (n=28,236)**	**Medicare (n=7,719)**
Model 1	1.00	1.14 [1.09, 1.18]	1.16 [1.09, 1.23]	1.26 [1.19, 1.32]	1.00	1.05 [1.03, 1.07]
Model 2	1.00	1.09 [1.06, 1.14]	1.12 [1.07, 1.18]	1.18 [1.09, 1.26]	1.00	1.01 [0.99, 1.02]
Model 3	1.00	1.04 [1.01, 1.07]	1.04 [1.00, 1.09]	1.09 [1.04, 1.14]	1.00	1.01 [0.99, 1.03]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=11,607)**	**3rd Q (n=12,214)**	**2nd Q (n=8,725)**	**Low SES (n=3,409)**	**Supplemental Insurance Plan (n=28,236)**	**Medicare (n=7,719)**
Model 1	1.00	1.11 [1.06, 1.15]	1.18 [1.13, 1.24]	1.26 [1.20, 1.32]	1.00	1.05 [1.03, 1.07]
Model 2	1.00	1.08 [1.03, 1.12]	1.13 [1.09, 1.18]	1.23 [1.17, 1.28]	1.00	1.00 [0.99, 1.02]
Model 3	1.00	1.02 [0.98, 1.06]	1.04 [1.00, 1.08]	1.09 [1.05, 1.14]	1.00	1.01 [1.00, 1.03]

Table 12B. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=19,187)**	**3rd Q (n=8,122)**	**2nd Q (n=4,635)**	**Low SES (n=4,011)**	**Supplemental Insurance Plan (n=28,236)**	**Medicare (n=7,719)**
Model 1	1.00	1.04 [1.00, 1.07]	1.07 [1.02, 1.12]	0.98 [0.93, 1.04]	1.00	1.06 [1.04, 1.07]
Model 2	1.00	1.00 [0.96, 1.04]	1.02 [0.97, 1.06]	0.97 [0.92, 1.01]	1.00	1.01 [0.99, 1.03]
Model 3	1.00	1.00 [0.97, 1.04]	1.00 [0.96, 1.03]	0.97 [0.93, 1.02]	1.00	1.01 [0.99, 1.03]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

Table 12C. Multilevel regression model for the association of tract racial composition with CKD prevalence by race

	Model 1 (PR, 95% CI)	**Model 2 (PR, 95% CI)**	**Model 3 (PR, 95% CI)**	P-value for interaction of tract % black with race
Blacks (n=8,611)				0.01
OR per 5% increase in blacks in census tract	1.03 [1.01, 1.04]	1.00 [0.99, 1.02]	1.00 [0.99, 1.02]	
Whites (n=103,421)				
OR per 5% increase in blacks in census tract	1.03 [1.02, 1.05]	1.02 [1.01, 1.03]	1.01 [1.00, 1.02]	

SES: socioeconomic status, PR: prevalence ratio of CKD

Model 1: tract racial composition, insurance (Medicaid or Medicare vs. other insurance or supplemental insurance plan), age, sex, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, and diabetes
Model 2: model 1 + tract median value of owner occupied housing units (quartiles) + tract % >25 years with a Bachelor's degree or more (quartiles) + tract household income (quartiles)

Analyses using a more restrictive definition for insurance status [complete coverage with certain insurance type between 6/1/2017 and 12/31/2018] (Tables 13A and 13B)

Table 13A Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals <65 years

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=55,332)**	**3rd Q (n=41,562)**	**2nd Q (n=15,145)**	**Low SES 1st Q (n=11,626)**	**Other Insurance (n=84,411)**	**Medicaid (n=2,183)**
Model 1	1.00	1.16 [1.10, 1.19]	1.21 [1.20, 1.36]	1.46 [1.35, 1.58]	1.00	1.74 [1.60, 1.89]
Model 2	1.00	1.17 [1.11, 1.22]	1.29 [1.21, 1.37]	1.48 [1.38, 1.59]	1.00	1.81 [1.67, 1.97]
Model 3	1.00	1.04 [1.00, 1.08]	1.07 [1.02, 1.13]	1.17 [1.09, 1.25]	1.00	1.51 [1.42, 1.59]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=38,118)**	**3rd Q (n=39,882)**	**2nd Q (n=31,605)**	**Low SES (n=14,084)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.19 [1.13, 1.26]	1.31 [1.23, 1.38]	1.41 [1.31, 1.53]	1.00	1.75 [1.61, 1.91]
Model 2	1.00	1.19 [1.13, 1.26]	1.30 [1.23, 1.38]	1.40 [1.29, 1.52]	1.00	1.83 [1.68, 1.99]
Model 3	1.00	1.07 [1.03, 1.12]	1.08 [1.04, 1.13]	1.11 [1.05, 1.18]	1.00	1.51 [1.43, 1.60]

Table 13A. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=67,029)**	**3rd Q (n=26,600)**	**2nd Q (n=15,434)**	**Low SES (n=14,626)**	**Other Insurance (n=118,430)**	**Medicaid (n=5,259)**
Model 1	1.00	1.13 [1.07, 1.19]	1.19 [1.11, 1.27]	1.07 [0.99, 1.17]	1.00	1.78 [1.64, 1.95]
Model 2	1.00	1.14 [1.08, 1.21]	1.20 [1.12, 1.28]	1.09 [0.99, 1.19]	1.00	1.86 [1.71, 2.02]
Model 3	1.00	1.09 [1.04, 1.13]	1.08 [1.03, 1.14]	0.99 [0.94, 1.06]	1.00	1.51 [1.43, 1.60]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

Table 13B. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals ≥ 65 years

Median value of owner-occupied housing units					Insurance	
PR, 95%CI	**High SES 4th Q (n=25,967)**	**3rd Q (n=20,125)**	**2nd Q (n=6,717)**	**Low SES 1st Q (n=4,483)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,304)**
Model 1	1.00	1.13 [1.09, 1.16]	1.12 [1.06, 1.18]	1.18 [1.12, 1.23]	1.00	1.04 [1.02, 1.05]
Model 2	1.00	1.09 [1.07, 1.12]	1.10 [1.05, 1.15]	1.13 [1.05, 1.21]	1.00	1.00 [0.99, 1.02]
Model 3	1.00	1.04 [1.02, 1.07]	1.04 [1.00, 1.09]	1.07 [1.03, 1.12]	1.00	1.01 [0.99, 1.02]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=18,223)**	**3rd Q (n=19,766)**	**2nd Q (n=14,108)**	**Low SES (n=5,195)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,304)**
Model 1	1.00	1.10 [1.06, 1.15]	1.16 [1.11, 1.20]	1.19 [1.14, 1.25]	1.00	1.04 [1.02, 1.05]
Model 2	1.00	1.07 [1.04, 1.11]	1.13 [1.09, 1.17]	1.18 [1.14, 1.23]	1.00	1.01 [0.99, 1.02]
Model 3	1.00	1.03 [1.00, 1.06]	1.05 [1.02, 1.08]	1.09 [1.05, 1.12]	1.00	1.01 [1.00, 1.02]

Table 13B. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=30,449)**	**3rd Q (n=13,181)**	**2nd Q (n=7,287)**	**Low SES (n=6,375)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,304)**
Model 1	1.00	1.05 [1.01, 1.09]	1.07 [1.03, 1.12]	0.99 [0.95, 1.05]	1.00	1.04 [1.03, 1.05]
Model 2	1.00	1.01 [0.98, 1.04]	1.04 [1.00, 1.08]	0.98 [0.94, 1.03]	1.00	1.01 [0.99, 1.02]
Model 3	1.00	1.01 [0.98, 1.03]	1.01 [0.98, 1.04]	1.00 [0.96, 1.03]	1.00	1.01 [0.99, 1.02]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

Analyses using a 12 month time frame (12/31/2017 to 12/31/2018) (Tables 14A, 14B, and 14C)

Table 14A Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals <65 years

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=43,950)**	**3rd Q (n=33,332)**	**2nd Q (n=12,100)**	**Low SES 1st Q (n=9,310)**	**Other Insurance (n=94,576)**	**Medicaid (n=4,116)**
Model 1	1.00	1.13 [1.08, 1.18]	1.22 [1.15, 1.29]	1.37 [1.27, 1.48]	1.00	1.70 [1.60, 1.81]
Model 2	1.00	1.15 [1.10, 1.19]	1.24 [1.17, 1.32]	1.41 [1.30, 1.52]	1.00	1.80 [1.69, 1.92]
Model 3	1.00	1.03 [0.99, 1.08]	1.06 [1.00, 1.11]	1.17 [1.08, 1.26]	1.00	1.50 [1.40, 1.58]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=30,123)**	**3rd Q (n=31,882)**	**2nd Q (n=25,346)**	**Low SES (n=11,341)**	**Other Insurance (n=94,576)**	**Medicaid (n=4,116)**
Model 1	1.00	1.17 [1.11, 1.23]	1.27 [1.20, 1.34]	1.37 [1.27, 1.47]	1.00	1.70 [1.60, 1.81]
Model 2	1.00	1.17 [1.11, 1.23]	1.26 [1.20, 1.33]	1.36 [1.26, 1.47]	1.00	1.81 [1.70, 1.92]
Model 3	1.00	1.06 [1.01, 1.11]	1.08 [1.03, 1.14]	1.09 [1.03, 1.17]	1.00	1.49 [1.40, 1.59]

Table 14A. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=53,732)**	**3rd Q (n=21,110)**	**2nd Q (n=12,317)**	**Low SES (n=11,533)**	**Other Insurance (n=94,576)**	**Medicaid (n=4,116)**
Model 1	1.00	1.13 [1.07, 1.18]	1.13 [1.06, 1.21]	1.03 [0.95, 1.11]	1.00	1.753[1.63, 1.84]
Model 2	1.00	1.15 [1.09, 1.20]	1.16 [1.09, 1.24]	1.06 [0.98, 1.14]	1.00	1.83 [1.73, 1.95]
Model 3	1.00	1.08 [1.03, 1.13]	1.07 [1.03, 1.13]	1.02 [0.96, 1.09]	1.00	1.50 [1.41, 1.59]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

Table 14B. Multilevel regression model for the association of tract level socioeconomic status and insurance status with CKD prevalence in individuals ≥ 65 years

	Median value of owner-occupied housing units				Insurance	
PR, 95%CI	**High SES 4th Q (n=22,517)**	**3rd Q (n=17,572)**	**2nd Q (n=5,887)**	**Low SES 1st Q (n=3,917)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.12 [1.08, 1.16]	1.13 [1.07, 1.19]	1.18 [1.12, 1.23]	1.00	1.04 [1.02, 1.06]
Model 2	1.00	1.09 [1.06, 1.12]	1.10 [1.05, 1.15]	1.13 [1.05, 1.21]	1.00	1.01 [0.99, 1.02]
Model 3	1.00	1.04 [1.01, 1.07]	1.04 [0.99, 1.09]	1.07 [1.02, 1.13]	1.00	1.01 [0.99, 1.02]
	%>25 years with a Bachelor's degree or more				**Insurance**	
PR, 95%CI	**High SES (n=15,834)**	**3rd Q (n=17,110)**	**2nd Q (n=12,366)**	**Low SES (n=4,583)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.11 [1.06, 1.15]	1.16 [1.11, 1.21]	1.19 [1.14, 1.25]	1.00	1.04 [1.03, 1.06]
Model 2	1.00	1.07 [1.04, 1.11]	1.13 [1.09, 1.18]	1.18 [1.13, 1.23]	1.00	1.01 [0.99, 1.02]
Model 3	1.00	1.03 [1.00, 1.02]	1.05 [1.02, 1.09]	1.08 [1.04, 1.12]	1.00	1.01 [1.00, 1.02]

Table 14B. (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=26,568)**	**3rd Q (n=1311,440)**	**2nd Q (n=6,363)**	**Low SES (n=5,522)**	**Supplemental Insurance Plan (n=45,573)**	**Medicare (n=11,719)**
Model 1	1.00	1.06 [1.02, 1.06]	1.07 [1.02, 1.12]	0.99 [0.94, 1.04]	1.00	1.04 [1.03, 1.06]
Model 2	1.00	1.02 [0.99, 1.05]	1.03 [1.00, 1.07]	0.98 [0.93, 1.03]	1.00	1.01 [0.99, 1.03]
Model 3	1.00	1.01 [0.98, 1.04]	1.01 [0.98, 1.04]	0.99 [0.96, 1.04]	1.00	1.01 [0.99, 1.02]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$140,600, 3rd Q: $95,000-$140,600, 2nd Q: $54,200-$95,000, low SES(1st Q): <$54,200

Model 1: tract SES, insurance status
Model 2: model 1, race, sex, age
Model 3: model 2 + obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, and diabetes

Table 14C. Multilevel regression model for the association of tract racial composition with CKD prevalence by race

	Model 1 (PR, 95% CI)	**Model 2 (PR, 95% CI)**	**Model 3 (PR, 95% CI)**	P-value for interaction of tract % black with race
Blacks (n=12,898)				0.01
OR per 5% increase in blacks in census tract	1.02 [1.01, 1.04]	1.01 [0.99, 1.02]	1.00 [0.99, 1.02]	
Whites (n=138,527)				
OR per 5% increase in blacks in census tract	1.02 [1.01, 1.03]	1.02 [1.01, 1.03]	1.02 [1.01, 1.02]	

SES: socioeconomic status, PR: prevalence ratio of CKD

Model 1: tract racial composition, insurance (Medicaid or Medicare vs. other insurance or supplemental insurance plan), age, sex, obesity, smoking, history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, and diabetes
Model 2: model 1 + tract median value of owner occupied housing units (quartiles) + tract % >25 years with a Bachelor's degree or more (quartiles) + tract household income (quartiles)

Table 15. Association of tract racial composition with CKD prevalence by race

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Blacks (n=16,130)			
Percent blacks in tract			
< 5% (n=3,664)	------	------	------
5 - 10% (n=3,474)	1.09 [0.96, 1.23]	1.08 [0.97, 1.21]	1.08 [0.97, 1.21]
10 - 15% (n=2,212)	1.12 [0.99, 1.28]	1.09 [0.96, 1.25]	1.08 [0.95, 1.25]
15 - 20% (n=1,967)	1.08 [0.92, 1.27]	1.05 [0.93, 1.19]	1.03 [0.90, 1.18]
20 - 25% (n=1,137)	1.24 [1.07, 1.47]	1.23 [1.08, 1.40]	1.21 [1.06, 1.40]
25 - 30% (n=584)	1.01 [0.83, 1.22]	0.92 [0.77, 1.12]	0.90 [0.74, 1.09]
30 - 35% (n=464)	1.21 [1.03, 1.43]	1.25 [1.05, 1.49]	1.19 [0.99, 1.44]
35 - 40% (n=725)	1.23 [0.98, 1.57]	1.07 [0.89, 1.30]	1.07 [0.87, 1.32]
40 - 45% (n=1,060)	1.16 [0.98, 1.37]	1.09 [0.97, 1.22]	1.08 [0.94, 1.23]
45 - 50% (n=261)	1.44 [1.26, 1.64]	1.36 [1.21, 1.52]	1.32 [1.13, 1.54]
50 - 55% (n=83)	1.57 [1.32, 1.87]	1.18 [0.92, 1.52]	1.16 [0.86, 1.55]
55 - 60% (n=181)	1.41 [1.03, 1.95]	1.19 [0.91, 1.57]	1.16 [0.86, 1.56]
>60%+ (n=315)	1.11 [0.75, 1.64]	0.91 [0.67, 1.24]	0.88 [0.65, 1.19]
Whites (n=169,139)			
Percent blacks in tract			
< 5% (n=91,543)	------	------	------
5 - 10% (n=41,620)	1.05 [1.01, 1.10]	1.02 [0.99, 1.05]	1.01 [0.98, 1.03]
10 - 15% (n=15,606)	1.15 [1.06, 1.24]	1.08 [1.04, 1.13]	1.05 [1.00, 1.09]
15 - 20% (n=9,703)	1.18 [1.09, 1.27]	1.10 [1.06, 1.15]	1.06 [1.01, 1.10]
20 - 25% (n=4,519)	1.07 [0.97, 1.17]	1.09 [1.03, 1.25]	1.06 [1.00, 1.11]
25 - 30% (n=1,791)	1.08 [0.86, 1.35]	1.15 [1.06, 1.24]	1.09 [1.01, 1.19]
30 - 35% (n=1,346)	1.22 [1.12, 1.33]	1.12 [1.01, 1.24]	1.02 [0.91, 1.15]
35 - 40% (n=1,219)	1.18 [1.02, 1.36]	1.15 [1.06, 1.25]	1.08 [1.01, 1.16]
40 - 45% (n=1,012)	1.02 [0.94, 1.10]	1.04 [0.93, 1.17]	0.98 [0.86, 1.10]
45 - 50% (n=252)	1.18 [0.93, 1.49]	1.32 [1.12, 1.54]	1.19 [1.03, 1.38]
50 - 55% (n=76)	1.01 [0.75, 1.36]	1.24 [1.01, 1.52]	1.11 [0.92, 1.35]
55 - 60% (n=211)	1.29 [0.92, 1.83]	1.19 [0.85, 1.68]	1.07 [0.76, 1.51]
>60%+ (n=218)	0.77 [0.49, 1.18]	0.84 [0.58, 1.22]	0.77 [0.52, 1.10]

SES: socioeconomic status, PR: prevalence ratio of CKD

Model 1: crude
Model 2: model 1 + age, insurance status + history of cardiovascular disease, stroke, cancer, hyperlipidemia, hypertension, diabetes, and outpatient status
Model 3: Model 2 + tract median value of owner occupied housing units, tract % >25 years with a Bachelor's degree or more (quartiles), tract household income (quartiles)

APPENDIX – CHAPTER 4

NOTES ON DATA ANALYSIS:

- **Defining primary care physician visit:**
  It is a completed outpatient office visits to family practice, family practice-internal medicine, internal medicine, obstetrics/gynecology, gerontology or geriatrics clinic visit.

- **Defining race:**
  We used electronic health record data. Race data is usually inputted at first visit to Fairview clinic by an administrator or nurse after asking the patient. A patients' race was considered black if at any time patient has identified as belonging to black race; of the remaining participants we identified sequentially "Asian", "American Indian or Alaska Native or Native Hawaiian or other", "white", and missing/not recorded race.

  Only 1% of our cohort are American Indian or Alaska native or Native Hawaiian and 5% Asian and 4% with missing race. Given the scarcity of data for the other races, we looked at the association of racial composition and chronic kidney disease stratified as black vs. white. When assessing the association of neighborhood socioeconomic status and insurance status with chronic kidney disease, we adjusted for race (4 categorical variables: black, white, other, and we including missingness as a covariate).

  Please note, for eGFR calculation using CKD-EPI, if race was not documented as black in the EHR, we considered it as other

- **Defining insurance status:**
  Patients insurance status was defined as a 4 level categorical variable:
  Medicaid (if <65 years), other insurance (if <65 years), Medicare (if ≥65 years), or supplemental insurance plan (if ≥65 years)

< 65 years:

- Patient considered to be on Medicaid if most recent insurance was reported as Medicaid (end date is not reported or on or after time of index eGFR and start date is before or at time of index eGFR).
- Patient considered to have "other insurance" if most recent insurance was reported as "other"/private insurance (end date is not reported or on or after time of index eGFR and start date is before or at time of index eGFR).
- Otherwise we considered patient to be uninsured (i.e. at most recent time, patient had no Medicaid or other insurance coverage)

≥ 65 years:

- Patients considered to be on Medicare (Part A, B or C*) if that was the only last insurance reported (end date is not reported or on or after time of index eGFR and start date is before or at time of index eGFR).
- Otherwise patients considered to have other supplemental insurance plan

*These include:
MEDICARE PT B ONLY
MEDICARE PT A
RR MEDICARE PT A ONLY
MEDICARE RAILROAD PART B ONLY
MEDICARE
MEDICARE HOMECARE & HOSPICE
ACO MEDICARE
UCARE MEDICARE [Medicare advantage plans]
MEDICARE ADVANTAGE
HEALTHPARTNERS MEDICARE ADVANTAGE
HUMANA MEDICARE ADVANTAGE
UNITED HEALTHCARE MEDICARE ADVANTAGE
ATENA MEDICARE ADVANTAGE
OSF MEDICARE ADVANTAGE
BCBS MEDICARE ADVANTAGE

- Number of tracts included for ACEi/ARB prescription compliance analysis is: 676 out of 704 in Twin Cities
  Median number of patients per tract: 16 [IQR: 8,33]
  Max number of patients: 173

- Number of tracts included for UACR measurement and CKD identification in the EHR analysis is: 676 out of 704 in Twin Cities
  Median number of patients per tract: 25 [IQR: 13, 48]
  Max number of patients: 227

Table 1. Kidney care measures and neighborhood socioeconomic status

	Overall		
	ACEi/ARB prescription compliance	**Urine albumin to creatinine ratio (UACR) measured**	**CKD identified in the EHR**
Median value of owner occupied housing units, n(%)			
Q1: < $165,200	1,022 (64%)	692 (29%)	1,406 (59%)
Q2: $165,200 - $188,100	1,482 (67%)	1,013 (32%)	1,863 (59%)
Q3: $188,100 - $231,300	3,952 (64%)	2,567 (29%)	5,091 (57%)
Q4: ≥ $231,300	4,426 (65%)	2,590 (24%)	5,448 (51%)
Percent of Residents > 25 years with a Bachelor's degree or more, n(%)			
Q1: < 20.4%	1,295 (67%)	865 (31%)	1,652 (59%)
Q2: 20.4% - 34.1%	3,011 (66%)	1,983 (30%)	3,820 (57%)
Q3: 34.1% - 48.1%	3,638 (64%)	2,347 (28%)	4,671 (55%)
Q4: ≥ 48.1%	2,939 (64%)	1,667 (23%)	3,666 (51%)
Median household income, n(%)			
Q1: <$35,935	1,137 (62%)	733 (27%)	1,542 (57%)
Q2: $35,935 - $47,379	1,521 (65%)	928 (27%)	1,978 (58%)
Q3: $47,379 - $62,343	2,532 (64%)	1,608 (27%)	3,323 (57%)
Q4: ≥ $62,343	5,688 (65%)	3,590 (27%)	6,954 (53%)

Median value of owner-occupied housing units: high SES (4^{th} quartile[Q]):≥$231,300, 3^{rd} Q: $188,100-$231,300, 2^{nd} Q: $165,200-$188,100, low SES(1^{st} Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4^{th} quartile[Q]):≥48.1%, 3^{rd} Q: 34.1%-48.1%, 2^{nd} Q: 20.4%-34.1%, low SES(1^{st} Q): <20.4%; Median household income: high SES (4^{th} quartile[Q]):≥$140,600, 3^{rd} Q: $95,000-$140,600, 2^{nd} Q: $54,200-$95,000, low SES(1^{st} Q): <$54,200

* Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking angiotensin converting enzyme inhibitor (ACEi) and angiotensin receptor blocker (ARB)

ACEi/ARB prescription compliance: number of patients ≥18 years on ACEi/ARB/ (number of patients ≥18 years who should be on ACEi/ARB – number of patients with ACEI/ARB exemption) x 100%.

*UACR measured: UACR measured in patients with CKD (eGFR <60 ml/min/1.73m^2). UACR measurement performance was defined as: number of patients who have UACR measured/ number of patients with CKD x 100%

* CKD identified in EHR was defined as: number of patients who have CKD (eGFR <60ml/min/1.73m^2) documented by ICD9/10 codes in EHR / number of patients with CKD x 100%

Table 2A. Kidney care measures and neighborhood socioeconomic status for blacks

	Blacks		
	ACEi/ARB prescription compliance	**Urine albumin to creatinine ratio (UACR) measured**	**CKD identified in the EHR**
Median value of owner occupied housing units, n(%)			
Q1: < $165,200	148 (65%)	95 (32%)	224 (77%)
Q2: $165,200 - $188,100	103 (65%)	72 (34%)	168 (80%)
Q3: $188,100 - $231,300	207 (67%)	136 (36%)	320 (84%)
Q4: ≥ $231,300	125 (67%)	83 (34%)	194 (79%)
Percent of Residents > 25 years with a Bachelor's degree or more, n(%)			
Q1: < 20.4%	128 (61%)	83 (33%)	198 (78%)
Q2: 20.4% - 34.1%	182 (66%)	124 (34%)	297 (82%)
Q3: 34.1% - 48.1%	177 (72%)	118 (37%)	261 (81%)
Q4: ≥ 48.1%	96 (63%)	61 (32%)	150 (79%)
Median household income, n(%)			
Q1: <$35,935	130 (63%)	89 (34%)	212 (81%)
Q2: $35,935 - $47,379	91 (67%)	65 (34%)	152 (80%)
Q3: $47,379 - $62,343	162 (67%)	90 (30%)	249 (82%)
Q4: ≥ $62,343	199 (66%)	142 (38%)	292 (78%)

Median value of owner-occupied housing units: high SES (4_{th} quartile[Q]):≥$231,300, 3_{rd} Q: $188,100-$231,300, 2_{nd} Q: $165,200-$188,100, low SES(1_{st} Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4_{th} quartile[Q]):≥48.1%, 3_{rd} Q: 34.1%-48.1%, 2_{nd} Q: 20.4%-34.1%, low SES(1_{st} Q): <20.4%; Median household income: high SES (4_{th} quartile[Q]):≥$140,600, 3_{rd} Q: $95,000-$140,600, 2_{nd} Q: $54,200-$95,000, low SES(1_{st} Q): <$54,200

* Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking angiotensin converting enzyme inhibitor (ACEi) and angiotensin receptor blocker (ARB)

ACEi/ARB prescription compliance: number of patients on ACEi/ARB/ (number of patients ≥18 years who should be on ACEi/ARB – number of patients with ACEi/ARB exemption) x 100%.

*UACR measured: UACR measured in patients with CKD (eGFR <60 ml/min/1.73m_2). UACR measurement performance was defined as: number of patients who have UACR measured/ number of patients with CKD x 100%

* CKD identified in EHR was defined as: number of patients who have CKD (eGFR <60ml/min/1.73m_2) documented by ICD9/10 codes in EHR / number of patients with CKD x 100%

Table 2B. Kidney care measures and neighborhood socioeconomic status for whites

	Whites		
	ACEi/ARB prescription compliance	**Urine albumin to creatinine ratio (UACR) measured**	**CKD identified in the EHR**
Median value of owner occupied housing units, n(%)			
Q1: < $165,200	678 (63%)	464 (29%)	918 (57%)
Q2: $165,200 - $188,100	1,233 (68%)	837 (32%)	1,503 (57%)
Q3: $188,100 - $231,300	3,484 (64%)	2,245 (28%)	4,396 (56%)
Q4: ≥ $231,300	3,981 (65%)	2,295 (24%)	4,872 (51%)
Percent of Residents > 25 years with a Bachelor's degree or more, n(%)			
Q1: < 20.4%	974 (67%)	656 (31%)	1,212 (58%)
Q2: 20.4% - 34.1%	2,583 (66%)	1,675 (29%)	3,163 (56%)
Q3: 34.1% - 48.1%	3,202 (63%)	2,057 (27%)	4,072 (54%)
Q4: ≥ 48.1%	2,618 (63%)	1,453 (22%)	3,243 (50%)
Median household income, n(%)			
Q1: <$35,935	898 (62%)	575 (26%)	1,171 (54%)
Q2: $35,935 - $47,379	1,292 (65%)	772 (27%)	1,647 (57%)
Q3: $47,379 - $62,343	2,123 (63%)	1,346 (27%)	2,734 (55%)
Q4: ≥ $62,343	5,062 (65%)	3,145 (27%)	6,131 (52%)

Median value of owner-occupied housing units: high SES (4_{th} quartile[Q]):≥$231,300, 3_{rd} Q: $188,100-$231,300, 2_{nd} Q: $165,200-$188,100, low SES(1_{st} Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4_{th} quartile[Q]):≥48.1%, 3_{rd} Q: 34.1%-48.1%, 2_{nd} Q: 20.4%-34.1%, low SES(1_{st} Q): <20.4%; Median household income: high SES (4_{th} quartile[Q]):≥$140,600, 3_{rd} Q: $95,000-$140,600, 2_{nd} Q: $54,200-$95,000, low SES(1_{st} Q): <$54,200

* Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking angiotensin converting enzyme inhibitor (ACEi) and angiotensin receptor blocker (ARB)

ACEi/ARB prescription compliance: number of patients on ACEi/ARB/ (number of patients ≥18 years who should be on ACEi/ARB – number of patients with ACEI/ARB exemption) x 100%.

*UACR measured: UACR measured in patients with CKD (eGFR <60 ml/min/1.73m_2). UACR measurement performance was defined as: number of patients who have UACR measured/ number of patients with CKD x 100%

* CKD identified in EHR was defined as: number of patients who have CKD (eGFR <60ml/min/1.73m_2) documented by ICD9/10 codes in EHR / number of patients with CKD x 100%

Tables 3A, 3B, and 3C are for the cohort included in the analysis of angiotensin prescription compliance

Table 3A. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for nonpregnant adults with HTN and CKD*

	Low SES (4th quartile of median value of owner occupied housing units[≥ $231,300]) N= 1,607	**High SES (1st quartile of median value of owner occupied housing units [< $165,200])** N= 6,825	**p-value**
Individual level demographic characteristics			
Age, mean (SD)	70.5 ± 15.2	73.3 ± 12.9	<0.001
Male, n(%)	617 (38%)	3,126 (46%)	<0.001
Black	229 (14%)	187 (3%)	<0.001
Individual social characteristics (n%)			
Smoker, n(%)	809 (50%)	3,327 (49%)	0.27
Medicaid or Medicare, n(%)	332 (21%)	1,101 (16%)	<0.001
Vitals			
Systolic BP, mmHg	133.4 ± 20.2	131.4 ± 19.7	0.001
Diastolic BP, mmHg	75.7 ± 12.5	74.3 ± 11.8	<0.001
Medical History			
Diabetes, n(%)	706 (44%)	2,217 (33%)	<0.001
Obese (BMI≥ 30 kg/m2), n(%)	706 (46%)	2,667 (42%)	0.001
Cardiovascular disease, n(%)	625 (39%)	2,996 (44%)	<0.001
Stroke, n(%)	169 (11%)	788 (12%)	0.26
Hyperlipidemia, n(%)	1,199 (75%)	5,367 (79%)	0.001
Cancer, n(%)	198 (12%)	1,121 (16%)	<0.001

* Adults (nonpregnant patients) with HTN and CKD (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day)
CKD: chronic kidney disease; HTN: hypertension; DM: diabetes; UACR: urine albumin to creatinine ratio; cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 3B. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for nonpregnant adults with HTN and CKD *

	Low SES (4th quartile of %>25 years with complete college education[≥ $48.1%]) N= 1,945	**High SES (1st quartile of %>25 years with complete college education [<20.4%])** N= 4,600	**p-value**
Individual level demographic characteristics			
Age, mean (SD)	70.0 ± 14.4	73.5 ± 12.9	<0.001
Male, n(%)	780 (40%)	2,105 (46%)	<0.001
Black	209 (11%)	153 (3%)	<0.001
Individual social characteristics			
Smoker, n(%)	1,004 (52%)	2,250 (49%)	0.05
Medicaid or Medicare, n(%)	418 (22%)	728 (16%)	<0.001
Vitals			
Systolic BP, mmHg	133.3 ± 20.3	131.6 ± 19.9	0.002
Diastolic BP, mmHg	75.3 ± 12.5	74.4+ 11.8	0.006
Medical History			
Diabetes, n(%)	877 (45%)	1,447 (32%)	<0.001
Obese (BMI≥ 30 kg/m2), n(%)	942 (51%)	1,663 (39%)	<0.001
Cardiovascular disease, n(%)	759 (39%)	2,059 (45%)	<0.001
Stroke, n(%)	206 (11%)	503 (11%)	0.67
Hyperlipidemia, n(%)	1,480 (76%)	3,571 (78%)	0.19
Cancer, n(%)	231 (12%)	766 (17%)	<0.001

* Adults (nonpregnant patients) with HTN and CKD (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day)
CKD: chronic kidney disease; HTN: hypertension; DM: diabetes; UACR: urine albumin to creatinine ratio; cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 3C. Characteristics of population by tract socioeconomic status in the Twin Cities metro area for nonpregnant adults with HTN and CKD *

	Low SES (4th quartile of household income [≥ $62,343]) N=1,807	**High SES (1st quartile of household income [<$35,935])** N=8,664	**p-value**
Individual level demographic characteristics			
Age, mean (SD)	71.9 ± 13.4	72.7 ± 13.1	0.01
Male, n(%)	779 (43%)	3,758 (43%)	0.86
Black	205 (11%)	303 (4%)	<0.001
Individual social characteristics			
Smoker, n(%)	921 (51%)	4,323 (50%)	0.42
Medicaid or Medicare, n(%)	300 (16%)	1,502 (18%)	0.02
Vitals			
Systolic BP, mmHg	132.5 ± 20.2	131.8 ± 19.6	0.18
Diastolic BP, mmHg	74.9 ± 11.5	74.4 ± 11.8	0.12
Medical History			
Diabetes, n(%)	677 (38%)	3,074 (36%)	0.12
Obese (BMI≥ 30 kg/m2), n(%)	736 (44%)	3,672 (45%)	0.50
Cardiovascular disease, n(%)	768 (43%)	3,725 (43%)	0.72
Stroke, n(%)	198 (11%)	956 (11%)	0.96
Hyperlipidemia, n(%)	1,347 (75%)	6,828 (79%)	<0.001
Cancer, n(%)	279 (15%)	1,394 (16%)	0.52

* Adults (nonpregnant patients) with HTN and CKD (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day)
CKD: chronic kidney disease; HTN: hypertension; DM: diabetes; UACR: urine albumin to creatinine ratio; cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Tables 4A, 4B, and 4C are for the cohort included in the analysis of UACR measurement and if CKD was documented in the EHR i.e. CKD defined as eGFR <60/ml/1.73m2

Table 4A. Characteristics of population by tract socioeconomic status in the Twin Cities metro area with chronic kidney disease

	Low SES (4th quartile of median value of owner occupied housing units[≥ $231,300]) N= 2,375	**High SES (1st quartile of median value of owner occupied housing units [< $165,200])** N= 10,611	**p-value**
Individual level demographic characteristics			
Age, mean (SD)	69.2 ± 15.4	70.9 ± 13.7	<0.001
Male, n(%)	892 (38%)	4,659 (44%)	<0.001
Black	292 (12%)	245 (2%)	<0.001
Individual social characteristics (n%)			
Smoker, n(%)	1,218 (51%)	4,886 (46%)	<0.001
Medicaid or Medicare, n(%)	474 (20%)	1,548 (15%)	<0.001
Vitals			
Systolic BP, mmHg	131.6 ± 20.6	129.6 ± 19.7	<0.001
Diastolic BP, mmHg	75.2 ± 15.6	74.3 ± 11.7	<0.001
Medical History			
Hypertension, n(%)	1,925 (81%)	7,938 (75%)	<0.001
Diabetes, n(%)	902 (38%)	2,842 (27%)	<0.001
Obese (BMI≥ 30 kg/m2), n(%)	972 (44%)	3,722 (38%)	<0.001
Cardiovascular disease, n(%)	868 (37%)	3,888 (37%)	0.95
Stroke, n(%)	237 (10%)	1,030 (10%)	0.72
Hyperlipidemia, n(%)	1,564 (66%)	7.217 (68%)	0.04
Cancer, n(%)	288 (12%)	1,630 (15%)	<0.001

Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 4B. Characteristics of population by tract socioeconomic status in the Twin Cities metro area with chronic kidney disease

	Low SES (4th quartile of %>25 years with complete college education[≥ $48.1%]) N= 2,795	**High SES (1st quartile of %>25 years with complete college education [<20.4%])** N= 7,173	**p-value**
Individual level demographic characteristics			
Age, mean (SD)	68.7 ± 14.7	71.2 ± 13.8	<0.001
Male, n(%)	1,086 (39%)	3,148 (44%)	<0.001
Black	254 (9%)	189 (3%)	<0.001
Individual social characteristics			
Smoker, n(%)	1,480 (53%)	3,265 (46%)	<0.001
Medicaid or Medicare, n(%)	558 (20%)	1,036 (15%)	<0.001
Vitals			
Systolic BP, mmHg	131.7 ± 20.7	129.6 ± 19.9	<0.001
Diastolic BP, mmHg	74.9 ± 12.6	74.3 ± 11.7	0.02
Medical History			
Hypertension, n(%)	2,260 (81%)	5,335 (74%)	<0.001
Diabetes, n(%)	1,080 (39%)	1,844 (26%)	<0.001
Obese (BMI≥ 30 kg/m_2), n(%)	1,245 48%)	2,290 (35%)	<0.001
Cardiovascular disease, n(%)	1,002 (36%)	2,666 (37%)	0.23
Stroke, n(%)	273 (10%)	661 (9%)	0.42
Hyperlipidemia, n(%)	1,891 (68%)	4,817 (67%)	0.65
Cancer, n(%)	336 (12%)	1,106 (15%)	<0.001

Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 4C. Characteristics of population by tract socioeconomic status in the Twin Cities metro area with chronic kidney disease

	Low SES (4th quartile of household income [≥ $62,343]) N=2,723	**High SES (1st quartile of household income [<$35,935])** N=13,104	**p-value**
Individual level demographic characteristics			
Age, mean (SD)	70.0 ± 14.1	70.7 ± 13.9	0.02
Male, n(%)	1,154 (42%)	5,453 (42%)	0.47
Black	260 (10%)	374 (3%)	<0.001
Individual social characteristics			
Smoker, n(%)	1,333 (49%)	6,234 (48%)	0.20
Medicaid or Medicare, n(%)	413 (15%)	2,106 (16%)	0.002
Vitals			
Systolic BP, mmHg	130.9 ± 20.2	130.2 ± 19.7	0.10
Diastolic BP, mmHg	74.7 ± 11.8	74.4 ± 11.9	0.20
Medical History			
Hypertension, n(%)	2,132 (78%)	10,073 (77%)	0.11
Diabetes, n(%)	866 (32%)	3,859 (29%)	0.02
Obese (BMI≥ 30 kg/m_2), n(%)	996 (40%)	4,988 (41%)	0.33
Cardiovascular disease, n(%)	1,024 (38%)	4,823 (37%)	0.44
Stroke, n(%)	262 (10%)	1,257 (10%)	0.99
Hyperlipidemia, n(%)	1,798 (66%)	9,041 (69%)	0.003
Cancer, n(%)	403 (15%)	1,984 (15%)	0.67

Cardiovascular disease includes congestive heart failure, acute myocardial infarction, ischemic heart disease, and peripheral vascular disease

Table 5 and 6: Defined CKD as eGFR <45 ml/min/1.73 m2 instead of eGFR <60 ml/min/1.73m2

Table 5. Multilevel regression model for the association of tract level socioeconomic status with urine albumin to creatinine measurement

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=3,200)	1.00	1.00	1.00
3rd Q (n=2,994)	1.19 [1.03, 1.24]	1.09 [0.99, 1.20]	1.00 [0.99, 1.19]
2nd Q (n=1,145)	1.20 [1.07, 1.35]	1.15 [1.04, 1.28]	1.11 [1.01, 1.22]
Low SES tract – 1st Q (n=926)	1.11 [0.96, 1.29]	1.08 [0.94, 1.26]	1.06 [0.93, 1.21]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=2,132)	1.00	1.00	1.00
3rd Q (n=2,719)	1.17 [1.07, 1.41]	1.14 [1.04, 1.35]	1.11 [1.00, 1.22]
2nd Q (n=2,361)	1.17 [1.05, 1.30]	1.12 [1.01, 1.25]	1.09 [0.99, 1.21]
Low SES tract – 1st Q (n=1,053)	1.23 [1.07, 1.41]	1.18 [1.04, 1.36]	1.12 [1.00, 1.26]
Median household income			
High SES tract – 4th Q (n=3,985)	1.00	1.00	1.00
3rd Q (n=2,033)	0.95 [0.87, 1.07]	0.95 [0.86, 1.04]	0.98 [0.90, 1.07]
2nd Q (n=1,273)	0.93 [0.82, 1.06]	0.93 [0.82, 1.05]	0.93 [0.84, 1.04]
Low SES tract – 1st Q (n=974)	0.93 [0.81, 1.07]	0.95 [0.83, 1.09]	0.98 [0.87, 1.10]

*UACR measured: UACR measured in patients with CKD (**eGFR <45 ml/min/1.73m2**). UACR measurement performance was defined as: number of patients who have UACR measured

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table 6. Multilevel regression model for the association of tract level socioeconomic status with chronic kidney disease (CKD) identification

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=3,200)	1.00	1.00	1.00
3rd Q (n=2,994)	1.03 [1.01, 1.06]	1.03 [1.01, 1.05]	1.02 [1.00, 1.03]
2nd Q (n=1,145)	1.03 [1.00, 1.06]	1.02 [0.98, 1.05]	1.01 [0.98, 1.03]
Low SES tract – 1st Q (n=926)	1.04 [1.01, 1.07]	1.03 [1.00, 1.06]	1.01 [0.98, 1.04]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=2,132)	1.00	1.00	1.00
3rd Q (n=2,719)	1.02 [0.99, 1.05]	1.02 [0.99, 1.04]	1.00 [0.98, 1.03]
2nd Q (n=2,361)	1.04 [1.02, 1.07]	1.03 [1.01, 1.06]	1.01 [0.99, 1.04]
Low SES tract – 1st Q (n=1,053)	1.04 [1.00, 1.07]	1.03 [1.0, 1.07]	1.02 [0.99, 1.05]
Median household income			
High SES tract – 4th Q (n=3,985)	1.00	1.00	1.00
3rd Q (n=2,033)	1.00 [0.98, 1.03]	1.00 [0.97, 1.02]	0.99 [0.97, 1.02]
2nd Q (n=1,273)	1.02 [0.99, 1.05]	1.01 [0.99, 1.05]	1.01 [0.99, 1.04]
Low SES tract – 1st Q (n=974)	0.99 [0.96, 1.02]	0.99 [0.96, 1.01]	0.99 [0.97, 1.02]

* CKD identified in EHR was defined as: number of patients who have CKD (**eGFR <45ml/min/1.73m2**) documented by ICD9/10 codes in EHR

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Tables 7, 8 and 9: Changing time period from 18 months (6/1/2017 - 12/31/2018) to 36 months (12/31/2015 – 12/31/2018)

Table 7. Multilevel regression model for the association of tract level socioeconomic status with angiotensin medication prescription compliance*

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=8,314)	1.00	1.00	1.00
3rd Q (n=7,542)	0.99 [0.97, 1.03]	0.99 [0.97, 1.03]	0.99 [0.96, 1.02]
2nd Q (n=2,680)	1.05 [1.01, 1.10]	1.03 [0.99, 1.07]	1.02 [0.98, 1.06]
Low SES tract – 1st Q (n=2,087)	0.99 [0.93, 1.07]	0.98 [0.92, 1.04]	0.97 [0.92, 1.03]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract (n=5,654) – 4th Q	1.00	1.00	1.00
3rd Q (n=6,938)	1.01 [0.97, 1.05]	1.01 [0.97, 1.07]	1.00 [0.97, 1.04]
2nd Q (n=5,582)	1.04 [0.99, 1.08]	1.03 [0.99, 1.07]	1.01 [0.98, 1.05]
Low SES tract – 1st Q(n=2,449)	1.06 [1.01, 1.10]	1.01 [0.98, 1.07]	1.01 [0.97, 1.05]
Median household income			
High SES tract – 4th Q (n=10,527)	1.00	1.00	1.00
3rd Q (n=4,895)	0.96 [0.93, 1.00]	0.99 [0.95, 1.02]	0.99 [0.95, 1.02]
2nd Q (n=2,931)	0.98 [0.94, 1.03]	1.00 [0.97, 1.05]	1.00 [0.96, 1.04]
Low SES tract – 1st Q (n=2,720)	0.96 [0.92, 1.00]	0.97 [0.93, 1.00]	0.97 [0.93, 1.01]

* Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking angiotensin converting enzyme inhibitor (ACEI) and angiotensin receptor blocker (ARB)
ACEI/ARB prescription compliance: yes if recommended ACEI/ARB prescribed

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Table 8. Multilevel regression model for the association of tract level socioeconomic status with urine albumin to creatinine measurement

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=13,304)	1.00	1.00	1.00
3rd Q (n=11,204)	1.18 [1.11, 1.26]	1.13 [1.06, 1.20]	1.05 [0.99, 1.12]
2nd Q (n=3,939)	1.33 [1.22, 1.45]	1.23 [1.14, 1.33]	1.10 [1.03, 1.18]
Low SES tract – 1st Q (n=3,108)	1.21 [1.09, 1.33]	1.17 [1.63, 1.29]	1.03 [0.95, 1.12]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=9,027)	1.00	1.00	1.00
3rd Q (n=10,602)	1.17 [1.09, 1.26]	1.12 [1.04, 1.21]	1.06 [0.99, 1.13]
2nd Q (n=8,352)	1.28 [1.19, 1.38]	1.19 [1.11, 1.27]	1.06 [1.00, 1.13]
Low SES tract – 1st Q (n=3,574)	1.35 [1.23, 1.47]	1.25 [1.15, 1.36]	1.07 [0.99, 1.16]
Median household income			
High SES tract – 4th Q (n=16,361)	1.00	1.00	1.00
3rd Q (n=7,377)	1.00 [0.94, 1.07]	0.99 [0.94, 1.06]	0.97 [0.92, 1.03]
2nd Q (n=4,331)	0.97 [0.88, 1.06]	0.98 [0.90, 1.07]	0.94 [0.87, 1.01]
Low SES tract – 1st Q (n=3,486)	0.96 [0.87, 1.07]	0.99 [0.90, 1.09]	0.99 [0.89, 1.09]

*UACR measured: UACR measured in patients with CKD (eGFR <60 ml/min/1.73m2).

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table 9. Multilevel regression model for the association of tract level socioeconomic status with chronic kidney disease (CKD) identification

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=13,304)	1.00	1.00	1.00
3rd Q (n=11,204)	1.11 [1.08, 1.15]	1.08 [1.05, 1.11]	1.03 [1.09, 1.06]
2nd Q (n=3,939)	1.15 [1.09, 1.21]	1.11 [1.06, 1.17]	1.04 [0.99, 1.09]
Low SES tract – 1st Q (n=3,108)	1.15 [1.11, 1.20]	1.11 [1.07, 1.16]	1.02 [0.99, 1.06]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=9,027)	1.00	1.00	1.00
3rd Q (n=10,602)	1.08 [1.05, 1.12]	1.06 [1.03, 1.10]	1.02 [0.99, 1.05]
2nd Q (n=8,352)	1.12 [1.08, 1.16]	1.09 [1.06, 1.14]	1.02 [0.98, 1.05]
Low SES tract – 1st Q (n=3,574)	1.15 [1.09, 1.20]	1.13 [1.08, 1.19]	1.03 [0.98, 1.08]
Median household income			
High SES tract – 4th Q (n=16,361)	1.00	1.00	1.00
3rd Q (n=7,377)	1.06 [1.03, 1.09]	1.04 [1.01, 1.08]	1.01 [0.98, 1.04]
2nd Q (n=4,331)	1.09 [1.04, 1.13]	1.07 [1.03, 1.11]	1.02 [0.98, 1.05]
Low SES tract – 1st Q (n=3,486)	1.08 [1.02, 1.14]	1.03 [0.98, 1.09]	1.02 [0.97, 1.07]

* CKD identified in EHR was defined as: number of patients who have CKD (eGFR <60ml/min/1.73m2) documented by ICD9/10 codes in EHR

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Tables 10, 11 and 12. Stratified by age <65 and ≥65

Table 10A. Multilevel regression model for the association of tract level socioeconomic status and insurance status with angiotensin medication compliance* in individuals <65 years (n=4,283)

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=1,603)**	**3rd Q (n=1,492)**	**2nd Q (n=630)**	**Low SES 1st Q (n=558)**	**Other Insurance (n=3,906)**	**Medicaid (n=287)**
Model 1	1.00	1.00 [0.95, 1.05]	0.97 [0.91, 1.05]	1.03 [0.96, 1.10]	1.00	0.87 [0.78, 0.96]
Model 2	1.00	1.00 [0.95, 1.05]	0.98 [0.90, 1.06]	1.02 [0.95, 1.09]	1.00	0.89 [0.81, 0.99]
Model 3	1.00	0.99 [0.94, 1.04]	0.96 [0.89, 1.04]	1.01 [0.94, 1.08]	1.00	0.89 [0.81, 1.00]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=1,030)**	**3rd Q (n=1,302)**	**2nd Q (n=1,269)**	**Low SES (n=682)**	**Other Insurance (n=3,906)**	**Medicaid (n=287)**
Model 1	1.00	1.03 [0.97, 1.09]	0.99 [0.93, 1.06]	1.01 [0.94, 1.08]	1.00	0.87 [0.78, 0.96]
Model 2	1.00	1.02 [0.96, 1.08]	0.98 [0.92, 1.05]	1.01 [0.94, 1.08]	1.00	0.89 [0.81, 0.99]
Model 3	1.00	1.00 [0.94, 1.06]	0.97 [0.91, 1.03]	0.99 [0.93, 1.06]	1.00	0.90 [0.81, 1.00]

Table 10A (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=2,160)**	**3rd Q (n=996)**	**2nd Q (n=612)**	**Low SES (n=515)**	**Other Insurance (n=3,906)**	**Medicaid (n=287)**
Model 1	1.00	1.00 [0.95, 1.05]	0.97 [0.90, 1.04]	0.93 [0.86, 1.00]	1.00	1.75 [1.63, 1.84]
Model 2	1.00	1.01 [0.95, 1.07]	0.97 [0.91, 1.04]	0.94 [0.87, 1.02]	1.00	0.89 [0.81, 1.00]
Model 3	1.00	1.01 [0.96, 1.07]	0.96 [0.90, 1.03]	0.95 [0.88, 1.03]	1.00	0.90 [0.81, 1.00]

* Adults (nonpregnant patients) with HTN and CKD (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) taking angiotensin converting enzyme inhibitor (ACEI) and angiotensin receptor blocker (ARB)

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: insurance status
Model 2: model 1 + age, race, sex, obesity, smoking
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension

Table 10B. Multilevel regression model for the association of tract level socioeconomic status and insurance status with angiotensin medication compliance* in individuals ≥65 years (n=12,493)

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=5,222)**	**3rd Q (n=4,652)**	**2nd Q (n=1,566)**	**Low SES 1st Q (n=1,053)**	**Supplemental Insurance Plan (n=9,665)**	**Medicare (n=2,767)**
Model 1	1.00	0.99 [0.96, 1.02]	1.07 [1.01, 1.12]	0.96 [0.88, 1.05]	1.00	1.03 [1.01, 1.05]
Model 2	1.00	0.99 [0.96, 1.02]	1.05 [1.00, 1.10]	0.96 [0.88, 1.05]	1.00	1.03 [1.01, 1.04]
Model 3	1.00	0.99 [0.96, 1.02]	1.04 [0.99, 1.09]	0.95 [0.87, 1.03]	1.00	1.02 [1.01, 1.04]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=3,570**	**3rd Q (n=4,366)**	**2nd Q (n=3,291)**	**Low SES (n=1,266)**	**Supplemental Insurance Plan (n=9,665)**	**Medicare (n=2,767)**
Model 1	1.00	0.99 [0.95, 1.04]	1.04 [1.01, 1.09]	1.06 [1.01, 1.11]	1.00	1.03 [1.01, 1.05]
Model 2	1.00	0.99 [0.95, 1.03]	1.04 [1.00, 1.08]	1.04 [0.99, 1.09]	1.00	1.03 [1.01, 1.04]
Model 3	1.00	0.99 [0.95, 1.03]	1.03 [0.99, 1.07]	1.02 [0.97, 1.07]	1.00	1.02 [1.01, 1.04]

Table 10B (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=6,504)**	**3rd Q (n=2,960)**	**2nd Q (n=1,722)**	**Low SES (n=1,307)**	**Supplemental Insurance Plan (n=9,665)**	**Medicare (n=2,767)**
Model 1	1.00	0.97 [0.92, 1.01]	1.00 [0.96, 1.05]	0.97 [0.93, 1.01]	1.00	1.03 [1.01, 1.05]
Model 2	1.00	0.97 [0.93, 1.01]	1.00 [0.96, 1.05]	0.97 [0.93, 1.01]	1.00	1.03 [1.01, 1.04]
Model 3	1.00	0.97 [0.93, 1.01]	0.99 [0.95, 1.05]	0.98 [0.94, 1.01]	1.00	1.02 [1.01, 1.04]

* Adults (nonpregnant patients) with HTN and CKD (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) taking angiotensin converting enzyme inhibitor (ACEI) and angiotensin receptor blocker (ARB)

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: insurance status
Model 2: model 1 + age, race, sex, obesity, smoking
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension

Table 11A. Multilevel regression model for the association of tract level socioeconomic status and insurance status with urine albumin to creatinine measures in individuals <65 years (n=7,753)

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=2,110)**	**3rd Q (n=2,436)**	**2nd Q (n=2,127)**	**Low SES 1st Q (n=1,080)**	**Other Insurance (n=7,025)**	**Medicaid (n=539)**
Model 1	1.00	1.15 [1.03, 1.27]	1.25 [1.11, 1.42]	1.23 [1.07, 1.41]	1.00	0.89 [0.74, 1.06]
Model 2	1.00	1.12 [1.01, 1.24]	1.19 [1.05, 1.35]	1.15 [0.99, 1.32]	1.00	0.89 [0.75, 1.08]
Model 3	1.00	0.98 [0.89, 1.07]	1.01 [0.89, 1.13]	0.95 [0.84, 1.06]	1.00	0.80 [0.68, 0.95]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=2,110)**	**3rd Q (n=2,436)**	**2nd Q (n=2,127)**	**Low SES (n=1,080)**	**Other Insurance (n=7,025)**	**Medicaid (n=539)**
Model 1	1.00	1.19 [1.06, 1.34]	1.25 [1.10, 1.42]	1.33 [1.16, 1.55]	1.00	0.89 [0.74, 1.06]
Model 2	1.00	1.15 [1.02, 1.29]	1.18 [1.04, 1.33]	1.21 [1.05, 1.40]	1.00	0.88 [0.73, 1.06]
Model 3	1.00	1.10 [0.99, 1.23]	1.03 [0.93, 1.15]	1.02 [0.90, 1.16]	1.00	0.80 [0.68, 0.95]

Table 11A (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=4,074)**	**3rd Q (n=1,739)**	**2nd Q (n=1,033)**	**Low SES (n=907)**	**Other Insurance (n=7,025)**	**Medicaid (n=539)**
Model 1	1.00	1.04 [0.94, 1.16]	1.01 [0.88, 1.16]	1.08 [0.93, 1.26]	1.00	0.92 [0.77, 1.09]
Model 2	1.00	1.01 [0.91, 1.12]	0.96 [0.84, 1.10]	1.09 [0.95, 1.27]	1.00	0.89 [0.75, 1.08]
Model 3	1.00	0.99 [0.91, 1.09]	0.92 [0.81, 1.04]	1.06 [0.92, 1.22]	1.00	0.81 [0.68, 0.96]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: insurance status
Model 2: model 1 + age, race, sex, obesity, smoking
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table 11B. Multilevel regression model for the association of tract level socioeconomic status and insurance status with urine albumin to creatinine measures in individuals ≥65 years (n=17,344)

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=7,382)**	**3rd Q (n=6,342)**	**2nd Q (n=2,123)**	**Low SES 1st Q (n=1,497)**	**Supplemental Insurance Plan (n=13,524)**	**Medicare (n=3,707)**
Model 1	1.00	1.19 [1.10, 1.29]	1.38 [1.24, 1.54]	1.23 [1.07, 1.42]	1.00	1.07 [1.05, 1.11]
Model 2	1.00	1.16 [1.08, 1.26]	1.30 [1.18, 1.44]	1.18 [1.02, 1.36]	1.00	1.09 [1.06, 1.12]
Model 3	1.00	1.09 [1.02, 1.18]	1.18 [1.07, 1.29]	1.03 [0.91, 1.18]	1.00	1.08 [1.05, 1.10]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=5,063)**	**3rd Q (n=6,014)**	**2nd Q (n=4,546)**	**Low SES (n=1,721)**	**Supplemental Insurance Plan (n=13,524)**	**Medicare (n=3,707)**
Model 1	1.00	1.21 [1.09, 1.32]	1.31 [1.19, 1.44]	1.37 [1.22, 1.55]	1.00	1.08 [1.05, 1.11]
Model 2	1.00	1.16 [1.06, 1.28]	1.24 [1.14, 1.36]	1.29 [1.15, 1.45]	1.00	1.09 [1.06, 1.12]
Model 3	1.00	1.09 [0.99, 1.19]	1.12 [1.03, 1.21]	1.10 [0.99, 1.23]	1.00	1.07 [1.05, 1.10]

Table 11B (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=9,030)**	**3rd Q (n=4,118)**	**2nd Q (n=2,358)**	**Low SES (n=1,838)**	**Supplemental Insurance Plan (n=13,524)**	**Medicare (n=3,707)**
Model 1	1.00	1.01 [0.92, 1.10]	0.98 [0.87, 1.09]	0.94 [0.84, 1.07]	1.00	1.08 [1.05, 1.11]
Model 2	1.00	0.99 [0.92, 1.08]	0.97 [0.87, 1.09]	0.92 [0.81, 1.05]	1.00	1.09 [1.06, 1.13]
Model 3	1.00	0.97 [0.90, 1.05]	0.92 [0.83, 1.02]	0.94 [0.84, 1.05]	1.00	1.08 [1.06, 1.11]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: insurance status
Model 2: model 1 + age, race, sex, obesity, smoking
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension

Table 12A. Multilevel regression model for the association of tract level socioeconomic status and insurance status with chronic kidney disease (CKD) identification in individuals <65 years (n=7,753)

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=3,229)**	**3rd Q (n=2,598)**	**2nd Q (n=1,041)**	**Low SES 1st Q (n=885)**	**Other Insurance (n=7,024)**	**Medicaid (n=539)**
Model 1	1.00	1.17 [1.10, 1.24]	1.24 [1.13, 1.36]	1.29 [1.19, 1.39]	1.00	1.41 [1.32, 1.51]
Model 2	1.00	1.15 [1.08, 1.23]	1.18 [1.08, 1.28]	1.19 [1.11, 1.27]	1.00	1.32 [1.23, 1.41]
Model 3	1.00	1.05 [0.99, 1.10]	1.05 [0.97, 1.13]	1.03 [0.97, 1.09]	1.00	1.07 [1.02, 1.14]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=2,110)**	**3rd Q (n=2,436)**	**2nd Q (n=2,127)**	**Low SES (n=1,080)**	**Other Insurance (n=7,024)**	**Medicaid (n=539)**
Model 1	1.00	1.09 [1.02, 1.18]	1.17 [1.08, 1.27]	1.23 [1.12, 1.35]	1.00	1.44 [1.34, 1.54]
Model 2	1.00	1.09 [1.01, 1.17]	1.12 [1.04, 1.21]	1.18 [1.08, 1.28]	1.00	1.33 [1.25, 1.42]
Model 3	1.00	1.03 [0.97, 1.09]	0.99 [0.92, 1.05]	1.02 [0.95, 1.10]	1.00	1.08 [1.01, 1.14]

Table 12A (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=4,074)**	**3rd Q (n=1,739)**	**2nd Q (n=1,033)**	**Low SES (n=907)**	**Other Insurance (n=7,024)**	**Medicaid (n=539)**
Model 1	1.00	1.12 [1.05, 1.20]	1.19 [1.10, 1.29]	1.18 [1.08, 1.29]	1.00	1.44 [1.34, 1.54]
Model 2	1.00	1.07 [1.00, 1.14]	1.12 [1.04, 1.20]	1.12 [1.03, 1.21]	1.00	1.34 [1.25, 1.43]
Model 3	1.00	1.03 [0.98, 1.09]	1.03 [0.97, 1.10]	1.05 [0.98, 1.13]	1.00	1.08 [1.01, 1.14]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: insurance status
Model 2: model 1 + age, race, sex, obesity, smoking
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table 12B. Multilevel regression model for the association of tract level socioeconomic status and insurance status with chronic kidney disease (CKD) identification in individuals ≥65 years (n=17,344)

Median value of owner-occupied housing units					**Insurance**	
PR, 95%CI	**High SES 4th Q (n=7,382)**	**3rd Q (n=6,342)**	**2nd Q (n=2,123)**	**Low SES 1st Q (n=1,497)**	**Supplemental Insurance Plan (n=13,524)**	**Medicare (n=3,707)**
Model 1	1.00	1.08 [1.04, 1.11]	1.11 [1.06, 1.17]	1.10 [1.05, 1.16]	1.00	1.01 [0.99, 1.03]
Model 2	1.00	1.06 [1.03, 1.09]	1.09 [1.04, 1.14]	1.07 [1.02, 1.12]	1.00	1.00 [1.08, 1.14]
Model 3	1.00	1.02 0.99, 1.05]	1.03 [0.98, 1.08]	1.02 [0.98, 1.07]	1.00	1.01 [1.00, 1.03]
%>25 years with a Bachelor's degree or more					**Insurance**	
PR, 95%CI	**High SES (n=5,063)**	**3rd Q (n=6,014)**	**2nd Q (n=4,546)**	**Low SES (n=1,721)**	**Supplemental Insurance Plan (n=13,524)**	**Medicare (n=3,707)**
Model 1	1.00	1.07 [1.03, 1.11]	1.10 [1.06, 1.15]	1.14 [1.08, 1.21]	1.00	1.01 [0.99, 1.03]
Model 2	1.00	1.05 [1.01, 1.09]	1.08 [1.04, 1.12]	1.11 [1.06, 1.17]	1.00	1.00 [0.99, 1.02]
Model 3	1.00	1.01 [0.98, 1.05]	1.02 [0.99, 1.06]	1.04 [0.99, 1.09]	1.00	1.01 [1.00, 1.03]

Table 12B (continued)

	Median household income				Insurance	
PR, 95%CI	**High SES (n=9,030)**	**3rd Q (n=4,118)**	**2nd Q (n=2,358)**	**Low SES (n=1,838)**	**Supplemental Insurance Plan (n=13,524)**	**Medicare (n=3,707)**
Model 1	1.00	1.04 [1.01, 1.08]	1.06 [1.01, 1.09]	1.03 [0.97, 1.09]	1.00	1.01 [0.99, 1.03]
Model 2	1.00	1.02 [0.99, 1.06]	1.04 [1.00, 1.08]	0.99 [0.94, 1.06]	1.00	1.01 [0.99, 1.02]
Model 3	1.00	1.00 [0.97, 1.03]	0.99 [0.96, 1.04]	1.00 [0.95, 1.05]	1.00	1.02 [1.00, 1.03]

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: insurance status
Model 2: model 1 + age, race, sex, obesity, smoking
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table 13. Multilevel regression model for the association of tract level socioeconomic status with angiotensin medication prescription compliance*
Defining ACEi/ARB prescription compliance based on the ACC/AHA and ADA guidelines

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=7,804)	1.00	1.00	1.00
3rd Q (n=7,137)	0.99 [0.97, 1.02]	0.99 [0.97, 1.02]	0.99 [0.97, 1.01]
2nd Q (n=2,600)	1.05 [1.01, 1.09]	1.03 [1.00, 1.07]	1.02 [0.98, 1.05]
Low SES tract – 1st Q (n=1,976)	0.99 [0.93, 1.05]	0.98 [0.93, 1.03]	0.96 [0.92, 1.01]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract (n=5,221) – 4th Q	1.00	1.00	1.00
3rd Q (n=6,561)	1.01 [0.97, 1.05]	1.00 [0.97, 1.04]	0.99 [0.96, 1.03]
2nd Q (n=5,376)	1.04 [1.00, 1.07]	1.03 [0.99, 1.06]	1.01 [0.98, 1.04]
Low SES tract – 1st Q(n=2,359)	1.05 [1.01, 1.09]	1.03 [0.99, 1.06]	1.00 [0.97, 1.04]
Median household income			
High SES tract – 4th Q (n=10,079)	1.00	1.00	1.00
3rd Q (n=4,597)	0.98 [0.95, 1.02]	0.99 [0.94, 1.02]	0.99 [0.96, 1.02]
2nd Q (n=2,728)	0.99 [0.96, 1.03]	1.00 [0.97, 1.03]	0.99 [0.96, 1.03]
Low SES tract – 1st Q (n=2,113)	0.97 [0.94, 1.00]	0.97 [0.94, 1.00]	0.98 [0.95, 1.01]

* Adults (nonpregnant patients) with HTN and CKD (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) taking angiotensin converting enzyme inhibitor (ACEi) and angiotensin receptor blocker (ARB) or **nonpregnant patients with DM, HTN and albuminuria (UACR >30mg/day)**

SES: socioeconomic status, PR: prevalence ratio of CKD for individual in low SES tract vs. high SES tract
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: model 1 + age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Tables 14, 15 and 16: only including creatinine obtained during primary care physician visits

Table 14. Multilevel regression model for the association of tract level socioeconomic status with angiotensin medication prescription compliance*

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=3,783)	1.00	1.00	1.00
3rd Q (n=3,404)	0.99 [0.96, 1.02]	0.99 [0.97, 1.02]	0.99 [0.96, 1.02]
2nd Q (n=1,271)	1.01 [0.97, 1.05]	1.01 [0.97, 1.05]	1.00 [0.96, 1.04]
Low SES tract – 1st Q (n=932)	0.97 [0.92, 1.03]	0.97 [0.92, 1.04]	0.96 [0.91, 1.01]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract (n=2,569) – 4th Q	1.00	1.00	1.00
3rd Q (n=3,122)	1.00 [0.97, 1.04]	0.99 [0.96, 1.04]	0.99 [0.96, 1.03]
2nd Q (n=2,547)	1.03 [0.99, 1.07]	1.02 [0.99, 1.06]	1.01 [0.97, 1.04]
Low SES tract – 1st Q(n=1,152)	1.01 [0.97, 1.06]	1.01 [0.97, 1.06]	0.99 [0.95, 1.04]
Median household income			
High SES tract – 4th Q (n=4,915)	1.00	1.00	1.00
3rd Q (n=2,162)	1.00 [0.97, 1.04]	1.01 [0.97, 1.01]	1.00 [0.97, 1.04]
2nd Q (n=1,299)	1.00 [0.97, 1.05]	1.01 [0.97, 1.05]	1.00 [0.97, 1.04]
Low SES tract – 1st Q (n=1,014)	0.97 [0.93, 1.01]	0.97 [0.93, 1.01]	0.98 [0.94, 1.02]

* Adults (nonpregnant patients) with hypertension and chronic kidney disease (stage 3 or higher, or stage 1 or 2 with UACR >300mg/day) should be taking angiotensin converting enzyme inhibitor (ACEI) and angiotensin receptor blocker (ARB)
ACEI/ARB prescription compliance: yes if recommended ACEI/ARB prescribed

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes

Table 15. Multilevel regression model for the association of tract level socioeconomic status with urine albumin to creatinine measurement

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=5,936)	1.00	1.00	1.00
3rd Q (n=4,948)	1.10 [1.00, 1.22]	1.08 [0.97, 1.20]	1.02 [0.92, 1.14]
2nd Q (n=1,803)	1.11 [0.97, 1.28]	1.06 [0.91, 1.23]	0.98 [0.84, 1.13]
Low SES tract – 1st Q (n=1,364)	1.02 [0.87, 1.21]	1.00 [0.84, 1.17]	0.88 [0.75, 1.02]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=4,051)	1.00	1.00	1.00
3rd Q (n=4,655)	1.17 [1.04, 1.32]	1.12 [0.99, 1.27]	1.08 [0.96, 1.22]
2nd Q (n=3,704)	1.18 [1.05, 1.33]	1.13 [1.01, 1.27]	1.03 [0.92, 1.16]
Low SES tract – 1st Q (n=1,641)	1.00 [0.85, 1.16]	0.94 [0.80, 1.10]	0.83 [0.72, 0.98]
Median household income			
High SES tract – 4th Q (n=7,432)	1.00	1.00	1.00
3rd Q (n=3,194)	1.06 [0.95, 1.19]	1.03 [0.92, 1.16]	1.03 [0.92, 1.16]
2nd Q (n=1,893)	1.01 [0.88, 1.16]	1.00 [0.88, 1.15]	0.97 [0.85, 1.10]
Low SES tract – 1st Q (n=1,532)	0.95 [0.81, 1.11]	0.94 [0.79, 1.10]	0.95 [0.81, 1.10]

*UACR measured: UACR measured in patients with CKD (eGFR <60 ml/min/1.73m2).

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR

Table 16. Multilevel regression model for the association of tract level socioeconomic status with chronic kidney disease (CKD) identification

	Model 1 (PR, 95% CI)	Model 2 (PR, 95% CI)	Model 3 (PR, 95% CI)
Median *value of owner-occupied housing units is the measure of SES*			
High SES tract – 4th Q (n=5,936)	1.00	1.00	1.00
3rd Q (n=4,948)	1.10 [1.06, 1.15]	1.08 [1.04, 1.12]	1.02 [0.97, 1.06]
2nd Q (n=1,803)	1.14 [1.08, 1.21]	1.11 [1.04, 1.17]	1.02 [0.97, 1.07]
Low SES tract – 1st Q (n=1,364)	1.15 [1.19, 1.21]	1.11 [1.05, 1.16]	1.01 [0.96, 1.05]
***Percent of residents >25 years with* a Bachelor's degree or more**			
High SES tract – 4th Q (n=4,051)	1.00	1.00	1.00
3rd Q (n=4,655)	1.07 [1.02, 1.12]	1.06 [1.01, 1.10]	1.00 [0.97, 1.04]
2nd Q (n=3,704)	1.11 [1.05, 1.16]	1.08 [1.03, 1.13]	1.00 [0.96, 1.04]
Low SES tract – 1st Q (n=1,641)	1.13 [1.07, 1.20]	1.11 [1.05, 1.17]	1.01 [0.96, 1.06]
Median household income			
High SES tract – 4th Q (n=7,432)	1.00	1.00	1.00
3rd Q (n=3,194)	1.09 [1.05, 1.14]	1.07 [1.03, 1.11]	1.03 [0.99, 1.06]
2nd Q (n=1,893)	1.07 [1.02, 1.13]	1.06 [1.01, 1.11]	1.01 [0.97, 1.05]
Low SES tract – 1st Q (n=1,532)	1.04 [0.97, 1.12]	1.01 [0.95, 1.08]	1.01 [0.96, 1.06]

* CKD identified in EHR was defined as: number of patients who have CKD (eGFR <60ml/min/1.73m2) documented by ICD9/10 codes in EHR

SES: socioeconomic status, PR: prevalence ratio
Median value of owner-occupied housing units: high SES (4th quartile[Q]):≥$231,300, 3rd Q: $188,100-$231,300, 2nd Q: $165,200-$188,100, low SES(1st Q): <$165,200; %>25 years with a Bachelor's degree or more: high SES (4th quartile[Q]):≥48.1%, 3rd Q: 34.1%-48.1%, 2nd Q: 20.4%-34.1%, low SES(1st Q): <20.4%; Median household income: high SES (4th quartile[Q]):≥$62,343, 3rd Q: $47,379 - $62,343, 2nd Q: $35,935 - $47,379, low SES(1st Q): <$35,935

Model 1: crude
Model 2: age, sex, race, obesity, smoking, insurance status
Model 3: model 2 + history of cardiovascular disease, stroke, cancer, hyperlipidemia, diabetes, hypertension, index eGFR