# The association between neighborhood socioeconomic status and the prevention and control of prediabetes and diabetes in King County, Washington

Dana H. Meranus

A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2014

Reading Committee:

Andreas Stergachis, Chair

Ali H. Mokdad

James P. LoGerfo, Sr.

Program Authorized to Offer Degree:

Public Health: Epidemiology

University of Washington

## Abstract

The association between neighborhood socioeconomic status and the prevention and control of prediabetes and diabetes in King County, Washington

Dana H. Meranus

Chair of the Supervisory Committee:

Professor Andreas (Andy) Stergachis

Department of Epidemiology & Department of Global Health

**Introduction:** Diabetes, a recognized and increasing public health problem, disproportionately affects low poverty neighborhoods. The mechanisms connecting place and health disparities have not been well-described at the community-level due to a lack of robust data representative of neighborhoods. Identifying disease prevention and management gaps in neighborhoods has importance for public health practitioners, policymakers, and population health.

**Methods:** Our cross-sectional study included adults who participated in the Monitoring Disparities in Chronic Conditions (MDCC) Study, a pilot chronic disease surveillance system in King County (KC), Washington (2011-2012), and who either (1) met American Diabetes

Association diabetes screening criteria or (2) reported a non-gestational prediabetes or diabetes mellitus diagnosis. Data were collected by questionnaire (self-reported) and pharmacy record abstraction. Neighborhood socioeconomic status (SES) was defined using the percentage of residents living at ≤200% federal poverty level from the United States Census Bureau American Community Survey. Weighted logistic regression modeled the association between neighborhood SES and health indicators for quality care, healthy behaviors, disease self-management, and clinical biomarkers. Sensitivity, specificity, and Cohen's kappa assessed concordance between self-reported medication use and pharmacy dispensing records.

**Results:** Among KC adults screened to participate in the MDCC Study, 52.4% who were eligible and agreed to participate completed the core survey; 89.9% of these participants met this dissertation's inclusion criteria. Given the same age, education, and regular healthcare source status, adults with diabetes in low SES neighborhoods, compared to high SES neighborhoods, are significantly less likely to achieve glycemic control (HbA1c, <8%) (OR: 0.19, 95% CI: 0.06-0.62). Significant neighborhood differences in the prevalence of risk factors, lifestyle, and unmet medical need may contribute to observed health disparities.

**Conclusion:** Using community-level data, we found that neighborhood SES was associated significantly with multiple health indicators, with adults living in higher poverty neighborhoods often faring worse. Interventions to prevent disease should target adults with multiple diabetes risk factors, prior to prediabetes diagnosis, to prevent the development of clinical disease and comorbidities. High unmet medical need, and the absence of continuous, coordinated care contribute to health disparities, but we found evidence that neighborhood context is associated with health inequalities and disproportionate disease burden.

**Table of Contents**

## List of Figures

## List of Tables

**ACKNOWLEDGEMENTS**

I would like to thank my supervisory committee chair, Andy Stergachis, for his generous support, providing academic and professional opportunities, and thoughtful mentorship since my arrival at the University of Washington in 2009. I am grateful to have had the opportunity to be mentored by Ali Mokdad, and appreciate his time, generosity, advice, and support through the entire dissertation process. I appreciate the expertise, support and helpful feedback of David Solet, as well as his enthusiasm for both this research project, facilitating my access to PHSKC resources, and furthering my public health practice experiences. I also would like to thank Jim LoGerfo for offering his clinical expertise and guidance during this dissertation, allowing me to frame my project to have both clinical and social meaning. This research project would not have been possible without the assistance of Institute for Health Metrics and Evaluation (IHME) staff who enabled me to use IHME resources to complete my work; and, certainly not possible without the Monitoring Disparities in Chronic Conditions (MDCC) study team that designed and implemented the MDCC study and unfailingly provided data and technical support. Additionally, this project would not have been possible without the support of the Public Health – Seattle & King County Assessment, Policy Development, and Evaluation Unit, which provided me with guidance and access to multiple data sources. I would like to recognize the financial assistance I have received during my time at the University of Washington through research assistantships, at the Northwest Center for Public Health Practice (2009-2011) and the National Alzheimer's Coordinating Center (2011-2014). Finally, I would like to thank my mom, Barbara Meranus; my sister, Stacy Robin; and, my friends, as geographically dispersed as they all are, for their unfailing support and encouragement throughout my time in graduate school.

## Introduction

Diabetes is recognized as an important, and increasing, public health problem worldwide (1). As the diabetes burden grows, so does the cost associated with the disease: between 2007 and 2012, the estimated total economic cost of diagnosed diabetes increased 41%, from $174 billion to $245 billion (2). Ongoing population-based surveillance is essential to identify communities with the highest diabetes risk and burden to inform health strategies to reduce disease-related morbidity and premature mortality. Currently, a lack of robust data collection and continuous health-related data tracking at the neighborhood level prevent public health practitioners from adequately describing the association between neighborhoods and health. Our research takes advantage of a large-scale feasibility study that collected health-related data to be representative at the county level in King County (KC), Washington, where the number of people with diabetes has doubled in the past decade, disproportionately affecting individuals and neighborhoods with low socioeconomic status (SES) (3, 4).

### Conceptual model

The conceptual model (Figure 1) that provides the framework for this research builds on other models described previously that address social determinants of health (5-13). The model considers multiple levels of influence on health, proposing that neighborhood resources and the physical environment mediate the relationship between socioeconomic-political context and more proximate behavioral, stressor, health systems, and biological processes.

First, the framework considers fundamental and structural factors, basic conditions that drive observed social gradients (14), shaping both intermediate mechanisms and proximal factors on the pathways that influence health among people at high risk for diabetes, and those with diagnosed diabetes. We conceptualize poverty, the condition of a community in which people are located, as neighborhood socioeconomic position (SEP). A lower SEP leads to poorer overall health, both directly and indirectly (5, 15-18). Ultimately, the socioeconomic-political context influences multiple pathways that lead to health outcomes (5, 14). Next, the model conceptualizes intermediate factors as neighborhood physical environment and neighborhood resources, the availability of which has been estimated to be associated with a 38% lower incidence of diabetes (19).

Proximate factors typically gain the most attention in research on the prevention and management of morbidities. These proximate factors, conceptualized as health care access, receipt of care, behavioral processes, and stressors, are individual-level determinants differentially distributed by SEP directly, and also indirectly through the mediating effects of the neighborhood physical environment. Lack of health insurance is a primary reason why diabetes patients do not seek medical care (20), and uninsured individuals are less likely to receive preventive and management services and more likely to have low incomes (21). When healthcare access improves, socioeconomic inequalities can be reduced, although not eliminated completely (22-25). Additionally, socioeconomic differences exist in the receipt of disease-appropriate care and advice, like disease screening and routine management (26-28). Learning about diabetes management is important among those diagnosed, yet diabetes education rates among patients is particularly low among those with lower socioeconomic status, and those living outside urban areas (29). Further, differential adherence patterns to medication regimens are, in part, cost-related (30, 31). Poor control of blood glucose levels, and difficulty adhering to healthy behaviors, has been linked to stressors, such as perceived discrimination, with variation observed both by race/ethnicity and socioeconomic status (8, 10, 32-35). The framework, tracing the multiple pathways leading to health status, also accounts for the potential confounding/modifying effects of individual-level socioeconomic factors like age, income, education, marital status, and race/ethnicity on the SEP-health association.

## Specific Aims

The goal of our research was to understand the association between neighborhood poverty, neighborhood-level mechanisms, individual characteristics, healthcare access, and diabetes-related prevention and management strategies, using a cross-sectional study design. The primary aims of our study were to:

1. Identify the prevalence of individual-level and area-level neighborhood characteristics and their influence on the receipt of preventive healthcare measures and self-management behaviors among adults with multiple risk factors for prediabetes mellitus and diabetes mellitus.
2. Evaluate the relationship between neighborhood and the receipt of disease prevention and management services among King County adults diagnosed with prediabetes and diabetes.

The main outcomes for primary aims 1 and 2 included self-reported measures of quality of care, disease self-management, healthy behaviors, and clinical biomarkers. In addition to these primary aims, since the MDCC study collected pharmacy records, the secondary aim was to:

1. Validate self-reported chronic disease-related medication use for all participants with available pharmacy records who meet primary aims 1 and 2 inclusion criteria, using pharmacy-dispensing records as the "gold standard".

The outcome measure for this secondary aim was a score that represents the extent of agreement between self-reported medication use for chronic disease-related medications and pharmacy record data beyond that expected by chance alone.

**Project overview**

Following this introduction, a description of the study methods for the project is provided. More specific details regarding each research aim are provided in the chapters following this introduction. Chapter 1 considers the association between neighborhood SES, being screened for diabetes, and healthy behaviors among adults who have multiple diabetes risk factors (n=2,690). Chapter 2 presents the quality of healthcare and disease management of adults diagnosed with non-gestational prediabetes and diabetes (n=1,194), in relation to neighborhood SES. In Chapter 3, we assess the concordance between self-reported medication use for chronic conditions and pharmacy dispensing data (n=81), highlighting biases in self-reported data and the importance of self-reported information in disease surveillance systems. Chapter 4 descriptively synthesizes findings across the spectrum of disease progression, identifying points for public health intervention. Finally, we provide a brief conclusion that discusses Chapters 1-4 and the implications of our research.

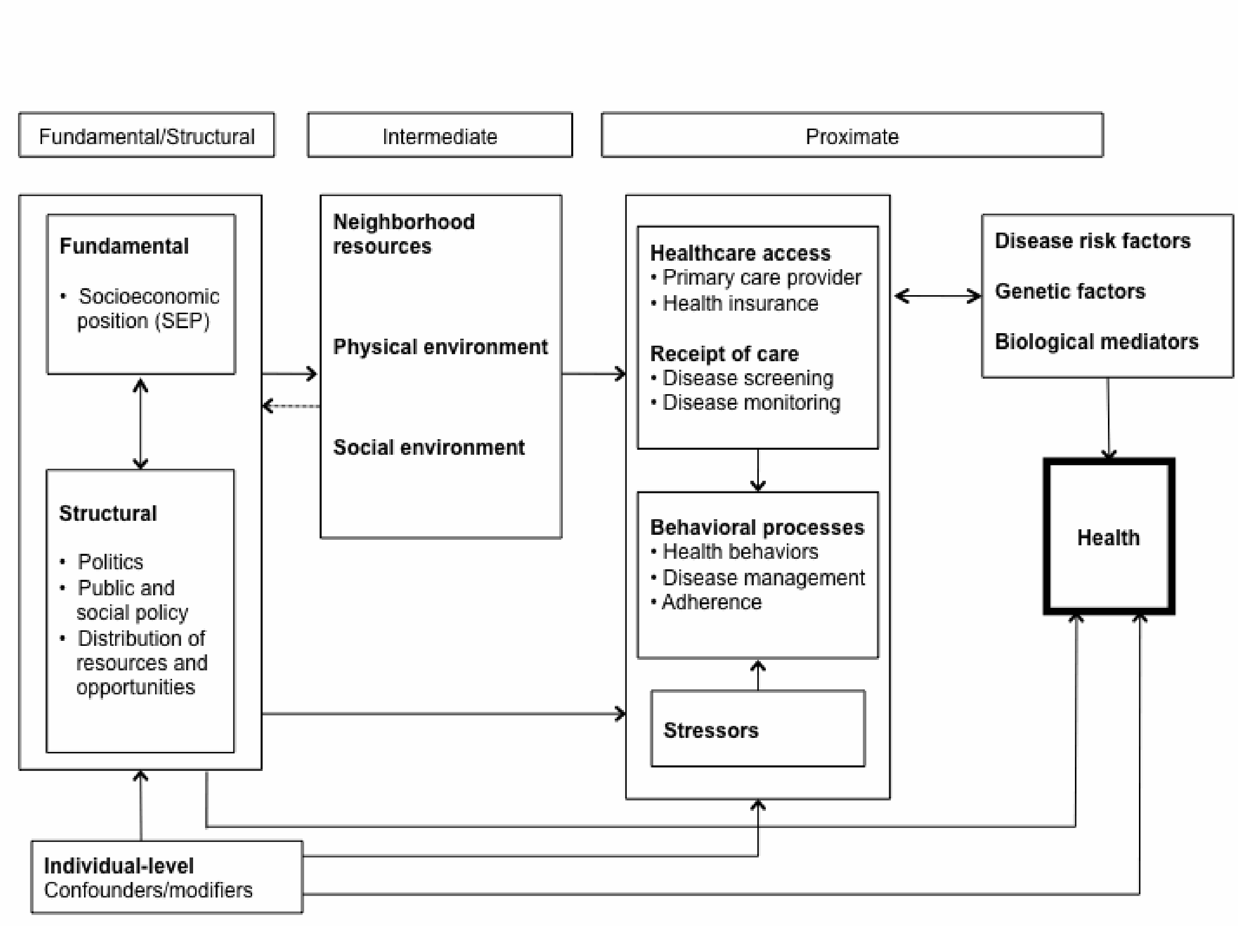


Figure 1. Conceptual model for the prevention and control of prediabetes and diabetes in King County: Neighborhood factors and disparities in health

**Dissertation Methods**

Data for this dissertation, all cross-sectional, came from multiple sources. The two main sources were:

(1) United States (U.S.) Census Bureau 2007-2011 American Community Survey (ACS) 5-year estimates; and,

(2) the Monitoring Disparities in Chronic Conditions (MDCC) Study.

The American Community Survey (ACS) is an ongoing survey conducted by the United States (U.S.) Census Bureau that provides small-area socioeconomic data (36). The 5-year estimates contain data at the census tract and census block group levels (Figure 1), are the most reliable and precise, and represent the largest sample size of ACS data (36). The large sample size associated with the 5-year estimates makes them ideal for examining small population groups. The statistical reliability of data presented for the different census geographic units is contingent on the population size of a given area and the methods used to tabulate data. Data on poverty are sampled from the population, as opposed to being complete count data, and are subject to sampling error (36). Thus, the number of sample responses will directly influence the variability of the resulting data and statistical confidence (36).

At the time this research was conducted, the 2007-2011 ACS 5-year estimates were the most up-to-date data available. Since the ACS 5-year estimates are based on a population sample, they could be biased if the sample population does not accurately represent the socioeconomic distribution of the population from which it was drawn. In Washington State, coverage of the ACS was estimated near 100% between 2007-2011 and survey response rates hovered near 97% (37).

In chapters 1 and 2, we used a proxy for measuring neighborhood SES based on ACS 5-year estimates. Specifically, we consider as a proxy the percentage of persons in a neighborhood living at or below the 200% federal poverty level (FPL). Independent of the U.S. Census Bureau, poverty level has been validated as being the most robust socioeconomic indicator to detect health gradients at the census tract level (38). The 200% FPL captures all people described as "in poverty" under the official definition, plus people who have income above poverty, but less than 2 times their poverty threshold. Guidelines for defining poverty level were adapted from the U.S. Census Bureau. This official poverty measure was established by the Office of Management and Budget (OMB) in Statistical Policy Directive 14 and is the measure used by federal agencies in their statistical work. These poverty thresholds (Table 1) are based on money income before taxes, and exclude noncash benefits such as food stamps and housing subsidies. The actual poverty threshold is the dollar amount, varying based on the size of a family and the ages of its members, and accounts for the ability to purchase goods. Although updated annually for inflation, thresholds do not vary across the U.S., making this choice of exposure one that can be comparable across research conducted in different U.S. counties (39-41).

Although some researchers use a single composite indicator that combines education, occupation, and income as a proxy for SES, all three of these simple measures are multicollinear and represent independent effects, as well as many complex, unmeasured factors; the use of a composite indicator hinders the ability to observe interactions and independent effects of these measures (42-44). The use of a single measure enables our exposure to be considered as both an actual exposure, and as a proxy that represents neighborhood SES.

Neighborhood boundaries were based on King County health reporting areas (HRAs) (45). These HRAs, based on city boundaries, and neighborhood boundaries in larger cities and unincorporated areas, were created as a method by which to report geographic patterns of health within the county that would be meaningful for local policy. Data are grouped using 2010 census block groups and a zipcode-based grouping when block group is unavailable. Data from the ACS can be aggregated to HRA boundaries, although in some instances census block group boundaries and HRA boundaries do not align well (specifically, for Kent, Renton, Federal Way, and Auburn), so approximations cannot be generated for those specific HRA neighborhoods. Because of this, poverty level estimates generated for these HRAs will be an estimate of an aggregated estimate. Since HRAs are defined by aggregated census data, the data quality strengths and limitations associated with census tracts described above apply to them, too.

Although homogeneity in an areal unit is perceived as appropriate, census tracts do not account for perceived neighborhood, or for adjacency of resources that are easily accessible for a given household (38, 46). For example, catchment areas for local health providers may not overlap with census tract defined boundaries, but may be captured by using a larger geographic unit, such as HRA, to define 'neighborhood'. Further, a neighborhood does not need to be homogenous to affect its residents (42). Although excessive heterogeneity caused by data aggregation can dilute the ability to assess measures of poverty level, the impact of diversity in an area may model true patterns of neighborhood effects on individual outcomes more accurately, and may be relevant to health policy and programs. Specifically, residents' exposures to area characteristics likely extend beyond census tract boundaries which cannot account for the spatial correlation of geographic areas or adjacency, such as the impact of living in a census tract where a large percentage of residents live below poverty, but that is adjacent to a wealthier socioeconomic tract (38). An individual's perceived neighborhood depends on where he or she lives, and an individual living on the boundary of a census tract is likely more similar to residents of the adjoining tract than to residents on the far side of his/her own. In fact, independent of local poverty levels, proximity to resources in high-income areas may be more related to health (18). Thus, in relation to health-related outcomes, a wider, surrounding area poverty may magnify the impact of local poverty due to spatial isolation from resources available in wealthier areas, while surrounding affluence may minimize the impact of local poverty (46).

Study participants' addresses were geocoded using ArcGIS® software by Esri, and then mapped to HRAs. The 48 existing KC HRAs were aggregated into 4 exposure groups, defined a priori, based on the quartile distribution of 200% FPL estimates (Figure 2). Our final exposure groups were: low SES (>30% residents at 200% FPL, 12 HRAs), middle-low SES (25-30% residents at 200% FPL, 11 HRAs), middle-high SES (14-24% residents at 200% FPL, 14 HRAs), and high SES (<14% residents at 200% FPL, 11 HRAs).

The Monitoring Disparities in Chronic Conditions (MDCC) Study, funded by award number RC2HL101759 from the National Heart, Lung, and Blood Institute (NHLBI**)**, which is a part of the U.S. National Institutes of Health, was a pilot study in King County, Washington, implemented with the aim to design and test a novel data collection system that integrated multiple data sources to monitor chronic conditions and related risk factors at the local level.

The MDCC study was conducted between March 2011 and July 2012 and selected adult (≥18 years), non-institutionalized KC residents using a dual-sampling frame:

(1) A randomly selected community-based sample, with and without telephone landlines, from a commercially available list of King County addresses. Towards the end of the recruitment time period, community-based sampling focused on recruiting participants from areas with a high percentage of Hispanics, based on surname, or African Americans, based on census data; and, in order to increase the prevalence of

health conditions in study respondents above that sampled from the population, MDCC also recruited:

(2) A health facility-based sample. The health facility-based sample was selected from University of Washington (UW) Medical Center, UW Medicine Stroke Center, Harborview Medical Center, HealthPoint Community Health Centers, Northwest Hospital & Medical Center, Snoqualmie Valley Hospital, MultiCare Auburn Medical Center, Overlake Hospital Medical Center, Group Health Cooperative, and King County Emergency Medical Services (EMS). These KC residents were randomly sampled based on diagnostic codes on record or receipt of EMS care during the 24 months prior to selection for 12 chronic conditions (asthma, atria fibrillation, cardiac arrest, chronic obstructive pulmonary disease, congestive heart failure, coronary heart disease, non-gestational diabetes mellitus, hypercholesterolemia, non-gestational hypertension, myocardial infarction, renal failure, and stroke).

Data were gathered using multiple methods, including via telephone, trained interviewers from Battelle (a health research company), in-person interviews, paper surveys, and internet-based surveys. All MDCC participants completed a 45-minute core survey that asked questions about sociodemographic characteristics, general health, health-related behaviors, and medical history. All respondents who reported having received a prior diagnosis from a healthcare professional of one of the 12 chronic conditions of interest and obtaining medications or supplements from an identifiable pharmacy in the 30 days prior to the interview were asked to participate in a pharmacy dispensing records review. If consent was given, participants were asked for the names and locations of pharmacies where they had filled medication prescriptions for the past 2 to 5 years. All pharmacies identified were contacted to obtain pharmacy records. No incentive was offered for participation in the MDCC study.

MDCC participant selection and response rate (Tables 2 and 3): The MDCC study screened a total of 8,237 KC adults, just over half (53.7%) of whom had been recruited via community-based sampling methods. Among screened adults, 88.7% consented to participate; 49.3% of those who consented were from the community-based sample. After screened participants consented to study participation, interviewers assessed their eligibility for study inclusion. A much higher percentage of health facility-based sample individuals, 90.7%, were found to be eligible, compared to only 57.8% of community-based sample individuals. Overall, 73% of screened adults who consented to study participation were eligible. The MDCC response rate, calculated as all participants who initiated the MDCC core survey among all those eligible, was 77.7% (68.4% response rate from the community-based sample and 84.5% response rate from the health facility-based sample).

MDCC participants who initiated the core survey, but did not complete it, were excluded from analyses for this dissertation due to missing data relevant to the research. Thus, this dissertation included the 71.8% of all eligible adults who consented to study participation and who also completed the MDCC core survey (78.9% of the eligible health facility-based sample and 62.3% of the community-based sample). The final sample completing the core survey was composed of 36.9% community-based sample participants and 63.1% health facility-based sample participants.

Data analysis methods: We created weights based on participants' probability of selection to apply to statistical analyses. Additionally, post-stratification weights were used to relate data to the appropriate population-level: for the health facility-based sample, 2007-2008 hospital discharge data from the Comprehensive Hospital Abstract Reporting System (CHARS) were used as the population of total KC hospital admissions for the selected 12 conditions, weighted by sex and age group (10-year blocks); and, for the community-based sample, we used KC demographic data. After applying the initial and post-stratification weights, weight trimming also was used, at 5,000 for the community-based sample weights and at 100 for the health facility-based sample weights. All analyses presented were conducted using SAS statistical software (version 9.2; SAS Institute Inc., Cary, NC, USA).

This dissertation research received approval from the University of Washington Institutional Review Board.

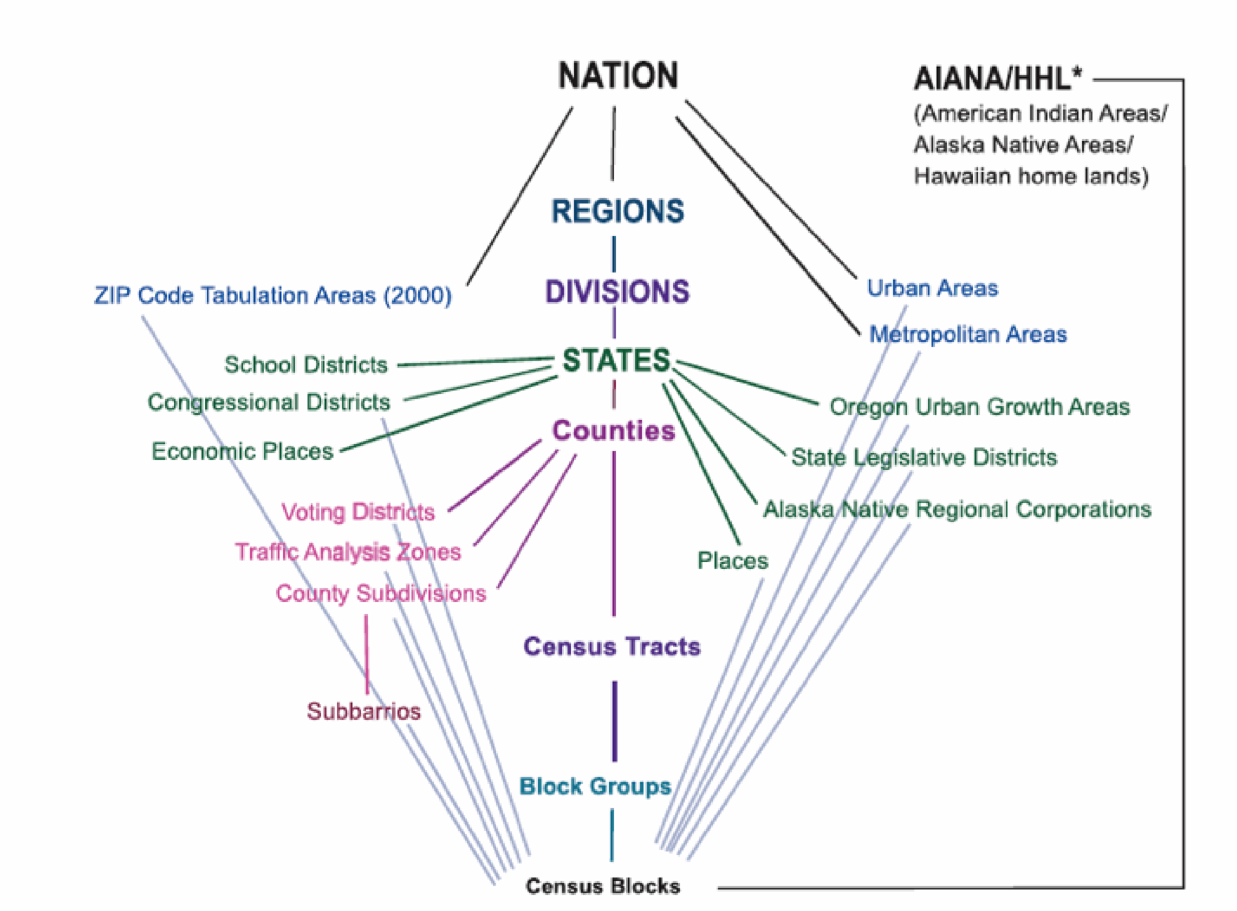


Figure 1. Hierarchy of census geographic entities, adapted from the United States Census Bureau, Geographic Areas and Concepts for the American Community Survey (Available at: http://www.census.gov/acs/www/guidance_for_data_users/geography/)

| Table 1. 200% Poverty thresholds for 2011 by size of family and number of related children under 18 years | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Size of family unit | Weighted average thresholds | Related children under 18 years | | | | | | | | |
| | | None | One | Two | Three | Four | Five | Six | Seven | Eight or more |
| One person (unrelated individual) | 22,968 | | | | | | | | | |
| Under 65 years | 23,404 | 23,404 | | | | | | | | |
| 65 years and over | 21,576 | 21,576 | | | | | | | | |
| Two people | 29,314 | | | | | | | | | |
| Householder under 65 years | 30,278 | 30,126 | 31,008 | | | | | | | |
| Householder 65 years and over | 27,218 | 27,192 | 30,892 | | | | | | | |
| Three people | 35,832 | 35,190 | 36,212 | 36,246 | | | | | | |
| Four people | 46,042 | 46,402 | 47,162 | 45,622 | 45,782 | | | | | |
| Five people | 54,502 | 55,958 | 56,772 | 55,034 | 53,688 | 52,868 | | | | |
| Six people | 61,694 | 64,362 | 64,618 | 63,286 | 62,010 | 60,112 | 58,988 | | | |
| Seven people | 70,170 | 74,058 | 74,520 | 72,926 | 71,814 | 69,744 | 67,330 | 64,680 | | |
| Eight people | 78,128 | 82,828 | 83,558 | 82,054 | 80,736 | 78,866 | 76,494 | 74,022 | 73,394 | |
| Nine people or more | 93,144 | 99,636 | 100,118 | 98,786 | 97,670 | 95,834 | 93,308 | 91,024 | 90,458 | 86,974 |

Source: U.S. Census Bureau.

Available at: http://www.census.gov/hhes/www/poverty/data/threshld/index.html

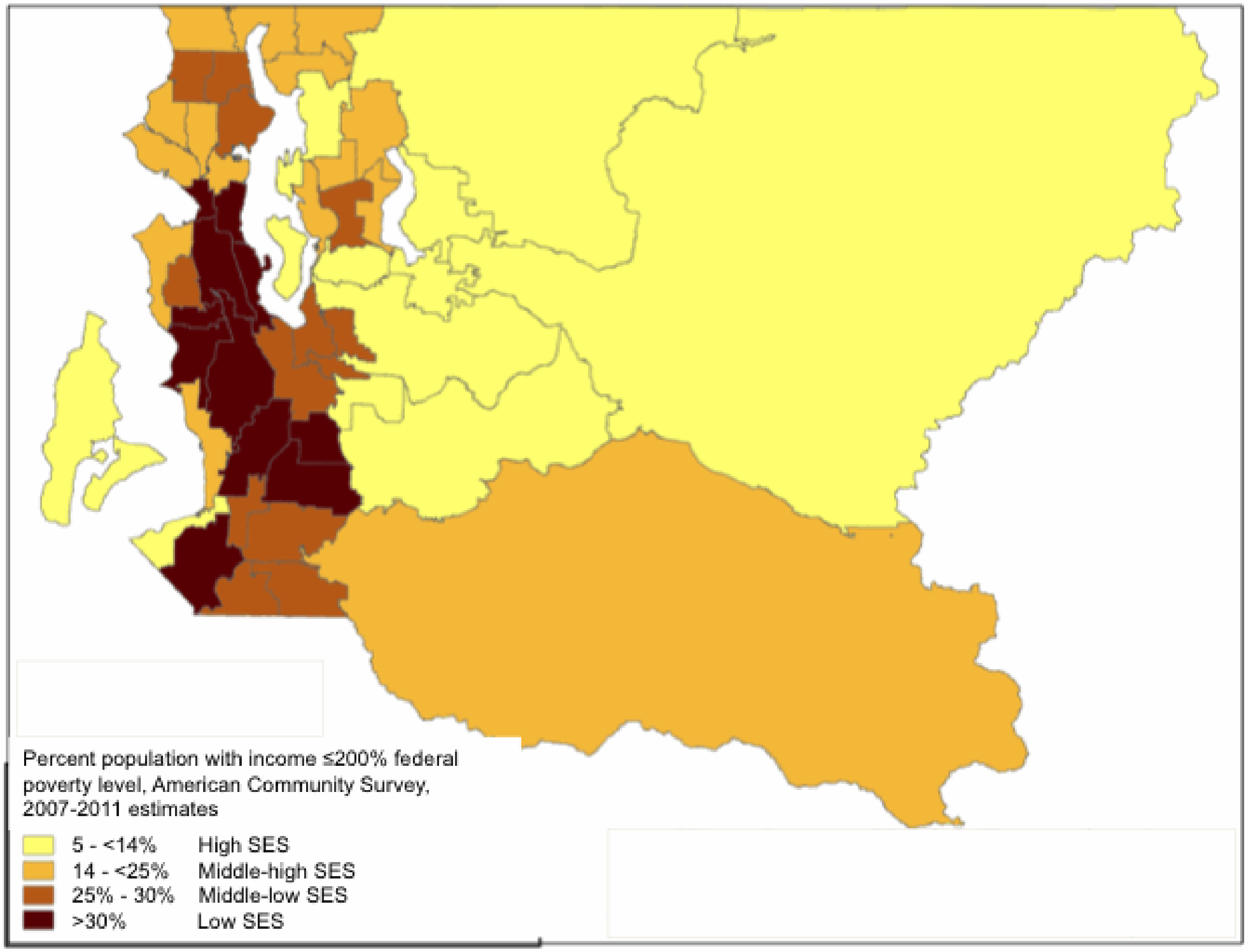


Figure 2. Map of King County Health Reporting Areas, aggregated into 4 exposure groups, by percent population with income ≤200% federal poverty level

Table 2. Participant selection for the Monitoring Disparities in Chronic Conditions (MDCC) study in King County, Washington, 2011-2012, by sampling method*

| | Community-based sample | Health facility-based sample | MDCC Total |
|---|---|---|---|
| | N | N | N |
| Adults screened | 4,427 | 3,810 | 8,237 |
| Agreed to participate | 3,603 | 3,703 | 7,306 |
| Eligible adults, among those who agreed to participate | 2,559 | 3,455 | 6,014 |
| Eligible adults who initiated the core survey | 1,751 | 2,923 | 4,674 |
| Eligible adults who completed the core survey | 1,593 | 2,727 | 4,320 |
| Eligible adults with multiple diabetes risk factors who initiated the core survey | 1,195 | 1,794 | 2,989 |
| Eligible adults with multiple diabetes risk factors who completed the core survey | 1,100 | 1,663 | 2,763 |
| Eligible adults with self-reported prediabetes or diabetes who initiated the core survey | 242 | 1,057 | 1,299 |
| Eligible adults with self-reported prediabetes or diabetes who completed the core survey | 229 | 1,009 | 1,238 |

*The MDCC study used a dual sampling frame of King County adults: (1) A randomly selected community-based sample of adults with and without landline telephones, and (2) a health facility-based sample of adults, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling.

Table 3. Response rate* for the Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012, by sampling method†

| | Community-based sample | Health facility-based sample | **MDCC Total** |
|---|---|---|---|
| | % | % | **%** |
| MDCC Study | 68.4 | 84.6 | **77.7** |

*Response rate was calculated as [# people who began or completed the MDCC core survey]/[All eligible King County adults who consented to study participation]. †The MDCC Study used a dual sampling frame of King County adults: (1) A randomly selected community-based sample of adults with and without landline telephones, and (2) a health facility-based sample of adults, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling.

**Chapter 1:** The impact of neighborhood socioeconomic status on disease prevention and healthy behavior among King County adults with multiple risk factors for non-gestational prediabetes and diabetes

**ABSTRACT**

**Introduction:** Diabetes, one of the most prevalent chronic illnesses, has a long preclinical phase during which effective healthcare interventions can lower the risk of developing prediabetes, lower elevated blood glucose, and prevent or delay diabetes and its complications. Lifestyle modifications that reduce body weight, such as a healthy diet and being physically active, and diabetes screening among adults with known diabetes risk factors are recognized strategies to prevent disease. Neighborhood poverty may contribute to different levels of preventive behavior and care, leading to geographical disparities in diabetes prevalence.

**Methods:** Using American Diabetes Association criteria for diabetes screening in adults with multiple diabetes risk factors, we selected study participants from the Monitoring Disparities in Chronic Conditions (MDCC) study. The MDCC study, which used community-based and health facility-based sampling, was conducted in King County (KC), Washington (2011-2012). We generated prevalence estimates of select health indicators across KC neighborhoods and estimated the odds of diabetes screening, physical activity levels, and healthy diet choices by neighborhood socioeconomic status (SES), which was defined by the percentage of residents living below the 200% federal poverty level.

**Results:** Our final sample included 2,690 non-institutionalized adults, 41% who were selected randomly from community-based sampling. The prevalence of diabetes screening 3 or fewer years ago was 77% for these KC adults. Adults in middle-low SES areas, compared to high SES neighborhood adults, were 37% less likely (OR: 0.63, 95% CI:0.40-1.01) to report sufficient weekly physical activity. This observation was borderline significant, but no significance remained after adjusting for age, individual income, education level and neighborhood walkability. The prevalence of fruit and vegetable consumption and purchasing low- or no-sodium foods was low across neighborhoods.

**Conclusions:** Our findings indicate that walkability was associated directly with physical activity levels, but neighborhood food environment did not mediate the pathway to diet choices. Among adults who are at high risk for developing diabetes, preventive care should target the reduction of overweight/obesity, through encouraging lifestyle modifications. Cost-related barriers may prevent adults from seeking care when needed, independent of neighborhood SES, limiting the contact with the healthcare system necessary for the success of disease prevention measures.

## Introduction

Diabetes is recognized as an important and growing public health problem worldwide (1, 47). In the United States (U.S.), diabetes affects 25.8 million individuals, including diagnosed and undiagnosed people (48). Additionally, 35% of adult Americans are estimated to have prediabetes, a condition in which blood glucose levels are higher than normal, but not high enough to be diagnosed as diabetes (48).

Diabetes has a lengthy, preclinical phase during which effective healthcare interventions can lower a person's risk of developing prediabetes, reverse prediabetes, and prevent or delay diabetes and its complications (26). For adults with multiple risk factors for diabetes, screening tests are available and are recommended to identify these individuals and subsequently address the health conditions that place them at high risk for disease (26). Identifying barriers to preventive services, such as screening for diabetes among high-risk individuals, can provide insights for developing more effective healthcare delivery programs. Additionally, understanding factors that prevent individuals from getting sufficient physical activity, as well as factors that lead to unhealthy diet choices, can inform where best to focus public health resources to improve the frequency of healthy behavior.

As the prevalence of diabetes risk factors and disease burden grows, so do disparities in its distribution (49). In King County (KC), Washington, neighborhood variations exist in diabetes and its related risk factors and complications, disproportionately affecting people and communities of low socioeconomic status (SES) (50). Data indicate that areas with higher poverty levels and adults with lower annual income have a higher prevalence of overweight and obesity, hypertension and high cholesterol, and low levels of physical activity (51). Available estimates show that among KC adults with an annual income <$35,000, 9-11% have diagnosed diabetes, compared to 4% who have ≥$75,000 annual income (51), with the gap in diabetes prevalence increasing steadily between adults living below and above 200% poverty over the last two decades (50). These income-related patterns in disease distribution contribute to significant neighborhood variation in mortality: 13% of deaths in low poverty areas are due to diabetes and 46% are diabetes-related, compared to 27% prevalence of diabetes deaths and 75% diabetes-related deaths in high poverty areas (51).

Tracking the mechanisms that contribute to observed disparities in chronic disease distribution across and within neighborhoods has the potential to identify and target preventive healthcare measures specific to community needs. The Monitoring Disparities in Chronic Conditions (MDCC) study, a large-scale feasibility study conducted in KC, set out to establish a robust data collection system that could identify both diagnosed and undiagnosed conditions at the community level through the integration of self-reported information, medical and pharmacy records, physical examination data, and laboratory measurements in order to describe chronic disease patterns locally. To understand the impact of neighborhood on the distribution of disease burden, we evaluated the association between neighborhood socioeconomic status (SES) and the receipt of preventive services, healthy behaviors, and the current disease burden among KC adults who meet criteria (26) for diabetes screening.

**Methods**

Study population. We selected study participants from the MDCC study, which is described in the Dissertation Methods section. Inclusion criteria for the analysis presented in this chapter followed the American Diabetes Association (ADA) guidelines for diabetes screening in adults with multiple risk factors for diabetes (26), which recommend screening for diabetes in all adults who are overweight (BMI ≥25 kg/m$^2$) and have at least one additional risk factor. Risk factors consist of physical inactivity, being a high-risk race/ethnicity (i.e., Black, Hispanic/Latino, American Indian, Pacific Islander), hypertension (≥140/90 mmHg or on therapy for hypertension), HDL cholesterol level (<35 mg/dl and/or a triglyceride level >250 mg/dl), history of cardiovascular disease, and other conditions associated with insulin resistance. Because age is a risk factor for diabetes, in the absence of additional risk factors, the ADA recommends screening all adults for diabetes beginning at age 45 years. We identified participants who met any of these criteria based on self-reported information.

Study exposure was neighborhood socioeconomic status (SES), using a proxy: the percentage of persons in a neighborhood living at or below the 200% federal poverty level (FPL), as described in the Dissertation Methods section of this document.

Study outcomes included health indicators encompassing the receipt of care of high quality and lifestyle behaviors. The ADA recommends screening for prediabetes and diabetes every 3 years (26), so we assessed diabetes screening recency (≤3 years ago vs. >3 years ago/never) to determine receipt of this preventive healthcare measure. Since an individual's lifestyle choices are the cornerstone of diabetes prevention, we also evaluated if participants reported sufficient physical activity (≥150 minutes/week vs. <150 minutes/week) (52), consuming ≥5 servings of fruits and vegetables daily (vs. <5 servings/day) (53), and, purchasing low- or no-sodium foods when grocery shopping (yes vs. no).

Analysis: Prevalence estimates of select health indicators and risk factors were generated by neighborhood SES. We estimated odds ratios for the association between neighborhood SES and study outcomes using weighted logistic regression. High SES neighborhoods served as the reference group in all models. We implemented 3 models for each of our outcomes. First, we generated crude estimates adjusting only for sampling method, to account for differences in participants who were selected randomly from the community and participants who were selected from health facilities with medically documented chronic conditions and healthcare system contact. Next, we adjusted these models for demographic characteristics that could act as potential confounders. These included categorical age, race, and annual income. In our final models, we considered health indicators and neighborhood characteristics that might confound or mediate any observed associations between neighborhood SES and the outcomes of interest.

Health indicators evaluated for model inclusion were health insurance coverage, unmet medical need (unable to see a doctor when needed in the past 12 months because of cost), and having a usual healthcare provider or place to obtain medical care. The neighborhood factors assessed were walkability (based on Walk Score® categories: car dependent, somewhat walkable, very walkable, and walker's paradise) (54); and, retail food environment index (RFEI), a ratio of total number of fast-food restaurants and convenience stores to the total number of supermarkets and produce vendors in an area (55).

To produce the final models, we assessed if covariate prevalence was statistically significant at a p-level of 0.05 across our exposure groups using a chi-square test. The association between potential covariates and outcomes were tested with the type III test of fixed effects.

**Results**

Study participants (Figure 1). A total of 2,743 (64%) MDCC participants who completed the core survey met study inclusion criteria. We excluded 53 (2%) of these participants because their address was either for a residence outside KC or unable to be geocoded. Our final sample included 2,690 participants, 59% selected via health facility records.

Demographics (Table 1). The KC population at an increased risk for prediabetes and diabetes was composed equally of males and females. Racial composition of this population was mostly White (77%), followed by 8% Black residents, 8% American Indian/Alaska Native, Asian, or Native Hawaiian/Pacific Islander, and 7% Hispanic. Low SES neighborhoods had a significantly higher prevalence of racial/ethnic minority residents than high SES neighborhoods. The retail food environment was statistically different across neighborhoods. Low SES neighborhoods had three times as many fast-food restaurants and convenience stores than healthier food outlets and high SES neighborhoods had an average of twice as many fast-food restaurants and convenience stores compared to healthier food outlets.

Chronic condition and risk factor prevalence (Table 2). Hypertension and hypercholesterolemia were the most prevalent chronic conditions in this sample, with frequencies estimated, respectively, at 34% and 30%. Cardiovascular disease burden was significantly higher in high SES neighborhoods. Low SES areas had the highest prevalence of overweight adults (70%), and high SES areas had the lowest overweight prevalence (56%). Differences in overweight burden across neighborhoods were out of statistical significance range ($p=0.06$).

Advice from a healthcare provider (Table 2). Among overweight individuals ($BMI \geq 25$ $kg/m^2$), 48% reported that they had been advised to lose weight, 56% had been instructed to increase physical activity levels, and 27% had received counseling to reduce consumption of high fat foods. Across neighborhoods, we observed a statistically significant difference in overweight adults who had been advised to eat fewer high fat foods ($p<0.001$); in low SES areas, 39% of overweight adults had received this advice, compared to 20-25% of overweight adults in other neighborhoods. Overall, we found that 28% of adults with multiple diabetes risk factors had been counseled to eat more fruits and vegetables, 23% to eat more fiber, and 13% to eat fish high in omega-3 fatty acids. Among individuals diagnosed with hypertension, 40% had received advice to reduce their salt intake and purchase low- or no-salt foods, with a significant difference in the frequency of advice across neighborhood SES ($p<0.0001$). Concerning diet advice, we observed a higher prevalence of reported advice receipt as neighborhood SES became lower.

Healthcare access (Table 2). At the time this study was conducted, nearly all KC adults at risk for diabetes had health insurance (92%) and a regular healthcare provider (92%). In low SES neighborhoods, compared to high SES neighborhoods, 3 times as many adults reported unmet medical need ($p=0.02$). Among those who did not have health insurance, unmet medical need was significantly higher ($p=0.01$) in low SES neighborhoods (78%) and high SES neighborhoods (64%), compared to neighborhoods of middle SES. Among adults with health insurance, unmet medical need ranged from 3% in high SES areas to 8% in middle-low SES areas.

Neighborhood SES, high quality of care, and healthy behavior (Table 3). Among adults who met ADA diabetes criteria for screening in 3-year intervals, 77% had been screened ≤3 years ago. Adjusting for age, race, education and annual income increased estimated odds ratios that were sampling method-adjusted substantially, leading to 92% (95% CI: 0.87-4.23) higher, but non-significant, odds of adults in low SES neighborhoods being screened in the past 3 years for diabetes, compared to adults in high SES neighborhoods. This indicates that given the same age, race, education and income, adults in lower SES neighborhoods, compared to adults in high SES neighborhoods, were more likely to be screened for diabetes 3 or fewer years ago. The additional adjustment of having a regular healthcare provider moved estimates closer to null, suggesting that having a provider mediates the observed associations. Having a regular healthcare provider mediated the association between neighborhood and screening recency the most in middle-low SES areas, lowering the estimate from 63% to 54% higher odds. None of the estimates for screening recency were statistically significant.

We observed the highest prevalence of sufficient physical activity, ≥150 minutes per week, in higher SES neighborhoods, reported by 70% of individuals. In sampling method-adjusted models, adults living in middle-low SES neighborhoods had a borderline significant 37% lower odds of reporting sufficient physical activity (95% CI: 0.40-1.01), compared to adults in high SES neighborhoods. Models adjusted for individual characteristics indicated that higher age, higher education and higher income were directly associated with getting sufficient physical activity. Neighborhood walkability appeared to mediate the association between neighborhood SES and sufficient physical activity in middle-high SES and low SES areas. After accounting for age, education, income, and walkability, compared to individuals in high SES areas, adults in middle-low SES neighborhoods were 15% less likely to report sufficient physical activity, though this association lacked statistical significance; and, adults in low SES neighborhoods had a non-significant 5% higher odds of reporting sufficient physical activity.

At 17% prevalence, low SES areas had the highest percentage of adults who reported meeting fruit and vegetable daily intake guidelines. About 12.5% of middle-low SES and high SES area residents reported consuming ≥5 fruit and vegetable servings per day, the lowest prevalence observed in this study. After adjustment for age, education, income and retail food environment, we observed statistically non-significant 28% higher odds (95% CI: 0.75-2.19) and 78% higher odds (95% CI: 0.91-3.49) of meeting daily fruit and vegetable dietary requirements in middle-high SES and low SES neighborhoods.

A little over half of adults with multiple diabetes risk factors reported buying low- or no-sodium foods. None of the odds ratio estimates for buying low- or no-sodium foods were statistically significant. Retail food environment did not mediate the pathway between neighborhood SES and buying low- or no-sodium foods.

Overall, neither individual income nor retail food environment appeared to have a significant or mediating effect on the association between neighborhood and healthy diet, although both did present a small amount of confounding of the association in lower SES neighborhoods. Notably, although negligible, we observed that lower annual household income and lower RFEI appeared to be associated with less purchasing of low- or no-sodium foods, and higher fruit and vegetable intake.

**Discussion**

Adults with multiple recognized diabetes risk factors represent an important target group for disease prevention. In this chapter, we found that, among adults who reported multiple risk factors for developing diabetes, 23% were not screened for diabetes at the ADA-recommended 3-year intervals. Often undetected until complications appear, current estimates predict that 27% of diabetes remains undiagnosed (56). Increasing the number of adults who are screened, among those who have been identified as having a high risk of developing diabetes, may detect a greater number of cases of undiagnosed disease before diabetes-related complications appear. Our findings reveal a missed opportunity for healthcare providers to address the management of existing disease risk factors and prevent the development of prediabetes and diabetes.

Research provides evidence that disparities in accessing quality healthcare are primarily based on social determinants, such as socioeconomic position and race/ethnicity, with patients of lower income and minority races/ethnicities primarily experiencing barriers to accessing quality care (28, 57). We observed a similar prevalence of diabetes screening across KC neighborhoods, and further, we found that given the same household income level, race/ethnic group membership, age, education-level and a source of regular healthcare, adults who lived in neighborhoods with lower SES had a greater likelihood of being screened for diabetes within recommended intervals than adults in higher SES areas. Once barriers to accessing care were overcome, our study shows that adults with multiple disease risk factors who live in low SES neighborhoods tend to receive preventive screening more frequently than comparable adults in higher SES neighborhoods. This observation may be due to community outreach programs and the location of services offered to high-risk adults located in high poverty areas, and social isolation of similar adults residing in more affluent neighborhoods where such outreach efforts may be scarce.

To receive high quality care, individuals should have a regular healthcare provider and the knowledge, financial means, and time to seek care (26). Adults in lower SES areas reported not seeking, or delaying, needed medical care due to cost in the past 12 months at more than 2-to-3 times the frequency than adults in higher SES areas, at the same rate as the most recent national estimates for unmet medical need (58). Not having health insurance appeared to be the reason for the majority of unmet medical need. Notably, among the uninsured, we found the second highest prevalence of unmet medical need among adults in high SES neighborhoods. Possibly, the costs associated with the healthcare providers these individuals typically see are too high to be absorbed out-of-pocket. Trends in the past decade show that out-of-pocket costs for individuals with health insurance have increased, particularly in individuals with high disease burden (59). Thus, even with the recent advent of nationally mandated health insurance, out-of-pocket costs for copayments and prescription medications likely will remain preventive factors in seeking medical care when needed for many adults.

We observed a higher prevalence of overweight adults in low SES areas, consistent with national trends (28). Due to the association between body weight and impaired blood glucose levels, targeting weight loss, through increasing physical activity levels and improving diet, remains the most effective non-pharmaceutical method to reduce body weight, blood pressure, high cholesterol, and heart disease, and consequently, also reduce the risk of developing prediabetes and diabetes (60-62). In our study, we found that a significantly higher percentage of overweight adults in low SES areas received advice to reduce consumption of high-fat foods. Additionally, in low SES neighborhoods, a high frequency of overweight individuals reported having received advice to lose weight and increase physical activity, as well as having been given advice related to healthy diet choices. This finding is positive, since past research suggests that providers may suggest, intentionally or unintentionally, lower expectations for patients in socially disadvantaged positions (63). It is unclear how King County may be different, but it might be related to overall healthier behaviors of county residents that lead to a greater frequency of overweight awareness, outreach programs targeting racial/ethnic communities, or adults seeking care from providers of similar racial/ethnic backgrounds, which is associated with better patient-provider communication (64, 65). Diet- and physical activity-related interventions can lead to behavioral change, though these healthy behaviors need to be sustained for positive benefits related to diabetes prevention to be observed over time (66, 67). Recently, primary care providers have been found to be more likely to advise patients on behavioral changes if patients have diagnosed chronic diseases (68). Providers were most likely to discuss physical activity, followed by dietary counseling, and finally, weight control advice (68). Consequently, KC health providers should focus on conveying to patients the importance of making healthy behaviors a part of a daily routine, as well as incorporating increased counseling and informationdissemination related to healthy lifestyle modifications, particularly among overweight individuals and patients without chronic conditions.

Where people live is associated with health (69). In our study, consistent with other research (70-72), we found that neighborhood walkability contributed to physical activity levels, but not necessarily prevalence of overweight. We observed that, through its confounding effect on model estimates, low annual household income was directly associated with reporting insufficient physical activity across all KC neighborhoods. This relationship might be due to less disposable income to pay for a gym membership or exercise classes, and in low SES areas, fewer accessible recreational resources within the neighborhood (73). We observed the highest consumption of fruits and vegetables in low SES neighborhoods, despite fewer healthier food retailers in these areas. This finding contrasts national trends that point to lower income households being more likely not to meet fruit and vegetable diet recommendations, often due to less access to healthy foods and high cost of fresh produce (74, 75). This observation could be associated with the significantly high percentage, 36%, of adults in low SES neighborhoods who reported having received advice to increase fruit and vegetable intake, compared to adults in high SES neighborhoods, although the cross-sectional study design prevents assessment of a causal relationship. Additionally, the higher prevalence of reported fruit and vegetable consumption in low SES areas could be due to the availability of public services such as soup kitchens, food banks, food stamps and other supplemental monthly assistance programs that provide either meals or funds for food purchases to low income individuals.

Our study had several limitations. Since the person-level data we used were self-reported, our findings are limited by recall and social desirability biases, such that participants may have over-reported healthy behavior or have forgotten medical advice offered previously, leading to an inflation of healthy behavior prevalence and underestimating the quality of care received. Since body weight is typically underestimated and height overestimated (76), it is likely our overweight prevalence estimates, based on body mass index, underestimate the true burden of obesity in KC. Additionally, given that approximately one-fourth of the U.S. population remains undiagnosed for diabetes (26), there likely were at least that many participants in this study with undiagnosed diabetes, further highlighting the need for scaled-up preventive measures. However, our screening prevalence estimate may underestimate the actual percentage of adults screened, since a glucose test is often part of the basic panel of blood tests ordered, which a patient might be unaware of if he or she had negative results for elevated blood sugar; notably, reported screening prevalence is consistent across neighborhoods, indicating that if there is bias in self-report due to lack of awareness, it is consistent across neighborhood SES. Although unavailable at the time of our analysis, laboratory measurements of blood specimens collected by the MDCC study will provide an estimate of undiagnosed disease among study participants. We weighted our data to make our findings representative of the KC population, but this method assumes no difference between study respondents and non-respondents; thus, findings were only as representative of the population to the extent that study participants represent this group of KC adults. The strategy of using both community-based sampling and health facility-based sampling served to contribute to the representativeness of our study population.

Adults who are at high risk for developing diabetes represent a priority group that should receive advice and care to manage existing diseases, as well as appropriate monitoring to capture presymptomatic disease that can be reversed. Overall, this study indicates that adults in lower SES neighborhoods faced cost-related barriers to accessing care and practicing healthy behaviors, but received similar levels of care as adults in high SES neighborhoods once able to access health resources; and, consumed more fruits and vegetables than adults in high SES neighborhoods. We suggest that strategies to connect people to affordable medical care with minimal or no out-of-pocket costs should be a focus of KC policy makers, and that health-related data continue to be collected at the local level to describe disparities in health.

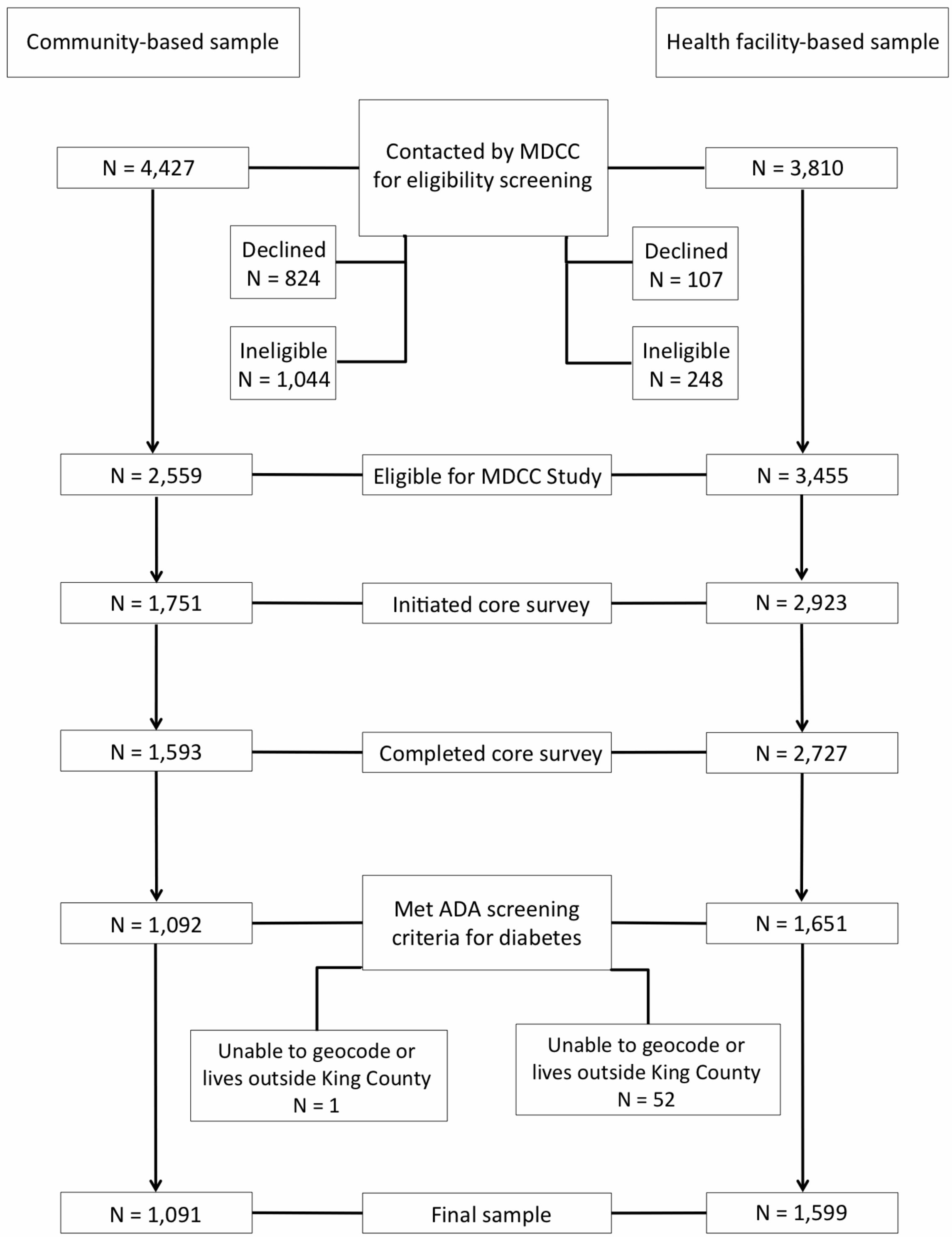


Figure 1. Selection of King County adults meeting American Diabetes Association (ADA) screening criteria for diabetes mellitus, from the Monitoring Disparities in Chronic Conditions (MDCC) Study

Table 1. Characteristics of King County adults who meet American Diabetes Association screening criteria for diabetes mellitus, by neighborhood socioeconomic status[*] and sampling method[†], Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | |
|---|---|---|---|---|---|
| | High | Middle-high | Middle-low | Low | Total |
| **Community-based sample** | | | | | |
| | % (SE)[‡] | % (SE)[‡] | % (SE)[‡] | % (SE)[‡] | % (SE)[‡] |
| Sex, male | 54.5 (4.18) | 51.8 (3.65) | 51.6 (5.16) | 44.3 (5.32) | 50.6 (2.29) |
| Race[§] | | | | | |
| Non-Hispanic White | 92.5 (3.01) | 77.0 (4.27) | 72.9 (5.67) | 59.3 (5.72) | 88.5 (0.81) |
| Non-Hispanic Black | 2.4 (2.25) | 5.0 (2.55) | 11.2 (3.76) | 11.5 (3.85) | 4.3 (0.51) |
| Hispanic | 3.4 (1.30) | 9.3 (2.66) | 5.8 (1.87) | 14.9 (3.54) | 3.6 (0.48) |
| Other[||] | 1.8 (1.76) | 8.7 (3.37) | 10.2 (5.24) | 14.3 (5.69) | 3.6 (0.47) |
| Education | | | | | |
| < High school | 0.6 (0.50) | 4.0 (2.33) | 1.5 (0.86) | 5.6 (3.32) | 2.3 (0.39) |
| High school/GED | 8.7 (2.39) | 8.5 (2.05) | 8.9 (2.70) | 12.9 (3.74) | 12.1 (0.88) |
| Some college | 25.8 (3.79) | 25.5 (3.17) | 25.4 (4.48) | 25.2 (4.30) | 27.0 (1.17) |
| College graduate | 32.6 (3.95) | 35.1 (3.55) | 42.0 (5.39) | 27.8 (4.55) | 31.0 (1.22) |
| Graduate degree | 32.3 (4.18) | 26.9 (3.04) | 22.2 (3.58) | 28.6 (5.11) | 27.6 (1.16) |
| Employment status | | | | | |
| Employed | 61.0 (3.99) | 58.3 (3.63) | 54.9 (5.31) | 42.3 (5.11) | 28.3 (1.14) |
| Out of work, >1 year | 1.7 (1.17) | 4.1 (1.32) | 2.1 (1.21) | 4.4 (2.10) | 1.8 (0.35) |
| Out of work, <1 year | 3.1 (1.59) | 8.2 (2.52) | 5.5 (2.53) | 8.4 (3.60) | 8.1 (0.71) |
| Homemaker | 5.4 (1.87) | 4.3 (1.72) | 4.7 (1.72) | 10.1 (3.77) | 4.8 (0.58) |
| Student | 1.4 (1.02) | 3.5 (2.03) | 7.5 (4.26) | 7.0 (3.80) | 0.8 (0.23) |
| Retired | 27.3 (3.29) | 21.6 (2.37) | 25.3 (4.59) | 27.8 (4.60) | 56.2 (1.29) |
| Marital status[§] | | | | | |
| Single | 9.9 (3.17) | 18.9 (2.97) | 22.0 (4.92) | 22.7 (4.64) | 11.5 (0.81) |
| Married | 71.8 (3.85) | 52.5 (3.71) | 56.0 (5.16) | 54.2 (5.30) | 56.9 (1.30) |
| Divorced/separated | 7.0 (1.91) | 21.5 (3.17) | 11.7 (2.57) | 15.6 (3.60) | 16.7 (0.96) |
| Widowed | 11.3 (2.18) | 7.1 (1.81) | 10.3 (2.24) | 7.5 (1.70) | 14.9 (0.97) |
| Income | | | | | |
| <$15,000 | 1.2 (0.85) | 6.6 (2.31) | 9.5 (4.56) | 8.5 (3.68) | 13.5 (0.97) |
| $15,000 - <$35,000 | 10.8 (2.56) | 11.7 (2.70) | 11.9 (2.51) | 17.4 (4.30) | 18.3 (1.12) |
| $35,000 - <$50,000 | 7.4 (2.01) | 11.3 (2.60) | 9.4 (2.58) | 9.3 (2.63) | 11.9 (0.95) |
| $50,000 - <$75,000 | 13.0 (3.48) | 19.7 (3.15) | 15.9 (3.82) | 20.5 (5.21) | 14.1 (0.99) |
| ≥$75,000 | 67.7 (4.31) | 50.8 (4.08) | 53.3 (5.66) | 44.2 (5.77) | 42.2 (1.40) |
| Age[§], *years* | | | | | |
| 18 – 24 | 0 (0) | 4.2 (2.24) | 3.8 (3.72) | 6.4 (3.08) | 3.9 (1.35) |
| 25 – 34 | 1.0 (1.00) | 5.3 (2.30) | 3.4 (2.24) | 8.5 (2.88) | 4.9 (1.23) |
| 35 – 44 | 4.6 (2.32) | 9.5 (2.59) | 10.7 (3.15) | 18.8 (4.99) | 11.0 (1.75) |
| 45 – 64 | 68.3 (3.71) | 57.6 (3.68) | 56.2 (5.19) | 41.0 (5.08) | 55.5 (2.31) |
| ≥ 65 | 26.1 (3.20) | 23.4 (2.55) | 25.8 (4.34) | 25.3 (4.52) | 24.8 (1.76) |
| **Health facility-based sample** | | | | | |
| Sex[§], male | 55.1 (2.91) | 47.1 (2.01) | 43.0 (2.70) | 49.6 (3.36) | 48.3 (1.31) |
| Race[§] | | | | | |
| Non-Hispanic White | 92.7 (1.49) | 90.9 (1.12) | 89.2 (1.65) | 74.6 (2.90) | 88.5 (0.81) |
| Non-Hispanic Black | 0.6 (0.42) | 2.6 (0.61) | 4.1 (1.05) | 14.8 (2.37) | 4.3 (0.51) |
| Hispanic | 2.2 (0.82) | 3.2 (0.69) | 3.6 (1.02) | 7.2 (1.71) | 3.6 (0.48) |
| Other[||] | 4.5 (1.20) | 3.4 (0.70) | 3.1 (0.88) | 3.4 (1.21) | 3.6 (0.47) |
| Education[§] | | | | | |
| < High school | 0.6 (0.41) | 1.3 (0.48) | 3.2 (0.97) | 6.0 (1.58) | 2.3 (0.39) |

| | | | | | |
|---|---|---|---|---|---|
| High school/GED | 7.5 (1.58) | 10.1 (1.28) | 14.6 (2.00) | 20.5 (2.73) | 12.1 (0.88) |
| Some college | 26.4 (2.59) | 23.6 (1.72) | 30.7 (2.55) | 31.6 (3.13) | 27.0 (1.17) |
| College graduate | 32.8 (2.76) | 36.4 (1.95) | 25.1 (2.37) | 22.5 (2.82) | 31.0 (1.22) |
| Graduate degree | 32.8 (2.71) | 28.4 (1.80) | 26.4 (2.38) | 19.4 (2.64) | 27.6 (1.16) |
| Employment status[§] | | | | | |
| Employed | 32.6 (2.69) | 29.6 (1.77) | 23.5 (2.20) | 25.4 (2.86) | 28.3 (1.14) |
| Out of work, >1 year | 1.9 (0.77) | 1.2 (0.44) | 2.9 (0.91) | 1.7 (0.87) | 1.8 (0.35) |
| Out of work, <1 year | 6.0 (1.34) | 4.6 (0.83) | 11.9 (1.78) | 15.4 (2.41) | 8.1 (0.71) |
| Homemaker | 5.9 (1.41) | 3.2 (0.75) | 6.4 (1.35) | 5.2 (1.55) | 4.8 (0.58) |
| Student | 0.3 (0.33) | 0.3 (0.20) | 0.5 (0.35) | 3.3 (1.27) | 0.8 (0.23) |
| Retired | 53.3 (2.90) | 61.1 (1.94) | 54.8 (2.72) | 48.9 (3.38) | 56.2 (1.29) |
| Marital status[§] | | | | | |
| Single | 5.3 (1.25) | 9.5 (1.14) | 15.1 (1.94) | 20.4 (2.69) | 11.5 (0.81) |
| Married | 73.6 (2.58) | 58.3 (2.00) | 46.8 (2.73) | 44.1 (3.34) | 56.9 (1.30) |
| Divorced/separated | 10.9 (1.81) | 14.7 (1.40) | 20.7 (2.21) | 24.5 (2.90) | 16.7 (0.96) |
| Widowed | 10.1 (1.83) | 17.4 (1.61) | 17.3 (2.19) | 11.0 (2.13) | 14.9 (0.97) |
| Income[§] | | | | | |
| <$15,000 | 4.3 (1.30) | 8.3 (1.20) | 16.9 (2.22) | 34.5 (3.45) | 13.5 (0.97) |
| $15,000 - <$35,000 | 9.9 (1.94) | 18.5 (1.74) | 22.6 (2.53) | 22.8 (3.06) | 18.3 (1.12) |
| $35,000 - <$50,000 | 9.2 (1.93) | 11.8 (1.46) | 15.9 (2.26) | 10.1 (2.23) | 11.9 (0.95) |
| $50,000 - <$75,000 | 14.3 (2.27) | 16.6 (1.64) | 12.0 (1.97) | 10.1 (2.09) | 14.1 (0.99) |
| ≥$75,000 | 62.2 (3.15) | 44.8 (2.17) | 32.7 (2.74) | 22.5 (3.01) | 42.2 (1.40) |
| Age[§], *years* | | | | | |
| 18 – 24 | 0 (0) | 0.2 (0.20) | 0.5 (0.31) | 0 (0) | 0.2 (0.11) |
| 25 – 34 | 1.0 (0.51) | 1.3 (0.44) | 2.3 (0.81) | 2.3 (1.03) | 1.6 (0.32) |
| 35 – 44 | 3.8 (1.12) | 3.7 (0.73) | 2.4 (0.77) | 9.0 (1.96) | 4.2 (0.52) |
| 45 – 64 | 36.0 (2.77) | 29.5 (1.76) | 36.0 (2.56) | 44.9 (3.33) | 34.6 (1.22) |
| ≥ 65 | 59.2 (2.85) | 65.2 (1.85) | 58.7 (2.64) | 43.8 (3.33) | 59.4 (1.27) |
| **Total** | | | | | |
| Sex, male | 54.6 (3.41) | 51.0 (3.04) | 49.9 (4.20) | 44.9 (4.71) | 50.2 (1.91) |
| Race[§] | | | | | |
| Non-Hispanic White | 92.5 (2.43) | 79.4 (3.60) | 76.1 (4.68) | 61.1 (5.13) | 77.2 (2.18) |
| Non-Hispanic Black | 2.0 (1.81) | 4.6 (2.11) | 9.8 (3.04) | 11.9 (3.40) | 6.7 (1.32) |
| Hispanic | 3.1 (1.05) | 8.2 (2.20) | 5.3 (1.51) | 14.0 (3.13) | 8.0 (1.18) |
| Other[‖] | 2.3 (1.43) | 7.8 (2.80) | 8.8 (4.26) | 13.0 (1.07) | 8.1 (1.83) |
| Education | | | | | |
| < High school | 0.6 (0.41) | 3.5 (1.93) | 1.8 (0.72) | 5.6 (2.94) | 3.1 (1.03) |
| High school/GED | 8.4 (1.94) | 8.8 (1.70) | 10.0 (2.21) | 13.8 (3.32) | 10.1 (1.14) |
| Some college | 25.9 (3.08) | 25.2 (2.63) | 26.4 (3.63) | 25.9 (3.82) | 25.7 (1.62) |
| College graduate | 32.6 (3.21) | 35.3 (2.95) | 38.7 (4.43) | 27.2 (4.02) | 33.7 (1.83) |
| Graduate degree | 32.4 (3.39) | 27.2 (2.52) | 23.0 (2.93) | 27.5 (4.53) | 27.4 (1.66) |
| Employment status | | | | | |
| Employed | 55.3 (3.37) | 53.3 (3.04) | 48.6 (4.22) | 40.4 (4.49) | 50.0 (1.93) |
| Out of work, >1 year | 1.7 (0.95) | 3.6 (1.09) | 2.4 (0.99) | 4.1 (1.86) | 3.1 (0.65) |
| Out of work, <1 year | 3.7 (1.30) | 7.6 (2.09) | 6.8 (2.06) | 9.2 (3.18) | 7.1 (1.19) |
| Homemaker | 5.5 (1.52) | 4.1 (1.42) | 5.0 (1.41) | 9.5 (3.35) | 5.7 (1.02) |
| Student | 1.2 (0.82) | 2.9 (1.68) | 6.1 (3.45) | 6.6 (3.37) | 4.0 (1.23) |
| Retired | 32.6 (2.84) | 28.5 (2.19) | 31.1 (3.76) | 30.2 (4.12) | 30.1 (1.55) |
| Marital status[§] | | | | | |
| Single | 9.0 (2.56) | 17.2 (2.46) | 20.6 (3.98) | 22.5 (4.12) | 17.5 (1.63) |
| Married | 72.1 (3.12) | 53.5 (3.08) | 54.2 (4.18) | 53.0 (4.71) | 57.0 (1.90) |
| Divorced/separated | 7.8 (1.57) | 20.3 (2.63) | 13.5 (2.15) | 16.7 (3.21) | 15.9 (1.39) |
| Widowed | 11.1 (1.78) | 8.9 (1.52) | 11.7 (1.88) | 7.9 (1.54) | 9.6 (0.86) |
| Income[§] | | | | | |
| <$15,000 | 1.8 (0.74) | 6.9 (1.92) | 10.9 (3.68) | 11.5 (3.27) | 7.8 (1.30) |

| | | | | | |
|---|---|---|---|---|---|
| $15,000 - <$35,000 | 10.6 (2.11) | 12.8 (2.25) | 13.9 (2.16) | 18.0 (3.82) | 13.8 (1.36) |
| $35,000 - <$50,000 | 7.7 (1.68) | 11.4 (2.16) | 10.7 (2.16) | 9.4 (2.34) | 10.1 (1.14) |
| $50,000 - <$75,000 | 13.3 (2.86) | 19.1 (2.62) | 15.2 (3.11) | 19.3 (4.64) | 17.3 (1.68) |
| ≥$75,000 | 66.6 (3.55) | 49.7 (3.39) | 49.3 (4.7) | 41.7 (5.11) | 51.0 (2.12) |
| Age§, years | | | | | |
| 18 – 24 | 0 (0) | 3.5 (1.86) | 3.2 (3.00) | 5.6 (2.73) | 3.2 (1.13) |
| 25 – 34 | 1.0 (0.81) | 4.6 (1.90) | 3.2 (1.81) | 7.8 (2.53) | 4.4 (1.02) |
| 35 – 44 | 4.4 (1.88) | 8.5 (2.16) | 9.1 (2.54) | 17.7 (4.41) | 9.8 (1.46) |
| 45 – 64 | 61.9 (3.15) | 52.7 (3.05) | 52.3 (4.20) | 41.4 (4.51) | 51.9 (1.92) |
| ≥ 65 | 32.7 (2.80) | 30.7 (2.31) | 32.3 (3.61) | 27.5 (4.01) | 30.7 (1.54) |

*Neighborhood socioeconomic status (SES) was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low SES, >30%). †The MDCC Study used a dual sampling frame of King County adults: (1) A randomly selected community-based sample of adults with and without landline telephones, and (2) a health facility-based sample of adults, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling. ‡Weighted percentage and standard error, data represent King County estimates. §Significantly different prevalence across neighborhoods at the 0.05 level, using a chi-square test. ||Other race includes American Indian/Alaska Native, Asian, Native Hawaiian/Other Pacific Islander, and other.

Table 2. Distribution of health indicators, by neighborhood socioeconomic status* for King County adults who meet American Diabetes Association screening criteria for diabetes mellitus, Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | |
|---|---|---|---|---|---|
| | High | Middle-high | Middle-low | Low | Total |
| **Healthcare access** | | | | | |
| | % (SE)† | % (SE)† | % (SE)† | % (SE)† | % (SE)† |
| Unmet medical need‡ | 4.4 (1.37) | 7.1 (1.66) | 10.0 (2.41) | 13.6 (2.96) | 8.6 (1.06) |
| Has health insurance | 2.6 (1.21) | 4.3 (1.21) | 7.8 (2.53) | 5.4 (1.73) | 4.83 (0.81) |
| No health insurance | 63.5 (15.4) | 41.0 (12.44) | 27.6 (11.05) | 77.6 (9.62) | 49.9 (7.63) |
| Has a healthcare provider | 95.4 (2.07) | 91.8 (2.33) | 90.8 (3.60) | 91.8 (2.66) | 92.3 (1.37) |
| One provider | 64.6 (3.36) | 66.1 (3.00) | 66.9 (4.06) | 61.2 (4.94) | 64.9 (1.92) |
| More than one provider | 30.8 (3.10) | 25.6 (2.55) | 24.0 (306) | 30.6 (4.89) | 27.3 (1.72) |
| Told to get regular checkups‡ | 36.8 (3.21) | 40.2 (2.88) | 45.1 (4.14) | 33.8 (4.06) | 39.1 (1.88) |
| **Chronic conditions and disease risk factors** | | | | | |
| Overweight (BMI $\geq$25 kg/$m^2$) | 55.6 (3.44) | 60.3 (2.95) | 61.3 (4.15) | 70.2 (3.92) | 61.7 (1.81) |
| Hypertension | 36.8 (3.28) | 32.2 (2.55) | 36.6 (3.76) | 30.8 (3.98) | 33.6 (1.65) |
| Hypercholesterolemia | 33.2 (3.17) | 26.9 (2.14) | 33.9 (3.80) | 29.9 (4.22) | 30.1 (1.58) |
| Coronary heart disease‡ | 11.3 (1.75) | 7.2 (0.89) | 9.7 (1.76) | 6.3 (1.19) | 8.3 (0.65) |
| Congestive heart failure‡ | 6.7 (1.70) | 2.2 (0.37) | 3.5 (1.00) | 3.6 (0.92) | 3.6 (0.45) |
| Atrial fibrillation‡ | 12.4 (1.88) | 11.3 (1.50) | 14.7 (2.11) | 7.5 (1.43) | 11.3 (0.87) |
| Myocardial infarction | 5.0 (1.06) | 3.9 (0.66) | 5.5 (1.11) | 3.7 (0.88) | 4.4 (0.44) |
| Stroke | 3.8 (0.84) | 3.6 (0.56) | 3.3 (0.70) | 4.1 (1.05) | 3.7 (0.38) |
| **Advice received from physician** | | | | | |
| **Overweight & advised to:** | | | | | |
| Lose weight | 50.4 (4.82) | 43.3 (3.84) | 46.6 (5.17) | 53.4 (5.96) | 47.6 (2.52) |
| Increase physical activity | 52.6 (4.84) | 50.8 (4.09) | 57.0 (5.06) | 63.7 (5.19) | 55.5 (2.50) |
| Eat fewer high fat foods‡ | 22.6 (3.79) | 20.9 (2.65) | 25.2 (3.88) | 39.1 (6.21) | 26.5 (2.24) |
| **Hypertension & advised to:** | | | | | |
| Lower blood pressure | 64.3 (5.01) | 66.3 (3.33) | 55.7 (5.62) | 58.6 (6.45) | 62.1 (2.42) |
| Reduce salt intake & buy low/no salt foods‡ | 31.2 (6.81) | 37.1 (5.38) | 42.8 (9.69) | 50.9 (9.22) | 40.1 (4.00) |
| **Nutrition advice, eat more:** | | | | | |
| Fruits & vegetables‡ | 19.7 (2.56) | 26.0 (2.82) | 28.2 (3.93) | 36.3 (4.85) | 27.5 (1.82) |
| Whole grains and/or fiber‡ | 16.9 (2.41) | 26.1 (2.83) | 20.4 (3.04) | 24.4 (4.29) | 22.9 (1.67) |
| Darkfish (salmon, tuna) ‡ | 9.0 (1.63) | 12.5 (1.53) | 12.7 (2.59) | 15.6 (3.41) | 12.6 (1.13) |

*Neighborhood socioeconomic status (SES) was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low SES, >30%). †Weighted percentage, with standard error, data represent King County estimates. ‡Chi-square test comparing prevalence across neighborhood SES was significant at the 0.05 level.

Table 3. Association* between neighborhood socioeconomic status† and quality of care and healthy behavior among King County adults who meet American Diabetes Association screening criteria for diabetes mellitus, Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | |
|---|---|---|---|---|---|
| | High | Middle-high | Middle-low | Low | Total % (SE)‡ |
| Quality of care: Most recent screening for diabetes, ≤3 years ago vs. >3 years ago or never | | | | | |
| ≤3 years ago, % (SE)‡ | 76.6 (3.64) | 76.2 (3.32) | 76.7 (4.28) | 77.0 (4.47) | 76.6 (1.97) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 1.00 (0.59-1.71) | 1.03 (0.56-1.91) | 1.08 (0.57-2.05) | |
| Adjusted for sampling method, age, race, education and income, OR (95% CI) | 1.00 | 1.35 (0.77-2.36) | 1.63 (0.87-3.05) | 1.92 (0.87-4.23) | |
| Adjusted for sampling method, age, race, education, income, and having a usual provider, OR (95% CI) | 1.00 | 1.37 (0.77-2.44) | 1.54 (0.81-2.93) | 1.85 (0.87-3.92) | |
| Healthy behavior: Sufficient physical activity (≥150 minutes/week) vs. insufficient physical activity (<150 minutes/week) | | | | | |
| Sufficient physical activity, % (SE)‡ | 70.2 (3.34) | 66.2 (3.09) | 59.9 (4.29) | 61.9 (4.63) | 64.8 (1.91) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 0.83 (0.55-1.25) | 0.63§ (0.40-1.01) | 0.68 (0.41-1.12) | |
| Adjusted for sampling method, age, education and income, OR (95% CI) | 1.00 | 1.15 (0.72-1.85) | 0.90 (0.53-1.50) | 1.11 (0.61-2.03) | |
| Adjusted for sampling method, age, education, income and walkability, OR (95% CI) | 1.00 | 1.07 (0.61-1.87) | 0.85 (0.46-1.56) | 1.05 (0.55-2.01) | |
| Healthy behavior: Fruit and vegetable intake, ≥5 servings/day vs. <5 servings/day | | | | | |
| ≥5 servings/day, % (SE)‡ | 12.6 (2.34) | 14.3 (1.76) | 12.4 (2.05) | 17.3 (3.73) | 14.2 (1.23) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 1.16 (0.70-1.91) | 0.98 (0.56-1.71) | 1.46 (0.76-2.83) | |
| Adjusted for sampling method, age, education and income, OR (95% CI) | 1.00 | 1.27 (0.74-2.19) | 1.01 (0.55-1.87) | 1.88 (0.91-3.90) | |
| Adjusted for sampling method, income and RFEI, OR (95% CI) | 1.00 | 1.28 (0.75-2.19) | 0.95 (0.46-1.95) | 1.78 (0.91-3.49) | |
| Healthy behavior: Buys low- or no-sodium foods, yes vs. no | | | | | |
| Buys low/no salt foods, % (SE)‡ | 56.2 (3.50) | 52.0 (3.11) | 53.1 (4.39) | 49.8 (4.88) | 52.5 (1.96) |

| | | | | |
|---|---|---|---|---|
| Adjusted for sampling method, OR (95% CI) | 1.00 | 0.85 (0.59-1.23) | 0.88 (0.56-1.38) | 0.79 (0.49-1.28) |
| Adjusted for sampling method, age, education and income, OR (95% CI) | 1.00 | 0.93 (0.62-1.40) | 1.11 (0.68-1.82) | 1.05 (0.62-1.78) |
| Adjusted for sampling method, age, education, income and RFEI, OR (95% CI) | 1.00 | 0.93 (0.62-1.40) | 1.16 (0.69-1.94) | 1.08 (0.62-1.88) |

*All estimates generated using logistic regression and weighted for survey design. †Neighborhood socioeconomic status (SES) was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low SES, >30%). ‡Weighted percentage, with standard error, data represent King County estimates. §Borderline significant.

**Chapter 2:** Disease management and quality of care among King County adults with non-gestational prediabetes and diabetes mellitus, by neighborhood socioeconomic status

**Abstract**

**Introduction:** Currently, 8.3% of Americans have diabetes. Diabetes is a condition that can be prevented, through the control of blood glucose levels, and managed to minimize complications from elevated blood glucose and comorbidities. Individuals and neighborhoods with high poverty are disproportionately affected by diabetes. To better prevent and manage disease, we evaluated the association between neighborhood socioeconomic status and health inequalities related to diabetes risk factor prevalence, healthy behavior, and the access and receipt of high quality care among adults diagnosed with non-gestational prediabetes and diabetes.

**Methods:** A large-scale feasibility study was conducted among King County, Washington adults. Participants were selected randomly using community-based sampling and health facility-based sampling on diagnostic codes for 12 chronic conditions. In our study, we included participants who self-reported having received a diagnosis of either prediabetes or diabetes. A proxy, 200% federal poverty level, defined neighborhood socioeconomic status (SES). Weighted logistic regression estimated the association between neighborhood and healthy behavior, quality of care, and clinical outcomes, using cross-sectional self-reported survey data.

**Results:** Diabetes patients in low SES neighborhoods had the lowest observed prevalence of taking a disease education class (46%) and regularly self-monitoring blood glucose (46%). Additionally, these adults were significantly less likely (OR: 0.19, 95% CI: 0.06-0.62) to achieve a hemoglobin A1c target level of <8% compared to diabetes patients in high SES neighborhoods. The lower odds of adults with diabetes who lived in low SES neighborhoods to meet health indicator goals, compared to adults in high SES neighborhoods, was directly associated with having regular healthcare providers, being a non-White race/ethnicity, and having a lower annual income.

**Conclusions:** Neighborhood disparities related to area poverty exist in disease self-management, healthcare access, and clinical outcomes. For diabetes patients, especially those who live in neighborhoods with lower SES, continuous, coordinated care from a team of regular healthcare providers is the link to receiving high quality care, actively self-managing disease, and achieving glycemic control. We recommend that interventions start by minimizing barriers to care access, especially those related to cost, as well as educating adults with diabetes on the importance of regular provider visits and a healthy lifestyle.

## Introduction

Projections estimate that 53.1 million people will be affected by diabetes in the United States (U.S.) by 2025 (77). Due to its high and increasing prevalence, economic costs, and potential adverse complications, the preventing, delaying and managing diabetes is a public health priority. Preceding diabetes is prediabetes, a reversible condition in which blood glucose levels are elevated, but not high enough to be classified as diabetes (48). Currently, prediabetes affects 35% of adult Americans (56). Guidelines recommend that adults with diagnosed prediabetes be screened annually to monitor blood glucose levels and be advised to increase healthy behaviors, such as improving diet and physical activity levels, which may prevent or delay diabetes (26, 78-80).

The same lifestyle modification strategies for adults with prediabetes are valuable in preventing the development and progression of comorbidities in diabetes patients (26, 81, 82). In addition to healthy lifestyle behaviors, a diabetes management strategy should include continuous, quality care from a team of healthcare professionals (26). Additionally, regardless of interventions to improve care delivery, diabetes-related outcomes only significantly improve when individuals are motivated to be responsible for their own health (83). Disease self-management activities among adults diagnosed with diabetes include taking a disease education course to increase disease awareness, self-monitoring blood glucose, seeking needed medical care in a timely fashion, and adhering to physician-recommended strategies (65).

Diabetes risk factor prevalence and disease burden disproportionately occurs in high poverty neighborhoods and among individuals of lower socioeconomic status (SES) (49). National- and state-level data depict this disparate chronic disease distribution. However, the absence of data for smaller areas to identify patterns of disease burden and health determinants is a significant gap in health research (84). The Monitoring Disparities in Chronic Conditions (MDCC) study set out to address the need for robust health data within neighborhoods through a large-scale feasibility study of chronic conditions in King County (KC), Washington.

In KC, the overall prevalence of diagnosed diabetes is 5% among adults, with a steadily growing gap in diabetes prevalence between adults living below and above the 200% federal poverty level (50, 51). Understanding the mechanisms that link neighborhood SES to observed health disparities locally would provide evidence to support funding and policy decisions that enable the development of healthy neighborhoods. Our research goal in this chapter is to describe the connection between neighborhood poverty and health inequalities related to risk factor prevalence, healthy behavior, and the access and receipt of quality healthcare among KC adults diagnosed with prediabetes and diabetes.

**Methods**

Study population: The research in this chapter included MDCC study participants who responded "yes" to one or both of the following questions on the MDCC study core survey: "has a doctor or other health professional ever told you that you had diabetes mellitus, otherwise known as diabetes, sugar diabetes, high blood glucose, or high blood sugar?", and "has a doctor or other health professional ever told you that you had prediabetes mellitus, otherwise known as prediabetes, borderline diabetes, impaired fasting glucose, impaired glucose tolerance, or impaired sugar tolerance?" Classification of diabetes (Type 1 or Type 2) was not assessed.

Exposure. The percentage of residents in a neighborhood living at or below the 200% federal poverty level (FPL) was used as a proxy for our exposure, neighborhood socioeconomic status (SES), as described in the Dissertation Methods section of this document.

Outcomes: We estimated the prevalence of high quality care indicators, advice related to practicing healthy behaviors received from healthcare providers, and healthy behaviors practiced among individuals diagnosed with prediabetes and diabetes. All outcomes were determined using self-reported data. To assess high quality of care, we assessed the recency of diabetes testing among adults who self-reported a prediabetes diagnosis (≤1 year vs. >1 year) and, among adults who reported a diabetes diagnosis, the number of times hemoglobin A1c (HbA1c) levels were checked in the past 12 months (≥2 times vs. <2 times), both standards of care recommended by the American Diabetes Association (ADA) (26). We measured healthy behavior using physical activity levels and nutrition choices among adults with prediabetes or diabetes, defined as: Meeting guidelines for sufficient physical activity (≥150 minutes per week) vs. insufficient physical activity (<150 minutes/week) (52); daily fruit and vegetable intake (≥5 servings/day vs. <5 servings/day) (53); and, purchasing low- or no-sodium foods when grocery shopping (yes vs. no). In order to measure participants' knowledge of disease and the practice of daily disease management, we assessed if participants diagnosed with diabetes took a diabetes education class (yes vs. no) and frequency of self-monitoring blood glucose (≥7 times/week vs. <7 times/week). Lastly, since glycemic control indicates controlled diabetes, we assessed the most recent HbA1c level among adults with diabetes using two different cutoff points. The ADA suggests a target of HbA1c <7% (26), although after accounting for patient characteristics such as age, additional comorbidities, and time since diabetes diagnosis a less stringent target for glycemic control may be more practical for some diabetes patients. Thus, we also evaluated glycemic control defined as HbA1c <8%, a cutoff level suggested by the National Committee for Quality Assurance based on the Healthcare Effectiveness Data and Information Set (85).

Analysis. We modeled the association between neighborhood SES and study outcomes using weighted logistic regression. We ran 3 models for each of our outcomes. First, we generated crude estimates, adjusting only for sampling method to account for differences in participants randomly selected from the community and participants selected from health facilities based on chronic condition diagnostic codes as described in the Dissertation Methods section of this dissertation. Next, we adjusted these models for demographic characteristics that could act as confounders. These included categorical age, race, education and annual income. In our final models, we considered different health indicators and neighborhood characteristics to estimate the modifiable factors that might account for any observed associations between neighborhood SES and the outcomes of interest. High SES neighborhoods served as the reference group in all models.

Health indicators evaluated for model inclusion were health insurance coverage (yes vs. no), unmet medical need (unable to see a healthcare provider when needed in the past 12 months because of cost), and having a usual healthcare provider or place to seek medical care (one provider/more than one provider/none). The neighborhood factors assessed included walkability (based on Walk Score® categories: car dependent, somewhat walkable, very walkable, and walker's paradise) (54); and, retail food environment index (RFEI), a ratio of total number of fast-food restaurants and convenience stores to the total number of supermarkets and produce vendors in an area (55).

To produce the final models, we used a chi-square test at a p-level of 0.05 to determine statistical significance of covariate prevalence across our exposure groups. The association between potential covariates and outcomes were tested with the type III test of fixed effects.

**Results**

Study participants (Figure 1). Among MDCC participants who completed the core survey, 1,228 (28%) reported a non-gestational prediabetes or diabetes diagnosis. We excluded 34 (3%) participants whose addresses were either outside KC or unable to be geocoded. Our final sample included 1,194 participants, 81% of whom were from the health facility-based sample. After applying weights, we observed that in high SES neighborhoods, adults with prediabetes were represented nearly equally from each sampling method, but in all other neighborhoods, 67-75% of adults with prediabetes were selected from the community-based sample.

Demographics (Table 1). We observed a 2.6:1 ratio of adults with diagnosed diabetes to adults with diagnosed prediabetes. The average age at diabetes diagnosis was 49.6 years (SE: 1.27). One-third of this diagnosed population lived in neighborhoods categorized as having middle-high SES. Among high-risk race/ethnic groups, Blacks had the highest percentage of prediabetes and diabetes (10%), followed by American Indian/Alaska Native, Asian, or Native Hawaiian/Pacific Islander (8%) residents and Hispanics (4%). The retail food environment differed significantly by neighborhood SES. Low SES neighborhoods favored less healthy options, with 3 times as many fast-food restaurants and convenience stores as grocery stores and produce vendors. Higher SES neighborhoods had approximately 2.1 times the number of fast-food restaurants and convenience stores as grocery stores and produce vendors.

Diabetes risk factors and comorbidities (Table 2). The frequency of coronary heart disease was significantly higher in adults with prediabetes and diabetes living in higher SES areas (p=0.01). Hypertension and hypercholesterolemia, with respective rates of 69% and 55%, were the most prevalent diabetes comorbidities in this population. Congestive heart failure among adults with diabetes was 9%, 3 times higher than the frequency found in adults with prediabetes. The prevalence of overweight in this population was 80%. The lower the SES of neighborhoods, the higher the prevalence of overweight adults with prediabetes and diabetes, although the distribution of overweight was not statistically significant across neighborhood SES ($p=0.50$).

Advice from healthcare professionals (Table 2). Among those who were overweight, approximately 80% reported that they had been advised by a healthcare professional to lose weight and to increase physical activity levels. Although not statistically different percentages across neighborhoods, overweight adults in high SES areas reported the highest prevalence of having received advice to lose weight (84%) and adults in middle-high SES areas reported the highest prevalence (86%) of having been advised to increase physical activity. Among those with hypertension, 65% had been advised to lower their blood pressure. The prevalence of more specific advice, to reduce salt intake and buy low- or no-sodium foods, was significantly different across neighborhoods ($p<0.01$), received by 70% of adults with hypertension in low SES neighborhoods, or 1.5-2 times the frequency as reported in other neighborhoods. Among individuals with hypercholesterolemia, 55% in low SES areas and 38% in high SES areas reported having been advised to eat fewer high fat and high cholesterol foods. This advice, to reduce high fat foods when hypercholesterolemia was present, was more frequently dispensed to patients with diabetes (59%) than patients with prediabetes (51%). Among patients with prediabetes, 46% had been told to have regular checkups, compared to 61% of patients with diabetes.

Healthcare access (Table 2). Overall, 98% of individuals with prediabetes and diabetes had a regular source of healthcare and 92% had health insurance. We observed statistically significant differences ($p<0.01$) in the number (none, 1 source, >1 source) of usual providers or places to seek healthcare per person across neighborhoods. High SES neighborhoods had the highest percentage (5%) of people with no regular healthcare facility or provider, but also the largest percentage of residents who reported having more than one usual healthcare source (52%). In lower SES areas, 24-26% of adults with prediabetes and diabetes reported having more than one provider, 72-75% reported one provider, and 1-2% had no usual healthcare provider. A lower percentage (94%) of individuals with prediabetes had a regular healthcare provider than patients with diagnosed diabetes (99%). Approximately 24% of adults with prediabetes and 14% with diabetes reported unmet medical need. Individuals with prediabetes without health insurance had the highest rate of unmet medical need, with 95% delaying or not receiving medical care in the past year due to cost, compared to 55% of individuals with diabetes. Even among those with health insurance, we observed, respectively, 18% and 10% whom had unmet medical need. The percentage of residents not receiving care in low SES areas because of cost was 24%, twice as high as the rate in high SES areas, but neighborhood differences in unmet need were not significantly different (p=0.23).

Neighborhood SES, quality of care, and diabetes self-management (Table 3). Across all KC neighborhoods, having a regular healthcare provider was directly associated with adults with prediabetes receiving an annual diabetes screening. Among KC adults with a prediabetes diagnosis, those living in middle-high SES areas and low SES areas reported the highest prevalence of having been tested for diabetes in the previous 12 months, 89% and 83%, respectively. Adults with prediabetes in middle-low SES areas reported the lowest prevalence of diabetes screening (68%). After adjusting for race, education, age and a usual healthcare provider, the odds ratio of 0.88 (95% CI: 0.12-6.44) in middle-low SES areas, compared to high SES areas, changed to 1.74 (95% CI: 0.42-7.28). Thus, after accounting for the higher prevalence of high-risk race/ethnic groups, as well as younger and less educated adults in these neighborhoods, the observed odds ratio indicates a non-significant 74% higher odds of being screened for diabetes among adults with prediabetes in low SES areas, compared to similar adults with prediabetes who live in high SES neighborhoods. In other words, we estimated that adults of the same race, age, and educational status are more likely to be screened for diabetes in non-high SES neighborhoods than adults with prediabetes in high SES neighborhoods. The wide confidence intervals associated with these estimates can be attributed to the small, unweighted sample size of adults with prediabetes in our study population. None of the odds ratios we estimated for the association between neighborhood SES and receiving annual diabetes screening were statistically significant.

We estimated an 83% prevalence of HbA1c levels being measured ≥2 times during the past 12 months in KC, with a high percentage of adults with diabetes reporting meeting this quality care indicator in all neighborhoods. After adjusting for race, age, education and income, adults with diabetes in middle-low SES neighborhoods were significantly less likely (OR: 0.39, 95% CI: 0.16-0.98) to have their HbA1c levels checked by a healthcare provider ≥2 times annually, compared to adults with diabetes in high SES areas. Additional adjustment for having a regular healthcare provider changed the estimate from 0.39 to 0.46 (95% CI: 0.18-1.15), rendering it non-significant and indicating mediation of the association between neighborhood SES and HbA1c testing by having a usual source of healthcare.

Overall, changes in model estimates after adjusting for sampling method, race, age, education and income indicate that in low SES areas, less frequent healthcare contact of high-risk race/ethnic groups and a greater percentage of diabetes patients with lower income mask the observed high prevalence of bi-annual or more HbA1c checking. High SES neighborhoods had a larger percentage of individuals with diagnosed diabetes selected from health facility-based sampling, whereas other neighborhoods had a higher prevalence of adults with diabetes selected from community-based sampling. In models that were sampling method-adjusted only, this may explain the estimated lower odds of HbA1c measurement frequency than the corresponding observed prevalence.

In middle-high SES neighborhoods, 69% of adults with diagnosed diabetes reported taking a diabetes education class. In low SES areas, 47% of adults with diagnosed diabetes reported taking a disease education course, the lowest prevalence we observed. Age, race, education and having a usual source of healthcare all confounded the association between neighborhood SES and taking a diabetes class. Specifically, we observed that lower age, being a high-risk race/ethnic group, lower educational attainment, and having a regular place of healthcare were directly associated with having taken a class. After adjusting for age, race, education, and having a regular provider, adults with diabetes in living in middle-high SES areas were significantly more likely (OR: 1.89, 95% CI: 1.02-3.48) to participate in a diabetes education class than adults with diabetes in high SES areas.

Adults with diabetes who lived in low SES areas reported the lowest prevalence of daily self-monitoring of blood glucose. After adjusting for race, age, education and income, adults with diabetes in low SES neighborhoods had 73% (95% CI: 0.12-0.62) significantly lower odds of daily self-monitoring of blood glucose levels, compared to individuals with diabetes in high SES areas. Following inclusion of having a regular source of healthcare to the model, the estimate moved slightly further from zero, indicating that having a provider is associated directly with performing daily blood glucose self-monitoring.

When we evaluated a target HbA1c level of <7%, 55% of KC adults with diagnosed diabetes achieved target HbA1c levels at their most recent checkup. After accounting for having a regular provider and age, adults with diabetes in low SES areas were 59% (95% CI: 0.15-1.15) less likely than adults with diabetes in high SES areas to have reported an HbA1c level <7%, though the estimated odds ratio was not statistically significant.

When we used a target HbA1c level of <8%, considered modest glycemic control, 86% of KC adults with diagnosed diabetes reported having met this level of blood glucose control at their most recent healthcare provider visit. After adjusting for age and a usual source of healthcare, adults with diabetes in low SES areas were 81% (95% CI: 0.06-0.62) significantly less likely to have achieved HbA1c levels <8% recently.

<u>Neighborhood SES and healthy behaviors (Table 4).</u> Among adults with prediabetes and diabetes living in middle-low SES neighborhoods, 66% reported sufficient physical activity, the highest prevalence observed across neighborhood SES. The lowest prevalence of adults who met weekly physical activity recommendations, 44%, was observed in low SES neighborhoods. Adjusting for age, education, income, and neighborhood walkability, we estimated a 2.43 higher odds (95% CI: 1.11-5.34) of sufficient physical activity among middle-low SES adults with prediabetes and diabetes, compared to those in high SES neighborhoods. Adjusted estimates provide evidence that lower annual income is associated with less sufficient physical activity. Neighborhood walkability did not appear to mediate the association between neighborhood and physical activity levels.

Daily fruit and vegetable intake was low: 17% of adults with prediabetes and 13% with diabetes met dietary recommendations. Overall, the highest prevalence of eating ≥5 servings of fruits and vegetables daily was 18%, reported by residents of high SES neighborhoods, followed by 17%, reported by residents of low SES neighborhoods. In the model adjusted for sampling method only, we estimated 59% (95% CI: 0.26-1.00) borderline significant lower odds of meeting fruit and vegetable daily intake recommendations among adults in middle-high SES neighborhood compared to adults in high SES areas. After adjusting for income, age, education and retail food environment, this estimated lower odds was no longer statistically significant (OR: 0.53, 95% CI: 0.25-1.15). The addition of retail food environment to models as a potential mediator of the association between neighborhood SES and fruit and vegetable daily intake did not change the estimated odds ratios.

Across all neighborhoods in King County, we estimated that 61% of residents with prediabetes and diabetes purchased low- or no-sodium foods. Individuals in middle-high SES neighborhoods and low SES neighborhoods were 16% (95% CI: 0.42-1.68) and 8% (95% CI: 0.42-2.04) less likely to buy these foods than those living in high SES neighborhoods. None of our model estimates were significant and retail food environment did not mediate the association.

**Discussion**

Our findings indicate that among adults with diagnosed diabetes, the most important determinant of receiving high quality care, actively self-managing disease, and achieving glycemic control is having a team of regular healthcare providers, especially for adults with diagnosed diabetes who live in neighborhoods with lower SES. However, having one or more usual providers or facilities at which to seek healthcare does not suggest health benefits transitively. The benefit of having a regular source of healthcare is amplified when patients receive regular checkups and seek medical care when needed, thus having continuity and coordination of disease management (28, 86).

In our study, 24% of KC adults with diagnosed prediabetes and 14% of KC adults with diabetes either delayed or did not seek needed medical care because of financial restraints. The largest burden of unmet need was in low SES areas, where 24% of adults did not seek care in the past year when necessary, twice the frequency reported in high SES areas. Cost-related barriers are a major obstacle for many diabetes patients, and lack of health insurance is a primary reason why these adults do not seek medical care (20). When care is sought by individuals with the same levels of health insurance, patients of racial/ethnic minority groups and residents of low SES neighborhoods are more likely to receive care in settings with rapid staff turnover, thus losing the benefits associated with stable care (28).

Notably, unmet medical need was reported by 95% of uninsured adults who reported a prior prediabetes diagnosis. After receipt of a prediabetes diagnosis, individuals should be screened for diabetes annually (26). This level of screening frequency is important to manage diabetes-related risk factors and to assess the effectiveness of prescribed prevention measures as part of a diabetes prevention program. A randomized clinical trial found that even if transient, a return to normal blood glucose levels among individuals with prediabetes was associated with a significant reduction of future diabetes (87). Our findings reveal considerable lost opportunity to prevent patients with prediabetes from progressing to diabetes, as well as from potentially capturing diabetes in early disease stages so that a plan to minimize diabetes comorbidities and complications can be developed.

Glycemic control is a measure of the effectiveness of disease management plans. Frequent assessment is an important strategy to inform ongoing diabetes care to achieve patients' goals to minimize disease-related adverse events (26, 88). Nationally, 65% of individuals diagnosed with diabetes have their HbA1c checked regularly (4). In KC, we found that 83% of residents with diagnosed diabetes have their HbA1c checked regularly. However, this finding did not translate to a higher prevalence of KC adults with diabetes meeting target HbA1c levels than diabetes patients at the national level; nationally, 54% of diabetes patients are estimated to meet target HbA1c levels (4), and in KC, we found that 55% meet these goals when blood glucose targets are set at HbA1c $<7\%$.

Target HbA1c levels recommended for patients diagnosed with diabetes are often $<7\%$ (26, 89, 90), but, in clinical practice, particularly among patients who are older, have many comorbidities, and a long disease duration, such stringent glycemic control is likely unattainable and could be unhealthy. Recent clinical guidelines promote intensive glycemic control, but also the importance of establishing individualized target glucose levels based on each patient's circumstances (85, 89, 90). A modest glycemic control target typically is HbA1c $<8\%$ (85). In low SES areas, although 85% of adults with diabetes reported having their HbA1c levels checked regularly, 60% reported having recent A1c levels $\geq 7\%$ and 28% reported recent A1c levels $\geq 8\%$. Clinical factors such as differences in baseline blood glucose levels, duration of disease, comorbidities, and medication side effects, as well as poor medication adherence among diabetes patients who receive medication to help control their blood glucose levels, likely contribute to a high number of adults with diabetes who are unable to achieve modest glycemic control targets (26, 91), despite receiving high quality care. Our findings indicated that even when applying modest glycemic control targets, living in a neighborhood with low SES was significantly associated with a lower odds of attaining clinical marker goals. Consequently, traditional "all or none" threshold measures may be poor indicators of clinical success, since thresholds do not account for change in HbA1c levels, and may unfairly evaluate health care performance, especially in settings with patients who initially have very poorly controlled disease.

Although the cross-sectional nature of our data prevents us from drawing conclusions of causality, it is noteworthy that in low SES areas, where glycemic control was the lowest, we also observed the lowest likelihood of achieving disease self-management health indicators and in middle-high SES areas, we observed the highest prevalence of adults who reported disease self-management, as well as the highest controlled blood glucose levels. If there is an association between these observations, these patterns would be consistent with previous reports that found diabetes patients who attend disease education courses are more likely to have their HbA1c levels checked, to self-monitor blood glucose, and to meet other measures of quality care, likely as an outcome of seeing their healthcare provider more regularly (92, 93).

Adherence to prevention strategies that include healthy behavior and prescribed medications often is driven by cost. Recent estimates found an overall 5% decline in high out-of-pocket burden between 2001-2011 among adults with diabetes (59), and in a longitudinal study among individuals with diabetes who were enrolled in a healthcare plan, provision of free test strips for self-monitoring blood glucose did not lead to better adherence to self-management strategies (94). In this study, however, annual income was directly associated with frequency of self-monitoring blood glucose, and it is reasonable to consider that high copayments and other factors connected to individual income may prevent these adults from testing their blood glucose as frequently as recommended. Notably, daily monitoring of blood glucose is recommended typically for patients taking insulin, but may be suggested to patients taking insulin less frequently than daily or using noninsulin therapies (26). Since we were unable to ascertain the frequency of diabetes patients taking insulin when our study was conducted, our estimates of blood glucose monitoring may make adherence to this disease management strategy appear lower than it really is in our study population.

Lifestyle changes in diet and exercise can reduce an individual's diabetes risk between 34-43% (60, 95, 96). Fruits and vegetables provide essential vitamins, minerals, and fiber, and can help with weight management, as well as reduce blood pressure and cardiovascular disease (97), yet nationally, and in KC, people fall short of meeting target fruit and vegetable consumption levels (98). Regarding physical activity, 56% of adults with prediabetes and diabetes reported sufficient physical activity, higher than the national estimate of 48% (58). Notably, physical activity guidelines also recommend incorporating moderate or high intensity muscle-strengthening activities at least 2 days weekly (52), but the MDCC study did not capture this information in its core survey.

Physician-based behavioral and diet-related counseling, as well as intensive interventions during randomized trials, have been shown to improve an individual's physical activity levels and diet choices, but have not always translated to improvements in intermediate outcomes, such as lowering blood pressure, or health outcomes, such as reducing mortality (66). Intensive lifestyle interventions have translated to weight loss, reduced glycated hemoglobin, and reduced diabetes incidence, but have produced mixed findings at successfully reducing all-cause or cardiovascular disease mortality over long-term follow-up (66, 67, 81, 82, 96). Among overweight adults, 79% had been advised to lose weight and 81% had been advised to increase physical activity; among all adults, 47% reported having received advice to eat more fruits and vegetables. Lifestyle counseling in a primary healthcare setting modestly improves patient behavior, but these healthy habits, especially if high intensity, are not always sustainable over time.

Due to the sampling method design of the MDCC study, this research included a higher percentage of adults with diabetes, compared to prediabetes, than is estimated in the population (48). Further, it is likely that a proportion of adults with prediabetes participating in the MDCC study were unaware of having elevated blood glucose, and were not captured in this research. Additionally, overall participation rates were higher among adults sampled via health facilities than adults sampled from the community, likely due to more interest in a study related to multiple chronic conditions. We found that, after applying weights to our prevalence estimates, 56% of KC adults with prediabetes and diabetes living in high SES areas were represented by participants selected from the health facility-based sampling frame, an indication that these adults had contact with the healthcare system in the past 24 months. In all other neighborhoods, ≥56% of KC adults with prediabetes and diabetes were represented by study participants selected via community-based sampling. Even after accounting for sampling method in our models, the odds ratios we estimated, as well as observed prevalence of health indicators, may be skewed to overestimating quality of care, disease self-management, and healthy behavior in high SES areas due to more contact with the healthcare system among these participants. Further, study participants may represent a population with lower disease severity, as these adults had to be healthy enough to participate in our study.

A main limitation of our study was its cross-sectional design. Since all data were collected at the same time, the temporality of events cannot be determined and only the prevalence of risk factors and outcomes can be assessed. Consequently, even though we observed high rates of healthy behavior and high rates of having received advice regarding that healthy behavior within the same neighborhoods, we cannot attribute this to causality. Further, our findings depend on the accuracy of self-reported data, which is subject to both recall and social desirability biases. Participants may over-report compliance with disease self-management, overestimating the prevalence of such behavior. If participants forget having been offered medical advice, or choose not to report having received advice if they did not to adhere to it, it would lead to an underestimation of the quality of care received. Additionally, participants may be unaware of their chronic conditions, not know the appropriate medical terminology for the condition, or be unwilling to report disease, leading to underreported disease prevalence in King County. Further, participants may falsely report or misreport their chronic condition status, despite being asked to report only conditions diagnosed by health professionals. Unavailable at the time of this analysis, the MDCC Study collected medical and pharmacy records, performed physical examinations, and conducted tests on biological specimens collected during examinations for a subset of MDCC participants, which will provide clarification on potential bias in disease, behavior, and care receipt reporting.

Disparities in health outcomes, health determinants, and healthcare access and quality are an ongoing policy priority in the United States (99). Our findings provide evidence that health disparities exist across communities, even after accounting for individual risk factors and healthcare access measures. Specifically, we observed that neighborhood poverty level in lower SES areas was associated significantly with lower odds of self-monitoring of blood glucose and reaching modest glycemic control targets. In other words, for adults diagnosed with prediabetes and diabetes in KC, living in a neighborhood with lower SES has adverse associations with the practice of disease self-management strategies and clinical outcomes. The aspects of neighborhood that contribute to these associations are unclear, but could be a range of socioeconomic health determinants, that may include: housing quality and affordability, educational access, public and social policy, societal and cultural values, distribution of resources, and social cohesion. However, likely due to community outreach efforts targeting high-risk adults in high poverty neighborhoods, we found that such adults often fare better living in low SES neighborhoods than their counterparts in high SES neighborhoods, who may be more socially isolated and have fewer community programs to access that meet their health and economic needs.

Efforts to reverse prediabetes and prevent diabetes development require continued perseverance in the face of an increasing absolute disease burden. In KC, existing initiatives that promote healthy neighborhoods should focus efforts on reducing barriers to continuous, regular healthcare, educating adults about managing their health, promoting and making accessible the available resources to make healthy lifestyle choices in all neighborhoods, and building social cohesion.

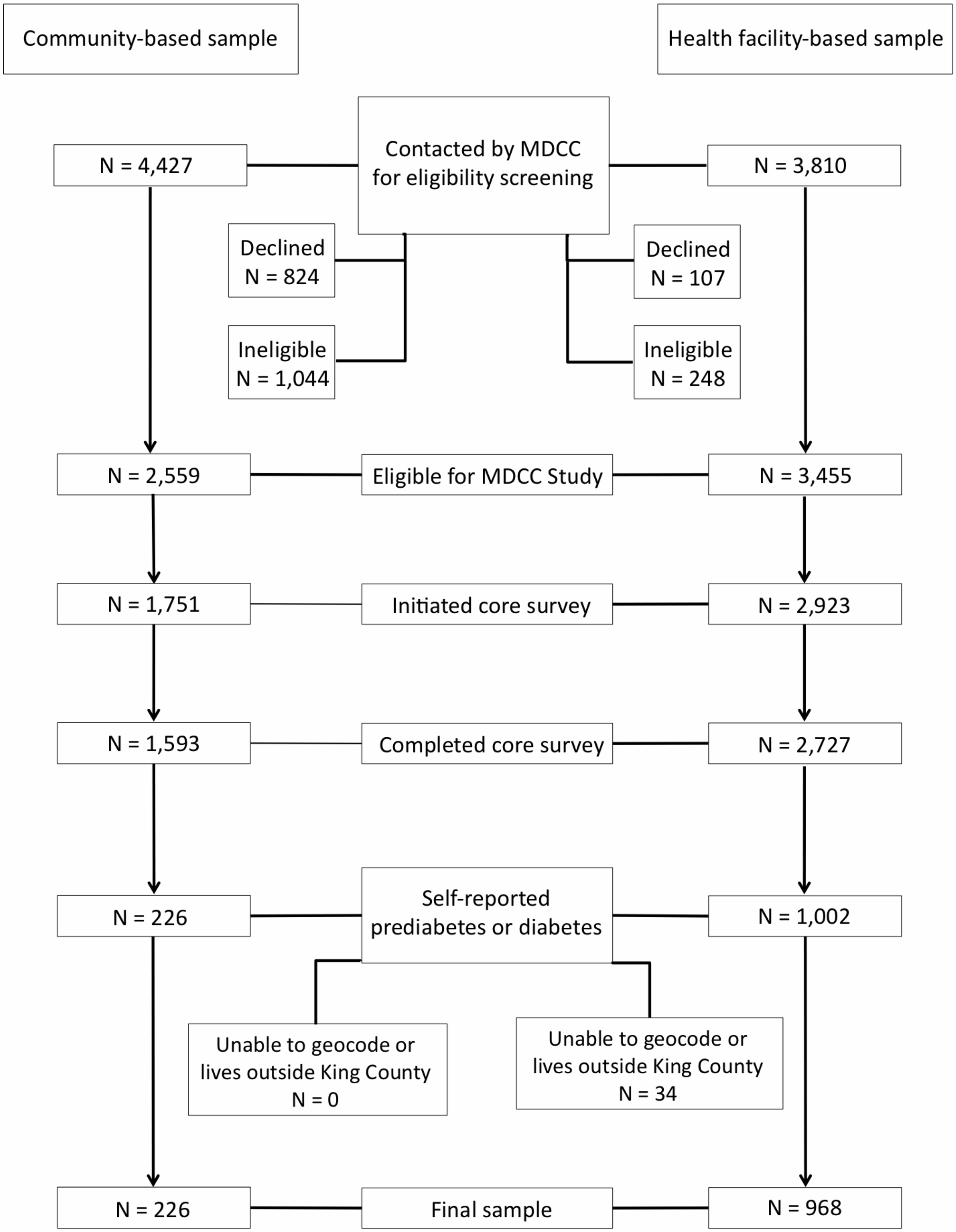


Figure 1. Selection of King County adults with non-gestational prediabetes and diabetes mellitus, from the Monitoring Disparities in Chronic Conditions (MDCC) Study

Table 1. Characteristics of King County adults with non-gestational prediabetes and diabetes mellitus, by neighborhood socioeconomic status * and sampling method†, Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | |
|---|---|---|---|---|---|
| | High | Middle-high | Middle-low | Low | Total |
| **Community-based sample** | | | | | |
| | % (SE)‡ | % (SE)‡ | % (SE)‡ | % (SE)‡ | % (SE)‡ |
| Sex, *male* | 31.7 (9.86) | 57.9 (8.13) | 51.2 (11.02) | 42.1 (7.88) | 48.4 (4.72) |
| Race | | | | | |
| Non-Hispanic White | 99.4 (0.40) | 85.2 (7.29) | 68.9 (12.01) | 63.4 (8.03) | 75.9 (4.92) |
| Non-Hispanic Black | 0 (0) | 0.9 (0.67) | 9.0 (5.03) | 26.9 (7.64) | 10.7 (2.92) |
| Hispanic | 0.6 (0.40) | 2.4 (0.92) | 2.4 (1.12) | 5.0 (1.71) | 3.0 (0.66) |
| Other§ | 0 (0) | 11.5 (7.37) | 19.7 (12.77) | 4.7 (4.55) | 10.4 (4.71) |
| Education | | | | | |
| < High school | 0.3 (0.33) | 3.2 (2.63) | 1.3 (1.33) | 7.6 (3.36) | 3.6 (1.35) |
| High school/GED | 9.8 (7.19) | 13.1 (4.70) | 4.5 (2.53) | 8.2 (3.48) | 8.9 (2.14) |
| Some college | 4.6 (4.31) | 25.9 (7.21) | 36.3 (9.82) | 24.6 (6.06) | 26.0 (3.85) |
| College graduate | 54.2 (11.14) | 29.9 (7.68) | 23.8 (7.38) | 32.1 (8.34) | 31.7 (4.38) |
| Graduate degree | 31.1 (9.77) | 27.9 (7.74) | 34.0 (12.04) | 27.5 (7.50) | 29.8 (4.79) |
| Employment status | | | | | |
| Employed | 65.2 (10.15) | 51.1 (7.86) | 53.8 (9.81) | 36.6 (8.27) | 49.3 (4.81) |
| Out of work, >1 year | 0.1 (0.11) | 6.4 (4.43) | 0.3 (0.26) | 1.8 (1.85) | 2.6 (1.54) |
| Out of work, <1 year | 4.4 (4.31) | 4.4 (3.13) | 6.8 (4.78) | 17.2 (5.67) | 8.8 (2.41) |
| Homemaker | 0 (0) | 0 (0) | 3.3 (3.26) | 1.6 (1.59) | 1.4 (1.0) |
| Student | 0 (0) | 0 (0) | 0 (0) | 0.3 (0.30) | 0.1 (0.09) |
| Retired | 30.3 (9.62) | 38.1 (7.00) | 35.8 (8.50) | 42.5 (8.09) | 37.8 (4.26) |
| Marital status | | | | | |
| Single | 0 (0) | 17.4 (5.85) | 22.2 (7.33) | 23.4 (7.57) | 18.4 (3.59) |
| Married | 78.7 (8.12) | 59.2 (7.56) | 46.8 (10.92) | 41.6 (7.74) | 52.8 (4.79) |
| Divorced/separated | 10.3 (5.50) | 14.7 (5.05) | 18.1 (12.86) | 25.6 (7.34) | 18.4 (4.51) |
| Widowed | 11.1 (6.31) | 8.8 (3.28) | 12.9 (5.11) | 9.5 (3.62) | 10.4 (2.17) |
| Income‖ | | | | | |
| <$15,000 | 0.4 (0.36) | 4.8 (3.22) | 16.7 (6.98) | 17.4 (5.60) | 11.1 (2.74) |
| $15,000 - <$35,000 | 2.9 (2.89) | 14.0 (4.83) | 23.0 (7.55) | 25.3 (7.67) | 18.4 (3.53) |
| $35,000 - <$50,000 | 7.7 (5.21) | 12.3 (4.39) | 20.5 (7.71) | 18.2 (6.89) | 15.6 (3.33) |
| $50,000 - <$75,000 | 19.1 (9.26) | 16.9 (7.28) | 7.6 (4.37) | 13.5 (4.67) | 13.9 (3.16) |
| ≥$75,000 | 69.9 (10.39) | 52.0 (8.89) | 32.1 (8.55) | 25.6 (7.43) | 41.0 (4.64) |

| | | | | | |
|---|---|---|---|---|---|
| Age, *years* | | | | | |
| 18 – 24 | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 25 – 34 | 8.8 (8.22) | 0 (0) | 8.7 (5.95) | 0 (0) | 3.4 (1.95) |
| 35 – 44 | 15.9 (10.03) | 12.5 (6.93) | 8.7 (5.87) | 13.4 (6.71) | 12.1 (3.57) |
| 45 – 64 | 33.2 (10.44) | 56.8 (7.94) | 55.1 (10.11) | 54.4 (7.95) | 52.9 (4.67) |
| ≥ 65 | 42.1 (10.70) | 30.7 (6.31) | 27.6 (7.45) | 32.3 (6.55) | 31.6 (3.72) |
| **Health facility-based sample** | | | | | |
| Sex, *male* | 56.4 (3.91) | 47.9 (2.75) | 44.6 (3.28) | 46.1 (3.82) | 48.3 (1.68) |
| Race[‖] | | | | | |
| Non-Hispanic White | 92.7 (2.04) | 90.6 (1.60) | 84.0 (2.37) | 63.7 (3.75) | 84.3 (1.22) |
| Non-Hispanic Black | 2.0 (1.16) | 3.9 (1.05) | 7.8 (1.75) | 21.5 (3.22) | 7.8 (0.90) |
| Hispanic | 2.9 (1.30) | 2.3 (0.81) | 5.0 (1.32) | 9.9 (2.30) | 4.6 (0.68) |
| Other[§] | 2.3 (1.16) | 3.2 (0.98) | 3.1 (1.18) | 4.9 (1.69) | 3.3 (0.61) |
| Education[‖] | | | | | |
| < High school | 3.3 (1.47) | 1.9 (0.78) | 6.2 (1.61) | 9.3 (2.21) | 4.7 (0.73) |
| High school/GED | 9.3 (2.35) | 11.0 (1.78) | 12.1 (2.17) | 15.7 (2.84) | 11.8 (1.11) |
| Some college | 29.7 (3.59) | 30.8 (2.54) | 35.9 (3.23) | 41.2 (3.85) | 33.9 (1.60) |
| College graduate | 28.6 (3.56) | 33.0 (2.62) | 27.5 (2.95) | 20.8 (3.05) | 28.4 (1.52) |
| Graduate degree | 29.0 (3.50) | 23.3 (2.27) | 18.4 (2.50) | 12.9 (2.65) | 21.2 (1.35) |
| Employment status[‖] | | | | | |
| Employed | 34.5 (3.71) | 30.0 (2.45) | 26.0 (2.92) | 31.8 (3.63) | 30.2 (1.53) |
| Out of work, >1 year | 1.3 (0.95) | 1.5 (0.69) | 3.4 (1.28) | 2.3 (1.17) | 2.1 (0.50) |
| Out of work, <1 year | 8.6 (2.17) | 9.6 (1.61) | 15.9 (2.41) | 20.9 (3.14) | 13.1 (1.13) |
| Homemaker | 5.3 (1.85) | 3.1 (1.00) | 3.3 (1.18) | 2.4 (1.23) | 3.4 (0.64) |
| Student | 0.7 (0.72) | 0.9 (0.52) | 1.3 (0.72) | 3.7 (1.50) | 1.5 (0.41) |
| Retired | 49.6 (3.94) | 55.0 (2.74) | 50.0 (3.35) | 38.9 (3.80) | 49.7 (1.70) |
| Marital status[‖] | | | | | |
| Single | 5.4 (1.73) | 15.6 (1.92) | 19.0 (2.54) | 30.5 (3.57) | 17.3 (1.24) |
| Married | 74.0 (3.46) | 54.8 (2.75) | 43.2 (3.29) | 39.3 (3.80) | 52.7 (1.69) |
| Divorced/separated | 10.0 (2.36) | 16.7 (2.07) | 22.3 (2.85) | 25.4 (3.43) | 18.5 (1.32) |
| Widowed | 10.6 (2.49) | 12.8 (1.96) | 15.4 (2.51) | 4.8 (1.73) | 11.5 (1.13) |
| Income[‖] | | | | | |
| <$15,000 | 8.0 (2.41) | 15.2 (2.16) | 19.7 (2.79) | 37.2 (4.00) | 19.2 (1.44) |
| $15,000 - <$35,000 | 21.8 (3.68) | 20.6 (2.47) | 25.4 (3.11) | 28.0 (3.81) | 23.5 (1.57) |
| $35,000 - <$50,000 | 6.2 (2.14) | 11.5 (1.95) | 14.8 (2.56) | 10.8 (2.54) | 11.3 (1.17) |
| $50,000 - <$75,000 | 19.8 (3.45) | 13.2 (2.00) | 14.9 (2.53) | 5.4 (1.89) | 13.4 (1.24) |

| | | | | | |
|---|---|---|---|---|---|
| ≥$75,000 | 44.2 (4.35) | 39.5 (2.90) | 25.3 (3.05) | 18.7 (3.19) | 32.6 (1.70) |
| Age, *years* | | | | | |
| 18 – 24 | 1.0 (0.78) | 0.2 (0.20) | 0 (0) | 0.2 (0.18) | 0.31 (0.17) |
| 25 – 34 | 2.1 (1.00) | 2.6 (0.86) | 3.5 (1.19) | 6.1 (1.87) | 3.4 (0.59) |
| 35 – 44 | 3.1 (1.38) | 6.7 (1.34) | 6.4 (1.60) | 11.2 (2.39) | 6.8 (0.83) |
| 45 – 64 | 42.6 (3.87) | 33.9 (2.54) | 37.6 (3.16) | 57.4 (3.85) | 41.0 (1.64) |
| ≥ 65 | 51.2 (3.91) | 56.6 (2.70) | 52.5 (3.30) | 25.1 (3.38) | 48.6 (1.68) |
| **Total** | | | | | |
| Sex, *male* | 44.9 (5.43) | 53.5 (4.68) | 48.6 (6.51) | 43.3 (5.64) | 48.3 (2.89) |
| Race[||] | | | | | |
| Non-Hispanic White | 95.8 (1.20) | 87.5 (4.20) | 74.8 (7.79) | 63.5 (5.73) | 79.3 (3.03) |
| Non-Hispanic Black | 1.1 (0.63) | 2.2 (0.62) | 8.6 (3.13) | 25.3 (5.45) | 9.6 (1.77) |
| Hispanic | 1.9 (0.74) | 2.4 (0.62) | 3.4 (0.91) | 6.4 (1.44) | 3.6 (0.49) |
| Other[§] | 1.24 (0.64) | 7.9 (4.27) | 13.2 (8.29) | 4.8 (3.21) | 7.5 (2.87) |
| Education | | | | | |
| < High school | 1.9 (0.83) | 2.6 (1.52) | 3.2 (1.09) | 8.1 (2.44) | 4.0 (0.86) |
| High school/GED | 9.5 (3.57) | 12.2 (2.76) | 7.4 (1.89) | 10.5 (2.63) | 10.1 (1.36) |
| Some college | 18.1 (3.19) | 28.1 (4.11) | 36.2 (5.90) | 29.6 (4.55) | 29.2 (2.41) |
| College graduate | 40.5 (5.89) | 31.3 (4.51) | 25.2 (4.79) | 28.7 (5.97) | 30.4 (2.68) |
| Graduate degree | 29.9 (4.88) | 25.9 (4.11) | 28.0 (7.66) | 23.1 (5.38) | 26.3 (2.96) |
| Employment status | | | | | |
| Employed | 48.9 (5.73) | 41.9 (5.04) | 43.1 (7.17) | 35.2 (5.94) | 41.6 (3.11) |
| Out of work, >1 year | 0.8 (0.51) | 4.3 (2.54) | 1.5 (0.56) | 2.0 (1.33) | 2.4 (0.94) |
| Out of work, <1 year | 6.6 (2.34) | 6.7 (1.92) | 10.3 (3.14) | 18.3 (4.07) | 10.5 (1.52) |
| Homemaker | 2.8 (1.03) | 1.4 (0.45) | 3.3 (2.06) | 1.8 (1.18) | 2.2 (0.66) |
| Student | 0.4 (0.39) | 0.4 (0.23) | 0.5 (0.29) | 1.3 (0.52) | 0.7 (0.18) |
| Retired | 40.6 (5.26) | 45.4 (4.53) | 41.3 (5.91) | 41.4 (5.73) | 42.6 (2.74) |
| Marital status[||] | | | | | |
| Single | 2.9 (0.98) | 16.6 (3.39) | 20.9 (4.59) | 25.5 (5.36) | 18.0 (2.19) |
| Married | 76.2 (4.2) | 57.2 (4.53) | 45.4 (6.48) | 40.9 (5.55) | 52.8 (2.93) |
| Divorced/separated | 10.1 (2.84) | 15.6 (2.99) | 19.8 (7.70) | 25.5 (5.31) | 18.4 (2.73) |
| Widowed | 10.8 (3.21) | 10.6 (2.08) | 13.9 (3.33) | 8.1 (2.55) | 10.8 (1.37) |
| Income[||] | | | | | |
| <$15,000 | 4.2 (1.33) | 9.0 (2.16) | 17.9 (4.28) | 22.9 (4.36) | 14.3 (1.78) |
| $15,000 - <$35,000 | 12.4 (2.71) | 16.7 (3.11) | 24.0 (4.62) | 26.0 (5.60) | 20.4 (2.25) |
| $35,000 - <$50,000 | 7.0 (2.80) | 11.9 (2.71) | 18.1 (4.66) | 16.1 (5.06) | 13.9 (2.08) |

| | | | | | |
|---|---|---|---|---|---|
| $50,000 - <$75,000 | 19.4 (4.93) | 15.4 (4.26) | 10.6 (2.80) | 11.3 (3.36) | 13.7 (1.99) |
| ≥$75,000 | 57.9 (6.01) | 46.9 (5.29) | 29.3 (5.18) | 23.7 (5.50) | 37.7 (2.93) |
| Age, *years* | | | | | |
| 18 – 24 | 0.6 (0.42) | 0.1 (0.39) | 0 (0) | 0.1 (0.05) | 0.1 (0.07) |
| 25 – 34 | 5.2 (3.94) | 1.1 (0.39) | 6.7 (3.68) | 1.8 (0.60) | 3.4 (1.19) |
| 35 – 44 | 9.1 (4.91) | 9.9 (3.99) | 7.8 (3.64) | 12.7 (4.75) | 9.9 (2.17) |
| 45 – 64 | 38.2 (5.32) | 46.8 (4.81) | 48.3 (6.68) | 55.3 (5.63) | 48.1 (2.92) |
| ≥ 65 | 47.0 (5.54) | 42.1 (4.27) | 37.3 (5.40) | 30.1 (4.59) | 38.5 (2.46) |

*Neighborhood socioeconomic status was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low-SES, >30%). †The MDCC Study used a dual sampling frame of King County adults: (1) A randomly selected community-based sample of adults with and without landline telephones, and (2) a health facility-based sample of adults, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling. ‡Weighted percentage and standard error, data represent King County estimates. §Other race includes American Indian/Alaska Native, Asian, Native Hawaiian/Other Pacific Islander, and other. ||Significantly different prevalence across neighborhoods at the 0.05 level, using a chi-square test.

Table 2. Distribution of health indicators by neighborhood socioeconomic status * for King County adults with non-gestational prediabetes and diabetes mellitus, Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | | | |
|---|---|---|---|---|---|---|---|
| | High | Middle-high | Middle-low | Low | Total | KC adults with prediabetes | KC adults with diabetes |
| **Healthcare access** | | | | | | | |
| | % (SE)† | % (SE)† | % (SE)† | % (SE)† | % (SE)† | % (SE)† | % (SE)† |
| Unmet medical need, overall | 12.5 (4.22) | 12.9 (3.32) | 16.9 (4.47) | 24.1 (6.14) | 16.7 (2.38) | 23.7 (5.77) | 13.8 (2.23) |
| ...Has health insurance | 8.9 (4.39) | 8.9 (2.92) | 10.7 (4.10) | 21.3 (7.01) | 12.4 (2.43) | 18.3 (6.25) | 10.3 (2.31) |
| ...No health insurance | 84.7 (9.93) | 84.5 (7.83) | 78.4 (8.57) | 44.6 (11.7) | 67.3 (7.77) | 95.3 (3.30) | 54.9 (8.70) |
| Has a healthcare provider | 95.5 (3.95) | 96.9 (2.05) | 98.4 (1.15) | 98.9 (0.47) | 97.6 (0.96) | 93.7 (3.18) | 99.1 (0.46) |
| One provider | 43.4 (5.42) | 59.0 (4.85) | 72.1 (4.79) | 75.0 (4.88) | 64.3 (2.70) | 68.9 (4.88) | 62.5 (3.21) |
| More than one provider | 52.2 (5.64) | 37.9 (4.80) | 26.3 (4.65) | 23.9 (4.87) | 33.4 (2.62) | 24.8 (4.18) | 36.7 (3.19) |
| **Modifiable prediabetes/diabetes risk factors and comorbidities** | | | | | | | |
| Overweight (BMI ≥25 $kg/m^2$) | 76.4 (5.34) | 78.7 (3.21) | 79.9 (4.31) | 85.0 (3.14) | 80.3 (1.95) | 82.5 (3.81) | 80.1 (2.20) |
| Hypertension | 57.9 (5.95) | 66.7 (5.0) | 68.7 (5.64) | 76.9 (4.32) | 68.6 (2.71) | 67.2 (5.47) | 69.7 (3.07) |
| Hypercholesterolemia | 54.3 (5.89) | 57.4 (4.89) | 55.1 (6.48) | 62.2 (5.54) | 54.5 (2.91) | 52.5 (5.73) | 58.5 (3.30) |
| Coronary heart disease‡ | 22.4 (3.72) | 19.8 (3.10) | 10.1 (1.92) | 13.5 (3.05) | 16.0 (1.52) | 14.3 (3.03) | 16.6 (1.78) |
| Congestive heart failure | 4.9 (1.30) | 7.9 (1.88) | 6.2 (1.67) | 7.7 (2.14) | 6.9 (0.96) | 2.8 (0.73) | 8.6 (1.32) |
| Atrial fibrillation | 24.5 (4.66) | 21.8 (3.59) | 11.5 (2.73) | 15.7 (4.79) | 17.9 (1.98) | 14.2 (3.32) | 18.8 (2.38) |
| Myocardial infarction | 11.2 (2.68) | 10.0 (2.17) | 6.5 (1.49) | 5.3 (1.81) | 8.1 (1.03) | 6.8 (1.74) | 8.5 (1.26) |
| Stroke | 7.9 (2.23) | 11.0 (2.64) | 5.9 (1.41) | 12.5 (4.41) | 9.5 (1.53) | 7.2 (2.73) | 10.4 (1.83) |
| **Advice received from physician** | | | | | | | |
| Have regular checkups | 58.1 (5.63) | 62.1 (4.52) | 56.5 (6.20) | 49.1 (5.74) | 56.7 (2.86) | 45.8 (5.43) | 61.3 (3.24) |
| **Overweight & advised to:** | | | | | | | |
| Lose weight | 83.7 (3.89) | 76.2 (5.28) | 78.7 (4.83) | 79.3 (4.63) | 78.8 (2.56) | 80.6 (4.77) | 78.1 (3.06) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Increase physical activity | 77.1 (5.05) | 86.3 (2.36) | 82.6 (3.97) | 73.6 (5.76) | 80.7 (2.22) | 82.9 (3.55) | 79.7 (2.78) |
| **Hypertension & advised to:** | | | | | | | |
| Lower blood pressure | 53.1 (6.48) | 66.1 (4.68) | 73.3 (6.08) | 59.2 (7.13) | 64.6 (3.26) | 62.5 (6.55) | 65.5 (3.76) |
| Reduce salt intake & buy low/no salt foods[‡] | 31.1 (7.82) | 41.4 (7.15) | 32.5 (9.12) | 69.6 (8.02) | 43.3 (4.75) | 46.0 (10.63) | 42.6 (5.22) |
| **Hypercholesterolemia & advised to:** | | | | | | | |
| Eat fewer high fat foods | 37.6 (5.28) | 45.1 (3.78) | 45.8 (6.33) | 55.3 (7.69) | 45.9 (2.91) | 50.8 (7.59) | 59.3 (4.36) |
| **Nutrition advice, eat more:** | | | | | | | |
| Fruits & vegetables | 43.4 (5.60) | 43.1 (4.65) | 50.2 (6.53) | 50.9 (5.79) | 47.0 (2.91) | 46.1 (5.54) | 47.4 (3.42) |
| Whole grains and/or fiber | 43.9 (5.75) | 35.9 (4.52) | 48.1 (6.72) | 45.6 (5.80) | 42.8 (2.97) | 47.3 (5.60) | 40.9 (3.49) |
| Darkfish (salmon, tuna) | 33.4 (5.53) | 26.1 (4.30) | 25.3 (5.10) | 28.1 (4.40) | 27.5 (2.42) | 29.8 (5.23) | 26.5 (2.63) |

*Neighborhood socioeconomic status was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low-SES, >30%). [†]Weighted percentage, with standard error, data represent King County estimates. [‡]Chi-square test comparing prevalence across neighborhood SES was significant at the 0.05 level.

Table 3. Association* between neighborhood socioeconomic status† and quality of care, disease management, and clinical outcomes in King County adults diagnosed with non-gestational prediabetes and diabetes, Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | |
|---|---|---|---|---|---|
| | High | Middle-high | Middle-low | Low | Total % (SE)‡ |
| **King County adults diagnosed with non-gestational prediabetes mellitus** | | | | | |
| Quality of care: Screening for diabetes in patients with prediabetes, ≤1 year ago vs. >1 year ago | | | | | |
| ≤1 year ago, % (SE)‡ | 73.7 (16.81) | 88.9 (5.37) | 67.7 (11.33) | 83.9 (9.22) | 79.4 (5.23) |
| Adjusted for sampling method, OR (95% CI), n=259 | 1.00 | 3.36 (0.43-26.2) | 0.88 (0.12-6.44) | 2.13 (0.24-19.27) | |
| Adjusted for sampling method, race, age, education and income, OR (95% CI) | 1.00 | 5.92 (1.36-25.73) | 1.87 (0.47-7.37) | 2.37 (0.25-22.85) | |
| Adjusted for sampling method, race, age, education and having a provider, OR (95% CI) | 1.00 | 5.63 (1.10-28.87) | 1.74 (0.42-7.28) | 2.42 (0.31-18.98) | |
| **King County adults diagnosed with non-gestational diabetes mellitus** | | | | | |
| Quality of care: Number of times HbA1c checked during the past 12 months, ≥2 times vs. <2 times | | | | | |
| ≥2 times, % (SE)‡ | 89.6 (2.91) | 83.1 (3.63) | 76.9 (4.94) | 84.9 (5.07) | 83.3 (2.20) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 0.56 (0.25-1.24) | 0.38§ (0.17-0.87) | 0.62 (0.23-1.63) | |
| Adjusted for sampling method, race, age, education and income, OR (95% CI) | 1.00 | 0.57 (0.24-1.34) | 0.39§ (0.16-0.98) | 0.85 (0.25-2.90) | |
| Adjusted for sampling method, race, age, education, income and having a provider, OR (95% CI) | 1.00 | 0.63 (0.27-1.48) | 0.46 (0.18-1.15) | 1.12 (0.36-3.45) | |
| Disease self-management: Took diabetes education class | | | | | |
| Yes, % (SE)‡ | 54.8 (6.19) | 69.2 (4.38) | 52.2 (9.04) | 46.7 (6.46) | 56.7 (3.51) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 1.86§ (0.98-3.51) | 0.90 (0.39-2.11) | 0.72 (0.35-1.48) | |
| Adjusted for sampling method, age, race, and education, OR (95% CI) | 1.00 | 1.76§ (0.97-3.19) | 0.79 (0.39-1.60) | 0.53 (0.26-1.08) | |
| Adjusted for sampling method, age, race, education and having a provider, OR (95% CI) | 1.00 | 1.89§ (1.02-3.48) | 0.91 (0.45-1.86) | 0.63 (0.30-1.36) | |
| Disease self-management: Self-monitor blood glucose, ≥7 times/week vs. <7 times/week | | | | | |
| ≥7 times/week, % (SE)‡ | 64.9 (5.70) | 64.0 (4.98) | 56.7 (9.47) | 46.0 (6.39) | 57.5 (3.55) |

| | | | | | |
|---|---|---|---|---|---|
| Adjusted for sampling method, OR (95% CI) | 1.00 | 0.98 (0.51-1.90) | 0.73 (0.30-1.74) | 0.49[§] (0.24-1.01) | |
| Adjusted for sampling method, race, age, education and income, OR (95% CI) | 1.00 | 0.88 (0.44-1.78) | 0.78 (0.38-1.61) | 0.27[§] (0.12-0.62) | |
| Adjusted for sampling method, race, age, education, income and having a usual provider, OR (95% CI) | 1.00 | 0.91 (0.45-1.85) | 0.81 (0.39-1.65) | 0.30[§] (0.13-0.68) | |
| Clinical outcomes: Most recent HbA1c level, <7% vs. ≥7% | | | | | |
| HbA1c <7%, % (SE)[‡] | 60.5 (7.01) | 62.8 (7.12) | 54.3 (7.50) | 40.0 (9.10) | 55.4 (4.12) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 1.08 (0.47-2.48) | 0.78 (0.33-1.81) | 0.39[§] (0.15-1.03) | |
| Adjusted for sampling method and age, OR (95% CI) | 1.00 | 1.12 (0.56-2.23) | 0.83 (0.39-1.79) | 0.42 (0.15-1.17) | |
| Adjusted for sampling method, age and having a provider, OR (95% CI) | 1.00 | 1.13 (0.56-2.27) | 0.77 (0.35-1.70) | 0.41 (0.15-1.15) | |
| Clinical outcomes: Most recent HbA1c level, <8% vs. ≥8% | | | | | |
| HbA1c <8%, % (SE)[‡] | 88.0 (2.90) | 92.1 (1.78) | 88.8 (2.59) | 71.7 (10.1) | 86.0 (2.81) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 1.50 (0.81-2.80) | 1.09 (0.57-2.08) | 0.23[§] (0.09-0.60) | |
| Adjusted for sampling method and age, OR (95% CI) | 1.00 | 1.44 (0.75-2.75) | 1.10 (0.56-2.17) | 0.21[§] (0.08-0.58) | |
| Adjusted for sampling method, age and having a provider, OR (95% CI) | 1.00 | 1.37 (0.71-2.68) | 0.99 (0.47-2.08) | 0.19[§] (0.06-0.62) | |

*All estimates generated using logistic regression, weighted for survey design. [†]Neighborhood socioeconomic status was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low-SES, >30%). [‡]Weighted percentage, with standard error, data represent King County estimates. [§]Significant or borderline significant estimate.

Table 4. Association* between neighborhood socioeconomic status† and healthy lifestyle indicators in King County adults diagnosed with non-gestational prediabetes or diabetes mellitus, Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | |
|---|---|---|---|---|---|
| | High | Middle-high | Middle-low | Low | Total % (SE)‡ |
| **Sufficient physical activity (≥150 minutes/week) vs. insufficient physical activity (<150 minutes/week)** | | | | | |
| Sufficient physical activity, % (SE)‡ | 56.2 (5.64) | 57.4 (4.63) | 66.2 (5.11) | 44.1 (5.78) | 56.3 (2.81) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 1.00 (0.55-1.81) | 1.42 (0.76-2.65) | 0.54 (0.28-1.05) | |
| Adjusted for sampling method, age, education and income, OR (95% CI) | 1.00 | 1.41 (0.72-2.77) | 2.31§ (1.10-4.83) | 1.01 (0.47-2.17) | |
| Adjusted for sampling method, age, education, income and walkability, OR (95% CI) | 1.00 | 1.41 (0.70-2.83) | 2.43§ (1.11-5.34) | 1.03 (0.47-2.26) | |
| **Fruit and vegetable intake, ≥5 servings/day vs. <5 servings/day** | | | | | |
| ≥5 servings/day, % (SE)‡ | 18.3 (4.11) | 10.2 (1.82) | 13.8 (4.10) | 17.3 (5.17) | 14.1 (1.94) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 0.51§ (0.26-1.00) | 0.72 (0.31-1.67) | 0.95 (0.39-2.27) | |
| Adjusted for sampling method, age, education and income, OR (95% CI) | 1.00 | 0.53 (0.25-1.15) | 0.80 (0.31-2.05) | 1.05 (0.39-2.83) | |
| Adjusted for sampling method, age, education, income and RFEI, OR (95% CI) | 1.00 | 0.53 (0.25-1.15) | 0.79 (0.30-2.07) | 1.03 (0.38-2.80) | |
| **Buying low- or no-sodium foods** | | | | | |
| Buys low/no salt foods, % (SE)‡ | 63.4 (5.62) | 59.5 (4.92) | 60.1 (7.27) | 61.3 (5.78) | 60.7 (3.06) |
| Adjusted for sampling method, OR (95% CI) | 1.00 | 0.85 (0.46-1.58) | 0.88 (0.42-1.85) | 0.93 (0.47-1.84) | |
| Adjusted for sampling method, age, education and income, OR (95% CI) | 1.00 | 0.84 (0.42-1.68) | 1.08 (0.52-2.24) | 0.94 (0.43-2.01) | |
| Adjusted for sampling method, age, education, income and RFEI, OR (95% CI) | 1.00 | 0.84 (0.42-1.68) | 1.06 (0.49-2.31) | 0.92 (0.42-2.04) | |

*All estimates generated using logistic regression, weighted for survey design. †Neighborhood socioeconomic status was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low-SES, >30%). ‡Weighted percentage, with standard error, data represent King County estimates. §Significant or borderline significant estimate.

**Chapter 3:** Validating self-reported medication use with pharmacy records among King County, Washington adults who have diabetes and diabetes-related chronic conditions

**Abstract**

**Introduction:** Pharmacological treatment is an effective disease prevention and management strategy for many chronic diseases, but medication non-adherence is a significant problem among patients. Existing studies use a variety of measures to determine medication use and adherence status, making it difficult to compare findings between studies. Establishing the relative reliability and validity of different medication use measures will contribute new information to improve both health-related outcomes and better understand the utility of various measures in surveillance systems.

**Methods:** Study participants who reported risk factors for diabetes or a diabetes diagnosis were selected from the Monitoring Disparities in Chronic Conditions (MDCC) Study, a large-scale feasibility study linking multiple sources conducted in King County, Washington (2011-2012). We evaluated the concordance between self-reported disease-specific medication use and pharmacy dispensing records, calculating sensitivity, specificity and Cohen's kappa.

**Results:** We obtained pharmacy records for 81 King County adults. We calculated 71% (95% CI: 63%-80%) sensitivity and 34% (95% CI: 23%-45%) specificity of self-reported medication use. Kappa was 0.06 (95% CI: -0.08-0.20), indicating poor agreement. Sensitivity and kappa improved when analysis was limited to participants who reported a chronic disease diagnosis.

**Conclusion:** The validity of self-reported chronic condition medication use was nearly excellent when patients were aware of and reported previously diagnosed conditions, but lacked robust sensitivity otherwise. When patients fail to report diagnosed disease and medication use, opportunities to assess gaps in the prescription of appropriate treatments and medication adherence are lost. Validating the use of self-reported information remains important because self-report is the most common method for exposure measurement in studies of non-infectious disease and may be a useful and feasible method for health data collection for widely implemented surveillance systems.

## Introduction

Chronic diseases, such as diabetes, constitute a major cause of morbidity and mortality in the United States (U.S.). Diabetes currently affects 25.8 million people in the U.S. (48). Once diagnosed, diabetes progression and related complications can be delayed through effective disease management. For 84% of adults diagnosed with diabetes, disease management includes treatment with insulin or oral hypoglycemic agents (48). Adherence to pharmacological treatment aimed at improving glycemic control and preventing the development and progression of diabetes comorbidities is an important component of disease management. However, medication adherence is a significant problem among patients (100-102). Evaluating patterns of adherence and risk factors for non-adherence is important to improve disease management strategies.

Medication adherence studies use a variety of different measures to determine an individual's medication use, making it difficult to compare findings between studies (103). Often, the measurement of medication use applied in research is selected because of method feasibility; namely, either using accessible data that have been collected previously, or using an easy or inexpensive collection approach. Self-reported medication use is a common, inexpensive measurement method, but is of limited reliability and validity, with little known about its optimal use (102-104). Pharmacy dispensing records have been reported as a reliable source of medication obtainment, based on comprehensiveness and the time-window covered (105, 106). Although objective, pharmacy records are limited in measurement scope since they indicate only whether or not a prescription was dispensed, not if the medication was consumed (103, 106). Consequently, there is recognition for the need of standardized and preferred measures of medication use (102).

Establishing the reliability and validity of medication use measures, as well as the implications of the accuracy of these measures when they are used to evaluate chronic illness outcomes, can contribute new information to the field about medication use data sources. Such information also could be used to establish a recall interval for measurement reliability and feasibility, particularly in patients with chronic conditions who likely are taking many medications. We validated self-reported chronic disease-related current medication use, using pharmacy-dispensing records as the "gold standard", to determine if residents of a large, urban county who have chronic conditions receive the appropriate pharmacological disease management and are knowledgeable about their disease, as well as to validate self-reported use of medicines as a primary collection tool for feasible, ongoing surveillance of health-related information.

**Methods**

Study population: In this chapter, we validated self-reported current chronic condition medication use with pharmacy dispensing records. Thus, our study population included all Monitoring Disparities in Chronic Conditions (MDCC) participants from our analyses in chapters 1 and 2 for whom pharmacy records were available.

Exposure classification: The primary measure validated was self-reported current medication use of chronic disease-related medications, based on the question, "during the past 30 days, or since your diagnosis, have you ever taken medication for this condition?" Possible responses were: "yes, currently taking medication", "yes, previously took medication, but not taking currently", and, "no, never took medication". In order to minimize misclassifying respondents with medication use as not having received medication, we excluded responses of "previously took medication" due to the limited timeframe for which we had pharmacy records.

We assigned each medication that appeared in pharmacy records to the chronic condition(s) it is approved to treat using the ambulatory care drug database system (107), which is based on Lexicon Plus®, a proprietary database of Cerner Multum, Inc., that contains the names of all prescription drug products available in the United States drug market. We focused on medications by chronic condition, rather than by drug class, since we were interested in how participants' knowledge of diseases corresponded to the predictive validity of self-report on health outcomes. Information on drug name, date(s) dispensed, quantity dispensed, and directions for use was abstracted from pharmacy records and stored in an electronic form created in DatStat 5.0 software.

We calculated the date that a dispensed prescription would be finished by a participant, if taken as prescribed, by adding together the most recent dispense date and the days supplied prescription duration. If the prescription duration was not listed on the pharmacy record, which occurred for 36 (3.4%) of the prescriptions, we calculated it using the quantity of medication dispensed and the prescription instructions, assuming the medication was taken as prescribed. In addition to missing prescription duration, 373 (35%) prescriptions also were missing the prescription instructions for use. For those records, we imputed the daily dose based on the average daily dose from all prescriptions for a given medication with non-missing information. The date of MDCC core survey completion was used as the reference date to identify medications currently being taken. We considered medication use to be current if an available pharmacy record indicated that medication had been dispensed and had not been completed in the past 30 days. If no pharmacy record was available for a reported medication, we classified it as never having been taken. Aspirin prescriptions for 8 participants were excluded from analysis, since we had no method to evaluate if these prescriptions were for one of the chronic conditions included in our study.

Analysis: We calculated sensitivity, specificity and 95% confidence intervals. Pharmacy records acted as the gold standard to validate dichotomous self-reported current medication use (yes/no). Sensitivity captures the proportion of participants who accurately report current medication use, confirmed by a pharmacy dispensing record. Specificity corresponds to the proportion of participants who correctly report no current medication use, validated by the absence of a pharmacy dispensing record. Additionally, we calculated Cohen's $\kappa$ to evaluate the extent of agreement between self-report and pharmacy records beyond that expected by chance alone. The kappa statistic usually ranges from 0 to 1, with 0 indicating agreement is no better than that expected by chance, and 1 representing near perfect agreement beyond chance (108). If the value of observed agreement is less than concordance expected by chance, kappa will be negative (109). Our study used the following guidelines on strength of agreement to interpret findings (108): <0.00=poor, 0.00-0.20=slight, 0.21-0.40=fair, 0.41-0.60=moderate, 0.61-0.80=substantial, 0.81-1.00=almost perfect.

In order to produce the most robust results, our primary analysis included all study participants. After generating estimates for the entire sample, we then assessed a subset of participants who reported at least one of the chronic conditions known to be a risk factor for, or comorbidity of, diabetes mellitus (110), namely: hypertension, hypercholesterolemia, congestive heart failure, and coronary heart disease. If a participant reported never having been told by a healthcare professional that they had a selected chronic condition, the MDCC survey skipped the question that asked participants if they took any medications for that condition. These participants were included in analyses and classified as not reporting current medication use. If a medication was indicated for multiple chronic conditions, we attributed its use to any chronic conditions reported by the participant, counting participants' reported current medication use as a true positive response. For example, if a prescription for albuterol was present for a participant who reported having COPD, but not asthma, we counted albuterol as a COPD-related prescription. As a secondary analysis, we validated responses only from participants who reported chronic condition(s) and subsequently were asked about disease-related medication use status.

**Results**

Record availability (Figure 1). Among MDCC study participants, 592 consented to pharmacy record review and provided names of pharmacies from where they had obtained prescriptions. Pharmacy records were requested for 525 (89%) of these participants, but due to incomplete consent forms for 4 participants, we obtained records for 521 (99%) of these 525 participants. Reasons for not obtaining pharmacy records for 76 (11.3%) study participants who consented to participate in the MDCC study's medical record review include: no pharmacy records being available; records on pharmacy file were out of the study time frame; the pharmacy charged too high of a cost for record provision; and, the pharmacy named by the study participant could not be located. At the time we conducted this analysis, pharmacy records were available for 81 (16%) participants. The other 440 (84%) records were unavailable at the time of our study abstraction and analysis either because they had not been requested yet from pharmacies; they had been requested, but not received; or, they had not yet been opened and tracked by MDCC study team members and catalogued as ready for abstraction. In total, 2,877 unique prescriptions were abstracted, which included 1,070 (37%) chronic condition medication prescriptions.

Participant characteristics (Table 1). Our study sample consisted of a higher percentage of participants from the community-based sample (59%) than the health facility-based sample. Just over half (53%) of participants had received a diagnosis of prediabetes or diabetes, while 47% met diabetes screening criteria. Nearly all participants were White, and were mostly male, well-educated, and married, with an average age of 66 years (SD: 10 years). Hypertension was the most frequently reported chronic condition, followed in order of highest to least prevalence by hypercholesterolemia, diabetes, atrial fibrillation, coronary heart disease, asthma, prediabetes, myocardial infarction, COPD, congestive heart failure, renal failure, cardiac arrest, and stroke. Disease prevalence was similar in both the community- and health facility-based samples.

We assessed demographic data for those participants whose pharmacy records were unavailable at the time of analysis. Overall, there were minimal differences. Among participants with inaccessible records at the time of this study, there were more Hispanics (4%, compared to 1%), a higher percentage with lower annual income (26% reporting <$35,000, compared to 19%), a higher percentage with self-reported cardiac arrest, congestive heart failure, myocardial infarction, and stroke, and fewer with self-reported atrial fibrillation and diabetes.

Pharmacy records indicated an average of 4.1 (SD: 2.9) currently used chronic disease medications per participant. The average duration of disease-related medication use ranged from a mean of 0.7 years (SD: 0.8) for medications to treat coronary heart disease up to a mean of 3.4 years (SD: 1.5) for diabetes medications. The mean number of refills for a unique medication, over the course of several prescriptions, was 7.0 (SD: 7.9).

Primary analysis (Table 2). Our primary analysis used 112 unique prescriptions whose medication availability overlapped the timeframe of reported current medication use. The sensitivity of self-reported current medication use was 71% (95% CI: 63%-80%) and the specificity was 34% (95% CI: 23%-45%). Cohen's kappa was 0.06 (95% CI: -0.08- 0.20), indicating poor agreement between self-report and pharmacy records. After limiting analysis to participants who reported the presence of hypertension, hypercholesterolemia, congestive heart failure, and/or coronary heart disease, there were 82 distinct current prescriptions available to validate self-report. We observed 71% (95% CI: 61%-81%) sensitivity and 27% (12%-43%) specificity. Kappa, which was -0.02 (-0.10-0.16), indicated agreement worse than that expected by chance.

Secondary analysis (Table 3). In our secondary analysis, we excluded pharmacy records for 27 currently dispensed medications indicated to treat conditions that were unreported by 16 (20%) participants. After eliminating prescriptions for participants who did not report disease diagnosis, sensitivity of self-report was 99% (95% CI: 96%-100%) and kappa was 0.34 (0.22-0.46), indicating fair agreement. Among participants who reported hypertension, hypercholesterolemia, congestive heart failure, and coronary heart disease, we calculated 100% sensitivity (95% CI: 100.0%-100.0%). The kappa value, 0.32 (95% CI: 0.15-0.49), indicated fair agreement between self-report and pharmacy records. Specificity values were the same as the respective values in our primary analysis, since there was no change to the number of participants who did not have pharmacy records available.

## Discussion

Contact with the healthcare system, having a correct diagnosis, and receipt of proper treatment are important components of high quality healthcare. The success of prescribed drug therapy, however, rests on patient adherence, which is influenced, in part, by patients' awareness of their disease and its corresponding symptoms (106). Independent of having reported a related disease diagnosis, we observed that self-reported current medication use for chronic conditions was moderately accurate. These findings were similar to prior reports of the sensitivity of self-reported oral hypoglycemic agents, though less sensitive than previous findings for antihypertensives and statins (111, 112). Specificity of current medication use, correctly reporting no use, was low among all participants. This finding likely is related, in part, to participants who reported medication use, but who were classified falsely as never having received medication as a result of pharmacy records not having been obtained for those prescriptions. Although pharmacy records are relatively easy to obtain and an objective measure of medication availability (106), they are only accurate when records are complete (105). If we had been able to obtain all known pharmacy records for study participants, we expect that both the observed specificity and sensitivity of self-reported current medication use would increase.

In our secondary analysis, in which we excluded prescriptions for participants who had not been asked about medication use for a chronic condition indicated by the prescription, we found nearly perfect sensitivity of self-reported related current medication use, and perfect sensitivity for medications to treat hypertension, hypercholesterolemia, coronary heart disease, and congestive heart failure. This finding corresponds to recent work indicating that disease awareness is the strongest predictor of self-report accuracy of prescription medication use (113).

Approximately 20% of participants who were receiving current treatment for a chronic disease did not report the corresponding diagnosis. This finding could be explained by multiple reasons. First, many of the medications being dispensed have several indications not captured by the 12 chronic conditions we assessed. Although the MDCC study has obtained medical records that will provide additional detail, at the time of analysis, we had no method by which to confirm the conditions that medications were prescribed to treat. Thus, participants may have correctly reported not having a chronic condition, as the medication dispensed currently was prescribed for a condition other than those the MDCC survey captured. For example, a beta blocker such as atenolol, which in this research was considered to treat conditions such as hypertension and coronary heart disease, may be used to treat migraine headaches. Additionally, adults may be reluctant to report medical conditions that they have due to perceived social stigma, perceived discrimination by the healthcare system, or personal opinions about illness, all known biases of self-reported information (106, 114). Additionally, individuals may be unaware that they have a chronic disease and, thus, unaware of the purpose of prescribed medications, highlighting the importance of quality patient-provider communication to promote medication adherence (115). In some instances, individuals with less severe chronic illness will be less likely to self-report having the condition (116). Self-report also is subject to recall bias, which we attempted to minimize by asking about short time windows of medication use and about specific chronic conditions (117, 118).

Validating the use of self-reported information for surveillance purposes remains important because it is the most common method for exposure measurement in studies of non-infectious disease (119). Self-reported data can provide medication use patterns beyond information found in pharmacy and administrative records, capturing medication taking, including nonprescription drugs and inpatient medication use, changes in regimen dosage or frequency not found in dispensing data, and actual use patterns for obtained medications. Pharmacy records, used to validate self-reported current medication use in this study, confirm prescription filling, but cannot validate medication use (103).

Pharmacy records obtained in this study indicated that participants, all of whom had at least one chronic condition, were prescribed an average of 4 chronic disease medications, lower than findings in other studies of chronic condition medications (103, 113). This could be due to incomplete pharmacy records, as well as a higher percentage of study participants who were selected from community-based sampling than health facility-based sampling and, thus, more likely to be healthier adults who have fewer prescribed medications. Additional methods for measuring medication use, such as clinical biomarkers and medical records, would aid in confirming the accuracy of our findings. The MDCC study will be linking these data sources together to provide a more thorough assessment of the validity of different methods of measuring medication use.

Our findings suggest that the performance of self-report as a measurement method depends on how questions are asked of study participants. In addition to asking about the use of medicines for specific diseases, which boosts self-report accuracy in surveys (117), asking participants to name the medications they use can provide detail about prescription regimens, and may further improve the precision of self-reported information, particularly for individuals who are unaware of or reluctant to report their conditions.

This study compared two commonly used methods for measuring medication use, with the goal of providing information on concordance between these two measures when used to determine medication taking among adults with chronic conditions. Reports of low concordance between self-reported medication use and pharmacy records is not uncommon (120). Factors such as patient age, duration of medication use, therapeutic class, the number of medications dispensed regularly, and the time window used to define prescription exposure all are associated with strength of agreement observed (105, 111-113, 121, 122). The poor to fair agreement we observed between reported medication use and pharmacy-dispensing records may be due to known properties of kappa. Specifically, the minimum value of kappa depends on marginal proportions, and even when proportions of agreement may be high, kappa depends partially on the prevalence of the attribute being measured, declining when the prevalence of disease is very high or low (123).

Our study has some limitations. Although our findings have implications for healthcare delivery, and likely for medically-unreached patient populations, they have limited generalizability, particularly among racial and ethnic minority groups that are disproportionately affected by chronic disease, known to have poor medication adherence, and to be disconnected from the health care system (28). In order to identify such patterns, higher research participation rates of racial/ethnic minority groups are needed. This connects to the main limitation of this study, specifically, its small sample size due to the inaccessibility of 84% of participants' obtained pharmacy records at the time we conducted this analysis. The exclusion of these participants was completely at random, that is, not based on any individual characteristics. However, we observed that among participants with unavailable records, there was a slightly higher percentage of Hispanics and lower income adults, characteristics that are associated with medication adherence rates and self-reporting biases (28, 124, 125). However, the different distribution of these characteristics between participants with and without pharmacy records available was not appreciably different, and should not have biased our findings.

The effectiveness of pharmacological disease management relies, in part, on disease diagnosis, appropriate medication prescription and monitoring, and medication adherence. Less than half of U.S. patients with diabetes receive appropriate disease-related treatment (126). Although effective therapies are available, the combination of failure to intensify treatment and poor adherence to medication regimens contribute to patients with diabetes not achieving recommended risk factor targets and can lead to more severe disease-related complications (127). Our focus on King County residents either at high-risk for prediabetes and diabetes or diagnosed with diabetes was intended to capture a population that should have access to healthcare and should receive evidence-based disease prevention and management measures.

Understanding why patients may not receive appropriate treatment or obtain and take prescribed regimens is critical to develop effective interventions. On its own, self-reported information related to health and chronic conditions appears to be a useful and feasible method to capture diagnosed disease and healthcare utilization. A surveillance system that links complete pharmacy record and medical examination information with self-reported data to track individual health determinants, treatment, and outcomes, can provide additional information related to healthcare system contact, the quality of care delivered, and clinical outcomes.

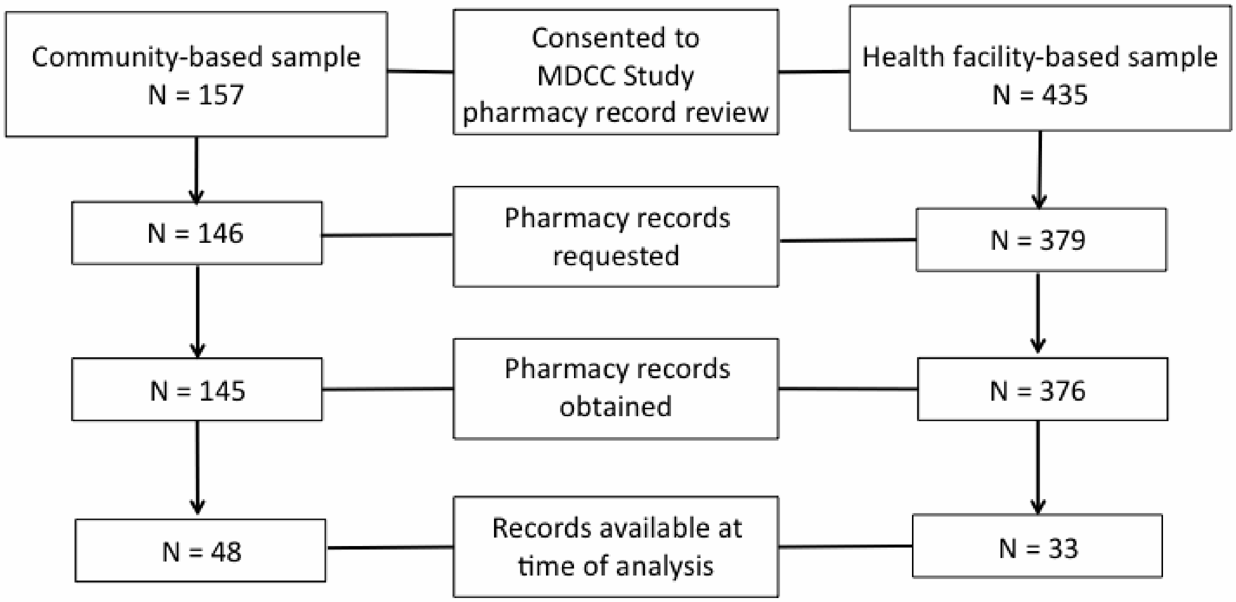


Figure 1. Selection of Monitoring Disparities in Chronic Conditions (MDCC) Study participants who consented to pharmacy record review

Table 1. Participant characteristics*, by sampling method[†], from King County, WA

| | Community-based sample (n=48) | Health facility-based sample (n=33) | Total (n=81) | Pharmacy records unavailable at time of analysis (n=440) |
|---|---|---|---|---|
| | *N (%) or mean (SD)* | | | |
| Race | | | | |
| White | 47 (97.9) | 31 (93.9) | 78 (96.3) | 399 (91.9) |
| Black | 0 (0) | 2 (6.1) | 2 (2.5) | 16 (3.7) |
| Hispanic | 1 (2.1) | 0 (0) | 1 (1.2) | 19 (4.4) |
| Sex, male | 23 (47.9) | 22 (66.7) | 45 (55.6) | 242 (55.0) |
| Age, years | 66.1 (9.8) | 65.0 (10.3) | 65.7 (10.0) | 66.1 (11.7) |
| Education | | | | |
| <High school | 0 (0) | 0 (0) | 0 (0) | 5 (1.1) |
| High school/GED | 3 (6.3) | 1 (3.0) | 4 (4.9) | 32 (7.3) |
| Some college | 17 (35.4) | 13 (39.4) | 30 (37.0) | 118 (26.8) |
| College/graduate degree | 28 (58.3) | 19 (57.6) | 47 (58.0) | 285 (64.8) |
| Employment status | | | | |
| Employed | 19 (39.6) | 9 (27.3) | 28 (34.6) | 140 (32.0) |
| Unemployed | 3 (6.3) | 4 (12.1) | 7 (8.6) | 37 (8.4) |
| Retired | 25 (52.1) | 19 (57.6) | 44 (54.3) | 252 (57.5) |
| Student | 1 (2.1) | 1 (3.0) | 2 (2.5) | 2 (0.5) |
| Homemaker | 0 (0) | 0 (0) | 0 (0) | 7 (1.6) |
| Marital status | | | | |
| Never married | 5 (10.4) | 5 (15.2) | 10 (12.4) | 50 (11.4) |
| Married/living as married | 28 (58.3) | 20 (57.6) | 48 (59.3) | 259 (58.9) |
| Divorced/separated | 8 (16.7) | 7 (21.2) | 15 (18.5) | 75 (17.0) |
| Widowed | 7 (14.6) | 1 (3.0) | 8 (9.9) | 56 (12.7) |
| Income* | | | | |
| <$15,000 | 2 (4.7) | 3 (10.3) | 5 (6.9) | 44 (11.1) |
| $15,000 - <$35,000 | 3 (7.0) | 6 (20.7) | 9 (12.5) | 59 (14.9) |
| $35,000 - <$50,000 | 5 (11.6) | 5 (17.2) | 10 (13.9) | 41 (10.4) |
| $50,000 - <$75,000 | 6 (13.9) | 6 (20.7) | 12 (16.7) | 76 (19.2) |
| ≥$75,000 | 27 (62.8) | 9 (31.0) | 36 (50.0) | 176 (44.4) |
| Self-reported chronic conditions | | | | |
| Asthma | 9 (18.8) | 8 (24.2) | 17 (21.0) | 92 (20.9) |
| Atrial fibrillation | 13 (27.1) | 14 (42.4) | 27 (33.3) | 121 (27.5) |

| | | | | |
|---|---|---|---|---|
| Cardiac arrest | 0 (0.0) | 2 (6.1) | 2 (2.5) | 29 (6.6) |
| Coronary heart disease | 8 (16.7) | 10 (30.3) | 18 (22.2) | 108 (24.5) |
| Congestive heart failure | 2 (4.2) | 5 (15.2) | 7 (8.6) | 63 (14.3) |
| Chronic obstructive pulmonary disease | 4 (8.3) | 4 (12.1) | 8 (9.9) | 44 (10.0) |
| Diabetes | 9 (18.8) | 23 (69.7) | 32 (39.5) | 94 (21.4) |
| Hypercholesterolemia | 30 (62.5) | 15 (45.5) | 45 (55.6) | 246 (55.9) |
| Hypertension | 29 (60.4) | 24 (72.7) | 53 (65.4) | 282 (64.1) |
| Myocardial infarction | 4 (8.3) | 6 (18.2) | 10 (12.4) | 70 (15.9) |
| Renal failure | 2 (4.2) | 4 (12.5) | 6 (7.4) | 31 (7.0) |
| Stroke | 1 (2.1) | 1 (3.0) | 2 (2.5) | 51 (11.6) |

*Data were missing for some participants. [†]The MDCC Study used a dual sampling frame of King County adults: (1) A randomly selected community-based sample of adults with and without landline telephones, and (2) a health facility-based sample of adults, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling.

Table 2. Primary analysis: Concordance between self-reported medication use and pharmacy dispensing records among King County, Washington adults (n=81) from the Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| Self-reported current medication use | Pharmacy records | | Sensitivity | Specificity | Cohen's kappa |
|---|---|---|---|---|---|
| Medications for 12* conditions | Currently dispensed medication | Never dispensed medication | % (95% CI) | % (95% CI) | % (95% CI) |
| Yes | 80 | 48 | | | |
| No | 32 | 25 | | | |
| Total | 112 | 73 | 71.4 (63.1-79.8) | 34.3 (23.4-45.1) | 0.06 (-0.08–0.20) |
| | Pharmacy records | | Sensitivity | Specificity | Cohen's kappa |
| Medications for 4† conditions | Currently dispensed medication | Never dispensed medication | % (95% CI) | % (95% CI) | % (95% CI) |
| Yes | 58 | 24 | | | |
| No | 24 | 9 | | | |
| Total | 82 | 33 | 70.7 (60.9-80.6) | 27.3 (12.1-42.5) | -0.02 (-0.20–0.16) |

*12 chronic conditions included: asthma, atrial fibrillation, cardiac arrest, coronary heart disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, hypercholesterolemia, hypertension, myocardial infarction, renal failure, and stroke. †4 Chronic conditions included: hypertension, hypercholesterolemia, coronary heart disease, and congestive heart failure.

Table 3. Secondary analysis: Concordance between self-reported medication use and pharmacy dispensing records among King County adults (n=81) who reported having at least one chronic condition, from the Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| Self-reported current medication use | Pharmacy records | | Sensitivity | Specificity | Cohen's kappa |
|---|---|---|---|---|---|
| Medications for 12* conditions | Currently dispensed medication | Never dispensed medication | % (95% CI) | % (95% CI) | κ (95% CI) |
| Yes | 80 | 48 | | | |
| No | 1 | 25 | | | |
| Total | 81 | 73 | 98.8 (96.4-100.0) | 34.3 (23.4-46.3) | 0.34 (0.22-0.46) |
| | Pharmacy records | | Sensitivity | Specificity | Cohen's kappa |
| Medications for 4† conditions | Currently dispensed medication | Never dispensed medication | % (95% CI) | % (95% CI) | % (95% CI) |
| Yes | 58 | 24 | | | |
| No | 0 | 9 | | | |
| Total | 58 | 33 | 100.0 (100.0-100.0) | 27.3 (12.1-42.5) | 0.32 (0.15-0.49) |

*12 chronic conditions included: asthma, atrial fibrillation, cardiac arrest, coronary heart disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, hypercholesterolemia, hypertension, myocardial infarction, renal failure, and stroke. †4 Chronic conditions included: hypertension, hypercholesterolemia, coronary heart disease, and congestive heart failure.

# **Chapter 4:** Opportunity for improvement: Identifying gaps in the diabetes prevention spectrum

## Introduction

The tenet of public health practice has been defined as "the strategic, organized, interdisciplinary application of knowledge, skills, and competencies...to improve the population's health" (128). Improving health begins with preventing disease. In order to prevent disease, several factors must align. Structurally, successful public health programs require public and political support, value acknowledgement, and the ability to reach target populations effectively. Next, continuous collection of robust data on the distribution of disease to identify where resources are needed, and the types of resources needed, is paramount to meet public health goals and track health-related patterns over time. Finally, the impact of barriers to healthcare access, care receipt, and healthy lifestyle choices, and how these factors may be tied to community-level resources and opportunities, physical environment, and cultural and societal values, must integrate into program delivery strategies.

More than one-quarter of Americans have multiple chronic conditions that jointly lead to adverse health outcomes (129), and by 2030, approximately 50% of Americans are expected to have more than one chronic condition (130). Among Americans with multiple chronic conditions, type 2 diabetes mellitus is one of the most common (129). Although the chronic disease morbidity and mortality burden continues to grow both in the United States (U.S.) and worldwide, chronic conditions are preventable. Public health practitioners strive to identify where in the spectrum of disease that healthcare interventions can most effectively minimize morbidity and mortality. Opportunities to prevent, delay, and manage diabetes exist at varying stages, namely: when multiple diabetes risk factors are present; once prediabetes has been diagnosed; and, after a diabetes diagnosis.

## Methods

In this chapter, we describe weighted prevalence estimates side-by-side for health indicators related to healthcare access and physician-dispensed advice for the entire MDCC study population divided into 5 distinct subpopulations. The 5 subpopulations are: (1) Participants selected using community-based sampling, with no risk factors that meet diabetes screening criteria as defined by the American Diabetes Association (ADA) (26), and who also reported never having received a prediabetes or diabetes diagnosis from a healthcare professional; (2) Adults with multiple diabetes risk factors who meet ADA diabetes screening criteria (26); (3) Adults who reported having been told by a healthcare professional that they had non-gestational prediabetes mellitus; (4) Adults who reported having been told by a healthcare professional that they had non-gestational diabetes mellitus; and, (5) Participants selected using health facility-based sampling who do not meet criteria for (2), (3), or (4). The goal of this descriptive comparison is to show the gradient of disease, unmet medical need, healthcare delivery, and healthy behaviors by these subpopulations that represent increasing disease severity and medical need.

## Results

Healthcare access: Healthcare access implies that people have contact with the healthcare system, the financial means to seek care, and the time and sufficient information to seek care (110). For a person with diagnosed diabetes, the ability to access care is imperative for disease management. Individuals with diabetes should have a regular source of ambulatory care, health insurance coverage, and accessibility to diabetes specialists (131). As with many chronic diseases, disparities in accessing care are primarily based on social determinants, such as socioeconomic position (SEP) and race/ethnicity, with adults of lower SEP and minority races/ethnicities primarily experiencing barriers to accessing care (91).

Most KC adults had a regular place where they could go when sick or in need of healthcare advice. The prevalence of adults with a usual provider increased across subpopulations, from 91% among the community-based sample to 99% of adults with diabetes. Adults selected from the health-facility based sample fell in-between, 96% of whom reported having a usual provider; those sampled from health facilities reported the highest frequency of one usual provider or place of medical care (72%). Adults with diabetes most frequently reported having more than one source of usual care (37%).

On March 23, 2010, the U.S. President signed the Affordable Care Act, under which all Americans are mandated to have health insurance, into law. The roll out of this law spans 4 years, having started in 2010 and continuing through 2014. Thus, our research was conducted prior to full implementation of this edict. When surveyed, 92% of KC adults had health insurance in 4 of the subgroups we assessed. The only strikingly different prevalence was observed among participants from the health facility sample: one-third of these adults reported being uninsured.

Unmet medical need due to healthcare being too costly was highest among the health facility sample (38%), followed by adults with prediabetes (24%), adults with diabetes (14%), and 9% each of the community-based sample and adults at risk for diabetes reporting unmet need. Delaying or not seeking medical care due to cost occurred most frequently for adults without health insurance, reported by 95% of adults with prediabetes and 55% of adults with diabetes. Even among those with health insurance, the frequency of those with unmet medical need was high among adults with prediabetes (18%), adults with diabetes (10%), and the health facility sample (20%).

Although we place focus in this chapter on accessing healthcare, healthcare system contact is insufficient to guarantee successful health outcomes. Specifically, healthcare access is not synonymous with access to high quality care. Generally, high quality care refers to the receipt of appropriate evidence-based care and advice at the time it is needed in order to achieve the best possible results (65). Additionally, care of high quality encompasses the appropriate level of use of services, balancing underuse and overuse, as well as avoiding misuse of services. Although there is a push to include patient-centered quality indicators when evaluating healthcare delivery, the Institute of Medicine recommends considering the impact on health, policy importance, and susceptibility of being influenced by the healthcare system when selecting a quality indicator (93). In high poverty areas, for example, where adults tend to have a greater number of multiple chronic conditions, barriers to care receipt, and unhealthy physical environments, meeting all-or-none indicator thresholds may not be realistic. Rather than setting thresholds, especially among patients with concurrent chronic conditions that require complex management, evaluating patient change in clinical biomarker levels may provide a fairer evaluation of healthcare performance.

Physician-based counseling. Thirteen percent of adults from the community-based sample reported meeting fruit and vegetable daily intake requirements and 10% in the health facility sample met requirements, consuming ≥5 fruit and vegetables daily. These percentages require improvement. Improvement can begin with more frequent dispensing of advice to meet these dietary guidelines, since currently less than half of KC adults reported having received advice to eat more fruits and vegetables, with only around 25% of both community-based sample adults and adults at risk for diabetes reporting having received this advice, despite the low prevalence who report meeting daily fruit and vegetable intake guidelines. Dietary advice ranging from decreasing sugar and salt intake, buying low or no salt products, eating fewer high fat foods, to increasing fiber, whole grain and darkfish consumption, was consistently provided to adults with prediabetes and diabetes the most frequently. This is consistent with findings that physicians are more likely to provide advice to patients with chronic conditions than those without (68). Although it is positive that these patients were being counseled on healthy eating, increasing such advice among patients prior to a prediabetes or diabetes diagnosis may be more effective as an intervention point to prevent subsequent disease. Physicians should not assume that healthier patients practice healthy behaviors, and with such patients who may have less additional or less severe health concerns to discuss during a regular checkup, extra time during a provider visit can be used for preventive counseling.

Also generated were prevalence estimates of advice pertinent to specific conditions. Among adults who were overweight, only 44% reported having been counseled to lose weight and 51% reported having been advised to increase physical activity in the community-based sample, with similar frequencies reported by overweight adults who were at risk for diabetes. Being overweight is one of the most widely recognized risk factors for diabetes, with BMI cutoffs lower in some high-risk race/ethnic groups (26), as well as being a risk factor for cardiovascular disease and other comorbidities. Discussing weight loss and methods to lose weight, such as an improved diet and increased physical activity, nearly doubles among adults with prediabetes and diabetes, hovering near 80%. The time to discuss weight loss should be before a patient has elevated blood glucose levels or cardiovascular complications.

## Discussion

We identified gaps in the delivery of preventive healthcare in the spectrum of diabetes development from its preclinical phase to clinical diagnosis. The connection between overweight/obesity and diabetes development is well-established, yet we found that 48% of adults who had multiple diabetes risk factors, including being overweight, were advised to lose weight, compared to 81% of adults with prediabetes who were advised to lose weight if they were overweight. Weight loss can reverse prediabetes, but the missed opportunity was not counseling a higher percentage of overweight adults to lose weight, especially those adults who had multiple diabetes risk factors. In addition, adults who are at high risk for diabetes should receive counseling on how to achieve weight loss: For example, eating fewer high fat foods, consuming more fruits and vegetables, increasing physical activity, and reducing salt intake as part of a strategy to lower blood pressure if hypertensive. Promoting healthy behavior not only can prevent elevated blood sugar, but also may reduce cardiovascular disease and other adverse health outcomes.

We observed a larger percentage of adults with diagnosed prediabetes, compared to adults with multiple risk factors for diabetes, receiving advice on diet and exercise habits. Because prediabetes is reversible, adults with prediabetes represent a critical point for delivery of intervention services. Unlike adults who have multiple diabetes risk factors, once informed their blood sugar levels are elevated, adults with diagnosed prediabetes may be more likely to adhere to physician recommendations because of the perceived adverse consequences of not doing so. The most alarming observation in our study population was the high percentage of adults with prediabetes who reported unmet medical need. Among those adults who had been diagnosed with diabetes and who were without health insurance, only 5% reported not needing to delay or not seeking medical care at all when they required it in the past 12 months. Consequently, although the population with diagnosed prediabetes may be a target intervention group, the high proportion of unmet need reported by these adults indicates reduced contact with the healthcare system when facing rising morbidities, and highlights the importance of minimizing the population who develops prediabetes through early risk factor reduction. At minimum, healthcare providers should consider following screening criteria for diabetes that are able to capture individuals with both prediabetes and diabetes (132) in order to prevent and reduce the maximum amount of morbidity and mortality.

Developing strategies to improve population health must consider two distinct populations, recently suggested in the context of target populations for diagnostic testing (132), but having larger implications for healthcare delivery. These two populations were described as those individuals who have contact with the healthcare system, but who do not receive appropriate, evidence-based care; and, those who have no contact with the healthcare system. Comparing estimates across the 5 subpopulations of MDCC study participants, we observed substantial gaps in unmet need between adults with recognized multiple risk factors for diabetes and adults who have been diagnosed with either prediabetes or diabetes; further, gaps exist in the advice received by these adults, signifying a missed opportunity to prevent disease. Healthier adults more frequently are able to seek medical care when needed, facing fewer cost-related restrictions, likely because they require less overall contact with the healthcare system and less complex interventions to manage their better overall health, which translates to less out-of-pocket costs for medical care. When an individual seeks care for a cold or an annual checkup, physicians should consider brief counseling related to lifestyle choices and running basic blood tests to ensure that these adults remain healthy.

We found that many adults, particularly those with more severe disease, do not have contact with the healthcare system due to cost. Due to high premiums and out-of-pocket costs, even once all individuals become covered by health insurance, it is unrealistic to expect that cost-related barriers to accessing care will improve significantly. Observed differences in disease burden persist beyond individual income. Specifically, disparities in geographic distribution of disease are connected to neighborhood poverty level. Partnerships between community-based organizations and healthcare systems can provide a platform for health advocacy within a community (133); approaches to reaching high poverty neighborhoods should be developed to meet specific community needs and gain support from local governmental organizations to build the infrastructure and recruit the resources necessary for program success.

Table 1. Comparison of select health indicators across the spectrum of diabetes progression in Monitoring Disparities in Chronic Conditions (MDCC) Study participants (2011-2012), by disease status*

| | MDCC Community-based sample (n=1,387) | Adults with multiple diabetes risk factors (n=2,690) | Adults with prediabetes (n=275) | Adults with diabetes (n=919) | MDCC Health facility-based sample, no diabetes (n=425) |
|---|---|---|---|---|---|
| | % (SE) | % (SE) | % (SE) | % (SE) | % (SE) |
| Have a regular source of healthcare | 90.6 (1.94) | 92.3 (1.81) | 94.0 (4.58) | 99.1 (3.21) | 96.0 (2.40) |
| One provider/facility | 64.4 (2.07) | 64.9 (1.92) | 68.9 (4.88) | 62.5 (3.21) | 71.6 (2.46) |
| More than one provider/facility | 26.2 (1.89) | 27.3 (1.72) | 24.8 (4.18) | 36.7 (3.19) | 24.4 (2.34) |
| Has health insurance | 92.0 (1.21) | 91.6 (1.20) | 91.7 (3.06) | 92.3 (1.30) | 66.7 (2.58) |
| Unmet medical need: Overall | 9.0 (1.21) | 8.6 (1.06) | 23.7 (5.77) | 13.8 (2.23) | 38.1 (2.69) |
| Among those with health insurance | 5.9 (1.06) | 4.83 (0.81) | 18.3 (6.25) | 10.3 (2.31) | 19.6 (2.66) |
| Among those w/o health insurance | 45.8 (7.98) | 49.9 (7.63) | 95.3 (3.30) | 54.9 (8.70) | 76.4 (4.11) |
| Chronic conditions, mean (SE) | 0.6 (0.03) | 1.2 (0.04) | 2.0 (0.15) | 3.3 (0.10) | 2.3 (0.08) |
| Hypertension | 18.9 (1.41) | 33.6 (1.65) | 67.2 (5.47) | 69.7 (3.07) | 57.3 (2.48) |
| Hypercholesterolemia | 16.8 (1.32) | 30.1 (1.58) | 52.5 (5.73) | 58.5 (3.30) | 45.6 (2.49) |
| Coronary heart disease | 2.88 (0.42) | 8.3 (0.65) | 14.3 (3.03) | 16.6 (1.78) | 11.1 (1.58) |
| Congestive heart failure | 1.50 (0.33) | 3.6 (0.45) | 2.81 (0.73) | 8.61 (1.32) | 7.13 (1.28) |
| **Sufficient physical activity** | 68.3 (1.98) | 64.8 (1.91) | 58.8 (5.49) | 55.3 (3.29) | 41.9 (2.50) |
| Insufficient physical activity & advised to increase physical activity | 50.5 (4.17) | 53.5 (3.52) | 78.3 (6.97) | 80.5 (2.81) | 71.6 (3.47) |
| **Meets fruit/vegetable daily intake requirements** | 12.5 (1.21) | 14.2 (1.23) | 17.0 (5.14) | 12.9 (1.66) | 10.4 (1.51) |
| Advised to eat more fruits/vegetables, among those not meeting intake | 26.3 (2.10) | 29.1 (2.03) | 43.0 (5.73) | 47.1 (3.82) | 46.2 (2.90) |
| **Buys low/no salt foods** | 43.8 (2.05) | 52.5 (1.96) | 56.6 (5.43) | 59.1 (3.53) | 47.6 (2.74) |

| | | | | | |
|---|---|---|---|---|---|
| **Hypertension and:** | | | | | |
| Buys low/no salt foods | 59.0 (4.01) | 63.1 (2.50) | 57.5 (6.83) | 62.5 (4.59) | 46.8 (3.67) |
| **Hypertension and advised to:** | | | | | |
| Lower blood pressure | 58.9 (3.92) | 62.1 (2.42) | 62.5 (6.55) | 65.5 (3.76) | 66.0 (3.50) |
| Cut down on salt | 35.4 (3.59) | 40.1 (2.46) | 53.2 (6.72) | 64.8 (3.71) | 48.6 (3.68) |
| Buy low/no salt foods | 14.9 (2.82) | 17.3 (2.06) | 25.7 (7.24) | 28.6 (3.26) | 23.9 (3.10) |
| Cut down on salt & buy low/no salt foods | 40.6 (6.05) | 50.9 (9.22) | 46.0 (10.63) | 42.6 (5.22) | 41.8 (513) |
| **Advised to:** | | | | | |
| Eat more fruits/vegetables | 25.0 (1.89) | 27.5 (1.82) | 46.1 (5.54) | 47.4 (3.42) | 44.5 (2.72) |
| Cut down on sugar in diet | 13.2 (1.44) | 15.1 (1.40) | 55.7 (5.33) | 58.4 (3.38) | 34.8 (2.62) |
| Increase physical activity | 39.5 (2.05) | 45.1 (1.93) | 75.5 (4.24) | 74.0 (2.66) | 65.4 (2.60) |
| Get regular checkups | 33.4 (1.90) | 39.1 (1.88) | 45.8 (5.43) | 61.3 (3.24) | 49.5 (2.74) |
| Cut down on salt | 13.0 (1.28) | 22.0 (1.53) | 43.0 (5.59) | 50.0 (3.43) | 35.8 (2.62) |
| Buy low/no salt foods | 6.0 (0.97) | 9.7 (1.16) | 23.7 (5.54) | 23.1 (2.42) | 19.5 (2.17) |
| Eat more whole grains and/or fiber | 19.9 (1.68) | 22.9 (1.67) | 47.3 (5.60) | 40.9 (3.49) | 36.7 (2.64) |
| Eat more darkfish | 10.4 (1.27) | 12.6 (1.13) | 29.8 (5.23) | 26.5 (2.63) | 23.6 (2.34) |
| Eat fewer high fat foods | 17.2 (1.44) | 24.3 (1.65) | 37.4 (5.54) | 42.4 (3.48) | 36.1 (2.63) |
| Lose weight | 24.6 (1.70) | 32.5 (1.77) | 73.3 (4.58) | 69.1 (2.92) | 49.3 (2.74) |
| Lower blood pressure | 13.3 (1.22) | 23.3 (1.41) | 41.4 (5.43) | 49.0 (3.44) | 38.9 (2.69) |
| **Overweight and:** | 46.3 (2.03) | 64.6 (1.86) | 83.2 (5.40) | 84.0 (3.24) | 65.5 (2.38) |
| Advised to lose weight | 43.8 (2.83) | 47.6 (2.52) | 80.6 (4.77) | 78.1 (3.06) | 67.9 (3.18) |
| Advised to increase physical activity | 51.4 (2.88) | 55.5 (2.50) | 82.9 (3.55) | 79.7 (2.78) | 72.9 (3.03) |
| **Hypercholesterolemia and advised to:** | | | | | |
| Eat fewer high fat foods | 49.6 (3.95) | 45.9 (2.91) | 50.8 (7.59) | 59.3 (4.36) | 55.9 (4.03) |
| Received flu vaccine, past 12 months | 44.3 (2.02) | 54.4 (1.92) | 67.0 (5.15) | 70.1 (2.83) | 42.1 (2.50) |
| Received pneumonia vaccine | 23.9 (1.59) | 36.5 (1.70) | 51.8 (5.53) | 64.5 (3.62) | 35.7 (2.43) |
| Current smoker | 6.6 (0.99) | 27.7 (1.49) | 36.4 (5.32) | 41.3 (3.27) | 15.5 (1.85) |

| | | | | | |
|---|---|---|---|---|---|
| Current smoker, advised to quit | 86.3 (4.99) | 19.8 (2.15) | 29.0 (9.89) | 22.2 (4.27) | 100.0 (0.00) |

*Divides entire MDCC study population into 5 subpopulations: (1) Adults with multiple risk factors for diabetes; (2) Adults reporting having prediabetes; (3) Adults reporting having diabetes; (4) All MDCC participants from the community-based sample not meeting criteria for (1), (2), or (3); and, (5) All MDCC participants from the health facility sample, not in (1), (2), or (3). †Weighted percentage and standard error.

## Conclusion

In this dissertation, we linked U.S. Census data and publicly available indices of neighborhood attributes with self-reported sociodemographics, health risk factors, healthcare utilization indicators, prior diagnosis of select health conditions, and pharmacy records collected by the cross-sectional Monitoring Disparities in Chronic Conditions (MDCC) study to evaluate the association between neighborhood socioeconomic status (SES) and a range of health indicators related to high quality care, healthy behavior, disease self-management, and clinical outcomes; and, we assessed the validity of self-reported health-related information in the context of chronic condition medication use reporting.

The strength of this research was the ability to integrate both area-level and individual-level measures to assess the impact of neighborhood on the receipt of preventive healthcare measures, disease management strategies, and health outcomes in a local context. The use of a single measure to define our exposure, the percentage of residents in a neighborhood living at or below the 200% federal poverty level, enabled our exposure to be considered independently and as a proxy that represents neighborhood SES. Further, the use of neighborhood data aggregated into groups corresponding to city boundaries resulted in findings that were meaningful to specific neighborhood environments in King County, WA. Our analysis captured the reality of the complex, hierarchical pathways that contribute to health, highlighting missed opportunities for disease prevention and the need for robust data representative at the local level to describe unique differences in healthcare and individual behavior across geographies. This research serves as a model for further work on the impact of geography on chronic conditions, while providing evidence for the importance of investing in local data collection.

Our project also had multiple limitations. First, since our data were cross-sectional, we were unable to draw any conclusions of causality between the significant associations we observed. Several potential biases may be inherent in this data. Recall and social desirability biases of self-reported data became apparent when validating self-reported medication use in Chapter 3 and when looking at the sensitivity of self-reported prior chronic condition diagnoses validated by MDCC study recruitment based on the presence of a diagnostic code for that condition in medical records for participants who were recruited via health facility-based sampling (Appendix, Table I). Thus, the prevalence estimates of diagnosed disease reported in this research, though variable by disease, likely underestimate the true prevalence in the King County, Washington population. On the other hand, some study participants may have overreported compliance with disease self-management, overestimating the prevalence of such behavior, and be more likely to forget having been offered medical advice, particularly if they chose not to adhere to it, underestimating the quality of care received.

Due to the focus on adults with multiple chronic conditions, as well as health facility-based sampling to increase the number of study participants with chronic disease above the prevalence found in studies using community-based sampling methods alone, the final cohort consisted of a greater percentage of participants selected from health facilities, representing a population with known healthcare system contact and disease burden. Among adults with multiple diabetes risk factors, 59.4% were selected from health facility sampling, and among adults with prediabetes and diabetes, 81.1% were selected via health facility sampling. Significant differences (Appendix, Table II) between participants from the two different sampling methods included a higher percentage of adults with multiple risk factors for diabetes from the health facility sample being screened 3 or fewer years ago (p=0.0003); a higher percentage of health facility sample participants reporting purchasing low- or no-sodium foods (p=0.0009); and, a higher percentage of community-based sample participants reporting sufficient weekly physical activity (p=0.0013). Further, the dual-frame sampling strategy led the MDCC study to estimate a 10.1% non-gestational diabetes prevalence and 4.3% prediabetes prevalence in KC (Table III), while nationally, there are approximately 3 times as many individuals with prediabetes then diabetes (48). No incentive was offered for MDCC study participation, so the higher response rate from the health facility sample likely is because these participants had a greater interest in being part of research related to multiple chronic conditions. However, participants had to be relatively healthy to participate in this research, so we likely did not capture KC adults with the most severe morbidities.

Additional exploration of data related to healthcare access and physician-provided advice between the health facility-based sample and the community-based sample revealed further significant differences between the two groups. Among participants with multiple diabetes risk factors (Appendix, Table IV), a higher percentage of community-based participants reported not having a regular healthcare provider (9%, compared to 2% of the health facility-based sample, p<0.0001). Significantly higher percentages of health facility-based participants with multiple diabetes risk factors reported having received advice from a healthcare professional to increase physical activity levels; get regular checkups; cut down on salt intake; buy low- or no salt foods; eat more darkfish; lose weight; and, lower blood pressure. The only offered advice that was reported by a significantly higher percentage of community-based sample participants was among those also reporting hypercholesterolemia, who had been advised to eat fewer high fat foods. When exploring the same factors among KC adults with diagnosed prediabetes or diabetes, community-based participants were significantly more likely than health facility-based participants to report having received advice to lose weight, to get regular checkups, and to increase physical activity if overweight. Particularly among adults with multiple diabetes risk factors, these findings indicate that the relatively high percentages of physician-provided advice we observed were likely due to the higher percentage of participants in the study who had been selected via health facility-based sampling.

The unweighted sample size permitted us to analyze associations across neighborhood SES by 4 categories, but prevented us from performing any stratified analyses by age, sex, or race/ethnicity (Appendix, Table IV). Further, weighting survey data, as we did for our analyses in chapters 1, 2, and 4, assumes no difference exists between respondents and non-respondents on variables of interest; thus, our findings represent the King County population to the extent that our study population represents the King County population (Appendix, Table V). The strategy used to capture study participants, sampling people with diabetes and other comorbidities from medical records, and community-based sampling that oversampled racial/ethnic minority adults who are known to have greater disease burden, aided in boosting the representativeness of our study population to the entire county.

Finally, bias can result if federal poverty level was highly correlated with covariates we included in logistic models, minimizing the ability to identify independent effects. Additionally, because cost of living varies between neighborhoods, living at or below 200% of the federal poverty level can have a different socioeconomic impact depending on where someone lives; we neutralized this issue by adjusting for individual income. We purposely adjusted our models for potential mediators, although this method is critiqued for removing the true effect being examined and thus, leading to an underestimation of the magnitude of association between exposure and outcome. We choose to allow this “bias” since we were interested in understanding the impact of multiple underlying processes. Independent effects that were observed between neighborhood SES and health after adjusting for mediators indicated that an independent effect of neighborhood poverty level existed. Aggregated data reduce the ability to detect associations, especially after adjustment for area differences and demographic covariates (134), so our detection of significant associations between neighborhood poverty and health outcomes was particularly meaningful in demonstrating the impact and reach of neighborhood context.

This research found an independent association of neighborhood poverty level and SES on multiple health indicators. We observed direct associations between neighborhood walkability and reporting sufficient physical activity across neighborhood SES; and, independent associations between neighborhood SES and: taking a diabetes education class in middle-high SES areas; sufficient physical activity in middle-low SES areas; and, self-monitoring blood glucose and modest glycemic control (HbA1c $<8\%$) in low SES areas. Additionally, we found a significant association between neighborhood SES and regular HbA1c checking by a healthcare provider in middle-low SES areas, which was mediated by having a usual source of healthcare. Overall, having a regular source of healthcare mediated the association between neighborhood SES and regular HbA1c checking and self-monitoring blood glucose, both of which are glycemic control strategies. Disease prevention measures implemented by healthcare providers, specifically diabetes screening, were associated with individual-level demographics (age, race, individual income, and education), but not neighborhood SES.

The concept of “neighborhood” is vague and difficult to define precisely. Yet, it is clear that despite the lack of a cogent, agreed upon neighborhood definition, areal measures act as determinants of population health. We conjecture that these observed associations trace back to structural and fundamental factors, as described in this project’s conceptual framework.

Structurally, laws and policies at federal, state, and local levels can promote healthy and safe neighborhoods, medical care, government provision of secure jobs and educational opportunities (5). However, political action is shaped by the cultural and societal values placed on health, and the ability of people to advocate for such action. The unequal distribution of material wealth, educational and employment opportunities, and political influence hinders such policy development, perpetuating socioeconomic inequalities.

Neighborhood inequities in resource and opportunity distribution encompass many social determinants: affordable housing, crime rates, social cohesion and support, exposure to environmental hazards, access to transportation, living wage jobs, access to education, and access to health resources. Ultimately, a lower socioeconomic position leads to poorer overall health, both directly and indirectly (5, 15-18). As research at both the societal and community levels continues, it will be important to separate individual-level disparities in disease burden, such as the high diabetes prevalence that exists in racial/ethnic minority groups (3, 47), from factors which may reflect variation in established risk factors for disease that have been reported to vary by race/ethnicity, such as SES and neighborhood (135-139). It is possible that observed racial inequalities, and other individual-based inequalities, are conditional on, and not interactive with, SES (139-141). If this is the case, when the unequal distribution of the fundamental and structural determinants of health driving disparities are removed, health inequalities among at-risk individuals might shrink appreciably, and possibly disappear (140).

Initiatives in King County aim to reach as many different communities as possible. Health-related information is translated into multiple languages and culturally appropriate materials and distributed through specific neighborhood and ethnic media to reach communities disproportionately affected by disease (142). Such efforts can improve health literacy among communities of color, low-income neighborhoods, and non-native English speakers. Programs aim to build affordable housing in close proximity to public schools, educational resources, healthcare facilities, public recreational facilities and parks, healthy food outlets, and transportation resources that enable mobility and access to economic opportunities. Additionally, outreach programs such as the Seattle & King County racial and ethnic approaches to health (REACH) coalition, which focuses on reducing health disparities related to diabetes in communities of color, offers African Americans, Asians, Pacific Islanders, and Hispanic/Latinos information and resources for diabetes through community-based interventions to combat disease-related inequalities. Finally, services like the Washington State Nutritional Assistance Program that subsidize food purchases for low-income individuals, and the acceptance of food stamps at King County farmer's markets, improve residents' chances of accessing healthy food options. Many of the differences we observed between neighborhoods, such as the high percentage of physical activity in middle-low SES neighborhoods (66% of adults with prediabetes or diabetes), compared to the 44% of adults in low SES neighborhoods; and, the 17% of low SES adults who met daily fruit and vegetable intake requirements, compared to 10% of middle-high SES adults and 14% of middle-low SES adults, may be due to differential distribution of community outreach programs, knowledge of outreach and supplemental assistance programs, and critical structures that enable people to access such resources. Although there are many initiatives in place in King County, our findings indicate that efforts to link people and places for opportunity, as well as community-based political empowerment, may need to focus on connecting to additional neighborhoods and casting interventions to a wider range of neighborhoods in order to address social determinants of health fully.

Our findings demonstrate the complexity of neighborhood, or where people live, and its association with the well-being of individuals. As a proxy for neighborhood SES, and representing the percentage of low-income residents in a neighborhood, our study exposure encompasses several political, social, cultural and environmental constructs that result in geographic health inequalities. The relative impact each construct has on individual health likely varies both by an individual's characteristics and by specific neighborhood characteristics, creating a complex social and epidemiological problem.

Strategies to improve diabetes prevention and disease-related outcomes should incorporate issues beyond the biological condition. Several factors, including the capacity and capability of healthcare providers, patient behavior, cultural, psychosocial, and economical factors, impact access to and the delivery of high quality care. Presently, the healthcare system and its patients are trapped in a cycle perpetuated by external social determinants. An increased focus on these social determinants of health may lead to better care, better health outcomes, reduced health care costs, and eventually, a healthier population.

## Appendix

Table I. Sensitivity of self-reported prior chronic condition diagnosis, validated by recruitment condition* (n=2,120)

| | Sensitivity of self-reported prior disease diagnosis |
|---|---|
| | % (SE)† |
| Non-gestational diabetes mellitus | 97.6 (0.81) |
| Atrial fibrillation | 92.7 (1.89) |
| Asthma | 91.0 (2.74) |
| Non-gestational hypertension | 90. 4 (1.18) |
| Coronary heart disease (unstable angina) | 80.2 (19.82) |
| Chronic obstructive pulmonary disease | 79.6 (4.81) |
| Hypercholesterolemia | 78.7 (2.61) |
| Congestive heart failure | 75.1 (6.04) |
| Acute myocardial infarction | 72.2 (4.23) |
| Stroke (cerebral infarction) | 64.9 (4.75) |
| Chronic renal failure | 62.4 (6.99) |

*The Monitoring Disparities in Chronic Conditions (MDCC) study recruited participants from health facilities and EMS records, based on diagnostic codes appearing in medical records for 12 selected chronic conditions. †Weighted percentage and standard error.

Table II. Prevalence of study outcomes for Monitoring Disparities in Chronic Conditions (MDCC) Study participants, 2011-2012, by sampling method*

| | Community-based sample | Health facility-based sample | Chi-square p-value |
|---|---|---|---|
| | % (SE)[†] | % (SE)[†] | |
| Diabetes screening, among adults with multiple risk factors for diabetes, ≤3 years ago | 75.1 (2.36) | 83.8 (1.09) | 0.0003[‡] |
| Diabetes screening, among adults with prediabetes, ≤1 year ago | 76.4 (7.49) | 86.0 (2.59) | 0.1637 |
| HbA1c regularly checked (2+ times annually) | 84.0 (3.83) | 82.4 (1.56) | 0.1540 |
| Self-monitor blood glucose daily | 53.7 (6.03) | 62.5 (1.89) | 0.1507 |
| Took diabetes education class | 55.7 (6.08) | 57.9 (1.91) | 0.7265 |
| Most recent HbA1c level, <7% | 58.7 (7.49) | 51.6 (2.35) | 0.3748 |
| Most recent HbA1c level, <8% | 91.2 (5.02) | 80.0 (1.89) | 0.1301 |
| Sufficient physical activity, ≥150 minutes/week | 67.8 (2.06) | 57.1 (1.03) | 0.0013[‡] |
| Fruit & vegetable intake, ≥5 servings/day | 14.1 (1.34) | 14.6 (0.73) | 0.7762 |
| Low or no salt foods | 52.4 (2.13) | 60.2 (1.03) | 0.0009[‡] |

*The MDCC Study used a dual sampling frame of King County residents: (1) A randomly selected community-based sample of residents with and without landline telephones, and (2) a health facility-based sample of residents, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling. [†]Weighted percentage and standard error. [‡]Significant difference in outcome between sampling method groups, at p<0.05.

Table III. Comparison of select health indicators in Monitoring Disparities in Chronic Conditions (MDCC) Study participants (2011-2012) with multiple diabetes risk factors (n=2,690), by sampling method*

| | Community-based sample | Health facility-based sample | Chi-square p-value |
|---|---|---|---|
| | % (SE)† | % (SE)† | |
| Have a regular source of healthcare | | | <0.0001‡ |
| No usual provider/facility | 8.9 (1.64) | 2.0 (0.37) | |
| One provider/facility | 65.7 (2.30) | 61.0 (1.29) | |
| More than one provider/facility | 25.3 (2.05) | 37.0 (1.27) | |
| Has health insurance | 91.6 (1.44) | 91.7 (0.72) | 0.9546 |
| Unmet medical need: Overall | 8.2 (1.28) | 10.4 (0.79) | 0.1634 |
| Among those with health insurance | 4.8 (0.97) | 5.2 (0.59) | 0.7102 |
| Among those w/o health insurance | 45.9 (9.03) | 69.6 (4.16) | 0.0158‡ |
| **Hypertension and:** | | | |
| Buys low/no salt foods | 64.0 (3.71) | 61.46 (1.60) | 0.5376 |
| **Hypertension and advised to:** | | | |
| Lower blood pressure | 62.3 (3.65) | 61.6 (1.58) | 0.5924 |
| Cut down on salt | 39.6 (3.70) | 41.0 (1.59) | 0.5826 |
| Buy low/no salt foods | 17.2 (3.11) | 17.3 (1.21) | 0.2455 |
| **Advised to:** | | | |
| Eat more fruits/vegetables | 27.1 (2.19) | 29.3 (1.18) | 0.4858 |
| Cut down on sugar in diet | 14.7 (1.68) | 17.0 (0.98) | 0.1566 |
| Increase physical activity | 43.9 (2.32) | 51.4 (1.31) | 0.0145‡ |
| Get regular checkups | 37.1 (2.11) | 48.8 (1.31) | <0.0001‡ |
| Cut down on salt | 19.4 (1.83) | 34.5 (1.25) | <0.0001‡ |
| Buy low/no salt foods | 8.6 (1.40) | 15.0 (0.93) | 0.0003‡ |
| Eat more whole grains and/or fiber | 22.5 (2.00) | 24.7 (1.12) | 0.7610 |
| Eat more darkfish | 11.5 (1.35) | 17.7 (0.99) | 0.0002‡ |
| Eat fewer high fat foods | 23.9 (1.98) | 26.3 (1.15) | 0.6340 |
| Lose weight | 31.4 (2.11) | 38.1 (1.26) | 0.0090‡ |
| Lower blood pressure | 19.2 (1.64) | 43.3 (1.30) | <0.0001‡ |
| **Overweight and:** | | | |
| Advised to lose weight | 46.7 (3.04) | 52.1 (1.62) | 0.0830 |
| Advised to increase physical activity | 54.6 (3.02) | 59.5 (1.60) | 0.2293 |

| | | | |
|---|---|---|---|
| **Hypercholesterolemia and advised to:** | | | |
| Eat fewer high fat foods | 49.2 (3.97) | 38.1 (1.80) | 0.0189‡ |

*The MDCC Study used a dual sampling frame of King County residents: (1) A randomly selected community-based sample of residents with and without landline telephones, and (2) a health facility-based sample, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling. †Weighted percentage and standard error. ‡Significant difference in outcome between sampling method groups, at p<0.05.

| Table IV. Comparison of select health indicators in Monitoring Disparities in Chronic Conditions (MDCC) Study participants (2011-2012) with self-reported non-gestational prediabetes mellitus or diabetes mellitus (n=1,194), by sampling method* | | | |
|---|---|---|---|
| | Community-based sample | Health facility-based sample | Chi-square p-value |
| | % (SE)† | % (SE)† | |
| Have a regular source of healthcare | | | |
| No usual provider/facility | 3.2 (1.59) | 1.3 (0.38) | 0.0618 |
| One provider/facility | 67.1 (4.37) | 60.1 (1.65) | |
| More than one provider/facility | 29.8 (4.23) | 38.6 (1.64) | |
| Has health insurance | 93.7 (2.01) | 89.7 (1.04) | 0.1310 |
| Unmet medical need: Overall | 17.3 (3.90) | 15.8 (1.24) | 0.6949 |
| Among those with health insurance | 14.2 (3.91) | 9.5 (1.04) | 0.1860 |
| Among those w/o health insurance | 64.8 (15.4) | 69.7 (4.87) | 0.7562 |
| **Hypertension and:** | | | |
| Buys low/no salt foods | 58.2 (6.31) | 65.2 (1.95) | 0.2699 |
| **Hypertension and advised to:** | | | |
| Lower blood pressure | 65.4 (5.55) | 64.9 (1.92) | 0.1190 |
| Cut down on salt | 66.3 (5.39) | 55.4 (2.00) | 0.1164 |
| Buy low/no salt foods | 11.2 (2.68) | 26.7 (1.77) | 0.7916 |
| **Advised to:** | | | |
| Eat more fruits/vegetables | 47.2 (4.75) | 46.7 (1.68) | 0.3994 |
| Cut down on sugar in diet | 58.8 (4.65) | 55.9 (1.67) | 0.7109 |
| Increase physical activity | 77.4 (3.58) | 70.1 (1.54) | 0.0915 |
| Get regular checkups | 57.4 (4.67) | 55.9 (1.68) | 0.0301‡ |
| Cut down on salt | 49.2 (4.78) | 46.2 (1.68) | 0.8924 |
| Buy low/no salt foods | 24.1 (3.86) | 22.0 (1.39) | 0.5350 |
| Eat more whole grains and/or fiber | 45.5 (4.83) | 38.8 (1.64) | 0.1383 |
| Eat more darkfish | 26.4 (3.93) | 29.0 (1.53) | 0.1718 |
| Eat fewer high fat foods | 42.0 (4.81) | 39.2 (1.65) | 0.4717 |
| Lose weight | 74.3 (3.95) | 65.3 (1.60) | 0.0445‡ |
| Lower blood pressure | 45.6 (4.80) | 48.7 (1.69) | 0.0260‡ |
| **Overweight and:** | | | |
| Advised to lose weight | 81.0 (4.01) | 76.2 (1.63) | 0.0906 |
| Advised to increase physical activity | 84.3 (3.37) | 75.0 (1.67) | 0.0206‡ |

| | | | |
|---|---|---|---|
| **Hypercholesterolemia and advised to:** | | | |
| Eat fewer high fat foods | 61.8 (6.09) | 49.7 (2.24) | 0.0995 |

*The MDCC Study used a dual sampling frame of King County residents: (1) A randomly selected community-based sample of residents with and without landline telephones, and (2) a health facility-based sample of residents, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling. †Weighted percentage and standard error. ‡Significant difference in outcome between sampling method groups, at $p<0.05$.

Table V. Prevalence of self-reported non-gestational prediabetes mellitus and diabetes mellitus among Monitoring Disparities in Chronic Conditions (MDCC) Study participants*, 2011-2012

| | Community-based sample | | Health facility-based sample | | Total | |
|---|---|---|---|---|---|---|
| | N | % (SE)† | N | % (SE)† | N | % (SE)† |
| Prediabetes | 83 | 3.5 (0.56) | 231 | 8.5 (0.20) | 314 | 4.3 (0.57) |
| Diabetes | 156 | 6.7 (0.48) | 798 | 27.9 (1.59) | 954 | 10.1 (0.62) |

*Denominator used includes respondents who completed the MDCC core survey, as well as adults who declined study participation, but completed an abbreviated survey that captured demographics and chronic conditions. †Weighted percentage and standard error.

Table VI. King County adults by diabetes status, neighborhood socioeconomic status* and sampling method[†], from the Monitoring Disparities in Chronic Conditions (MDCC) Study, 2011-2012

| | Neighborhood socioeconomic status (SES) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | High | | Middle-high | | Middle-low | | Low | |
| | N[§] | % (SE)[¶] | N[§] | % (SE)[¶] | N[§] | % (SE)[¶] | N[§] | % (SE)[¶] |
| **Adults with multiple risk factors for diabetes[‡]** | | | | | | | | |
| Community-based sample (n=1,091) | 198 | 17.9 (1.48) | 407 | 40.1 (2.27) | 201 | 18.9 (1.77) | 285 | 23.0 (2.10) |
| Health facility-based sample (n=1,599) | 314 | 21.4 (1.10) | 680 | 41.4 (1.29) | 365 | 22.5 (1.09) | 240 | 14.8 (0.92) |
| Total (n=2,690) | 512 | 18.5 (1.25) | 1,087 | 40.4 (1.89) | 566 | 19.5 (1.48) | 525 | 21.6 (1.75) |
| **Adults diagnosed with prediabetes or diabetes** | | | | | | | | |
| Community-based sample (n=226) | 28 | 11.5 (2.52) | 67 | 31.4 (4.32) | 52 | 27.6 (4.69) | 79 | 29.6 (4.15) |
| Health facility-based sample (n=968) | 176 | 19.4 (1.36) | 365 | 36.0 (1.60) | 251 | 25.9 (1.48) | 176 | 18.7 (1.31) |
| Total (n=1,194) | 204 | 14.7 (1.63) | 432 | 33.2 (2.65) | 303 | 26.9 (2.86) | 255 | 25.2 (2.51) |

*Neighborhood socioeconomic status was defined using a proxy; specifically, United States Census 2007-2011 American Community Survey 5-year estimates for percentage of residents living below the 200% federal poverty level (high SES, <14%; middle-high SES, 14-<25%; middle-low SES, 25-30%; low-SES, >30%). [†]The MDCC Study used a dual sampling frame of King County residents: (1) A randomly selected community-based sample of residents with and without landline telephones, and (2) a health facility-based sample of residents, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling. [§]Unweighted sample size. [¶]Weighted percentage and standard error. [‡]Based on American Diabetes Association criteria for diabetes testing in adults, 2011.

Table VII. Demographics of Monitoring Disparities in Chronic Conditions (MDCC) study participants*, by sampling method†, compared to United States (US) Census demographics (2008-2012 American Community Survey estimates)

**Community-based sample**

| | US Census | All MDCC study participants who completed a core survey (n=1,671) | | MDCC study non-respondents who completed a short demographic survey (n=69) | |
|---|---|---|---|---|---|
| | % | N | % (SE) | N | % (SE) |
| Sex, male, ≥18 years | 49.5 | 710 | 47.56 (1.64) | 31 | 57.55 (13.51) |
| Race | | | | | |
| Non-Hispanic White | 64.8 | 1289 | 75.79 (24.62) | 47 | 51.12 (36.97) |
| Non-Hispanic Black | 6.0 | 92 | 6.15 (8.62) | 7 | 5.57 (7.34) |
| Hispanic | 8.8 | 249 | 7.5 (10.42) | 7 | 4.86 (6.44) |
| Asian | 14.5 | 26 | 7.67 (10.41) | 4 | 19.16 (17.77) |
| Other, multiple races | 5.9 | | | | |
| Other, MDCC | | 14 | 2.88 (3.91) | 3 | 19.3 (17.9) |
| Education (25+) | | | | | |
| < High school | 8.0 | 43 | 2.47 (1.52) | 3 | 5.13 (3.23) |
| High school/GED | 17.0 | 125 | 8.10 (1.22) | 7 | 8.4 (4.86) |
| Some college | 20.8 | 391 | 22.58 (2.55) | 15 | 17.61 (2.12) |
| College graduate | 28.8 | 552 | 38.7 (2.04) | 14 | 22 (3.31) |
| Graduate degree | 17.2 | 476 | 28.15 (2.08) | 25 | 46.86 (1.53) |
| Employment status | | | | | |
| Employed | 65.1 | 880 | 61.31 (1.78) | Unavailable | |
| Unemployed | 5.2 | 122 | 8.18 (1.37) | | |
| Out of work, >1 year | | 79 | 5.34 (1.14) | | |
| Out of work, <1 year | | 43 | 2.83 (.26) | | |
| Not in labor force | 29.6 | 611 | 30.51 (1.57) | | |
| Homemaker | | 95 | 6.68 (1.81) | | |
| Student | | 35 | 6.36 (1.71) | | |
| Retired | | 481 | 17.47 (2.11) | | |
| Marital status | | | | Unavailable | |
| Single | 33.7 | 293 | 24.95 (2.36) | | |
| Married | 49.5 | 912 | 58.08 (2.95) | | |
| Divorced/separated | 12.5 | 258 | 11.07 (.66) | | |
| Widowed | 4.3 | 156 | 5.90 (.73) | | |
| Income | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| <$15,000 | 9.0 | 79 | 5.01 (1.47) | 9 | 26.97 (9.67) |
| $15,000 - <$35,000 | 14.8 | 177 | 13.11 (2.14) | 8 | 26.27 (12.34) |
| $35,000 - <$50,000 | 11.5 | 146 | 9.26 (1.07) | 6 | 4.99 (3.49) |
| $50,000 - <$75,000 | 17.1 | 209 | 16.71 (.72) | 7 | 13.76 (2.55) |
| ≥$75,000 | 47.6 | 620 | 55.91 (3.23) | 16 | 28.01 (20.07) |
| Age, *years* | | | | | |
| 18 – 24 (Census: 20-24) | 6.8 | 31 | 6.86 (.57) | 4 | 12.05 (2.45) |
| 25 – 34 | 16.3 | 122 | 18.59 (1.82) | 10 | 25.53 (4.73) |
| 35 – 44 | 15.4 | 231 | 20.38 (1.05) | 10 | 22.87 (2.18) |
| 45 – 64 | 26.8 | 693 | 36.46 (1.36) | 28 | 27.11 (5.94) |
| ≥ 65 | 11.0 | 500 | 17.71 (1.78) | 15 | 12.43 (1.11) |

**Health facility-based sample**

| | US Census | All MDCC study participants who completed a core survey (n=2,838) | | MDCC study non-respondents who completed a short survey on demographic information (n=64) | |
|---|---|---|---|---|---|
| | % | N | % (SE) | N | % (SE) |
| Sex, *male, ≥18 years* | 49.5 | 1443 | 48.03 (1.31) | 35 | 55.71 (2.42) |
| Race | | | | | |
| Non-Hispanic White | 64.8 | 2431 | 86.37 (15.79) | 51 | 85.66 (16.86) |
| Non-Hispanic Black | 6.0 | 177 | 6.00 (8.85) | 1 | 1.51 (2.28) |
| Hispanic | 8.8 | 118 | 3.92 (5.86) | 4 | 6.09 (8.95) |
| Asian | 14.5 | 65 | 2.36 (3.53) | 4 | 4.45 (7.97) |
| Other, incl. multiple races | 5.9 | | | | |
| Other, MDCC | | 40 | 1.35 (2.02) | 1 | 1.30 (1.91) |
| Education (25+) | | | | | |
| < High school | 8.0 | 84 | 3.24 (1.56) | 3 | 4.05 (.80) |
| High school/GED | 17.0 | 304 | 12.18 (.40) | 8 | 13.31 (3.02) |
| Some college | 20.8 | 803 | 29.82 (1.73) | 21 | 33.16 (2.01) |
| College graduate | 28.8 | 828 | 29.82 (1.68) | 11 | 16.29 (6.31) |
| Graduate degree | 17.2 | 749 | 24.94 (1.50) | 19 | 33.19 (4.29) |
| Employment status | | | | | |
| Employed | 65.1 | 927 | 29.37 (1.68) | Unavailable | |
| Unemployed | 5.2 | 340 | 12.30 (2.3) | | |
| Out of work, >1 year | | 286 | 10.35 (2.00) | | |

| | | | | | |
|---|---|---|---|---|---|
| Out of work, <1 year | | 54 | 1.95 (.34) | | |
| Not in labor force | 29.6 | 1481 | 58.33 (3.53) | | |
| Homemaker | | 117 | 4.64 (.53) | | |
| Student | | 35 | 1.27 (.4) | | |
| Retired | | 1329 | 52.41 (4.27) | | |
| Marital status | | | | | |
| Single/never been married | 33.7 | 419 | 14.22 (1.9) | Unavailable | |
| Married | 49.5 | 1565 | 55.03 (2.42) | | |
| Divorced/separated | 12.5 | 485 | 17.68 (1.15) | | |
| Widowed | 4.3 | 313 | 13.07 (.78) | | |
| Income | | | | | |
| <$15,000 | 9.0 | 332 | 16.99 (3.45) | 4 | 11.72 (3.11) |
| $15,000 - <$35,000 | 14.8 | 358 | 18.92 (1.41) | 3 | 6.81 (4.29) |
| $35,000 - <$50,000 | 11.5 | 204 | 11.09 (.55) | 5 | 13.08 (1.61) |
| $50,000 - <$75,000 | 17.1 | 304 | 14.79 (1.48) | 6 | 16.43 (3.84) |
| ≥$75,000 | 47.6 | 822 | 38.21 (2.90) | 18 | 51.95 (2.10) |
| Age, *years* | | | | | |
| 18 – 24 (Census: 20-24) | 6.8 | 10 | .32 (.05) | 1 | .91 (1.33) |
| 25 – 34 | 16.3 | 80 | 2.55 (.38) | 0 | 0 |
| 35 – 44 | 15.4 | 161 | 4.7 (1.88) | 4 | 6.85 (1.53) |
| 45 – 64 | 26.8 | 1064 | 35.87 (3.17) | 24 | 38.14 (6.24) |
| ≥ 65 | 11.0 | 1392 | 55.55 (5.34) | 32 | 54.1 (8.16) |

**Total**

| | US Census | All MDCC study participants who completed a core survey (n=4,509) | | MDCC study non-respondents who completed a short demographic survey (n=133) | |
|---|---|---|---|---|---|
| | % | N | % (SE) | N | % (SE) |
| Sex, *male, ≥18 years* | 49.5 | 2153 | 47.64 (1.5) | 66 | 57.42 (12.49) |
| Race | | | | | |
| Non-Hispanic White | 64.8 | 3720 | 77.49 (23.36) | 98 | 53.56 (36.70) |
| Non-Hispanic Black | 6.0 | 269 | 6.13 (8.65) | 8 | 5.28 (7.00) |
| Hispanic | 8.8 | 367 | 6.93 (9.74) | 11 | 4.94 (6.57) |
| Asian | 14.5 | 91 | 6.82 (9.4) | 8 | 1.82 (1.76) |
| Other, incl. multiple races | 5.9 | | | | |
| Other, MDCC | | 54 | 2.64 (3.64) | 4 | 18.03 (17.4) |

| | | | | | |
|---|---|---|---|---|---|
| Education (25+) | | | | | |
| < High school | 8.0 | 127 | 2.60 (1.51) | 6 | 5.05 (3.01) |
| High school/GED | 17.0 | 429 | 8.76 (1.09) | 15 | 8.75 (4.33) |
| Some college | 20.8 | 1194 | 23.76 (2.36) | 36 | 18.71 (2.10) |
| College graduate | 28.8 | 1380 | 37.26 (1.89) | 25 | 21.59 (2.56) |
| Graduate degree | 17.2 | 1225 | 27.62 (1.94) | 44 | 45.89 (1.55) |
| Employment status | | | | | |
| Employed | 65.1 | 1807 | 56.15 (.90) | Unavailable | |
| Unemployed | 5.2 | 462 | 8.84 (1.42) | | |
| Out of work, >1 year | | 365 | 6.15 (1.21) | | |
| Out of work, <1 year | | 97 | 2.69 (.24) | | |
| Not in labor force | 29.6 | 2092 | 35.01 (.61) | | |
| Homemaker | | 212 | 6.35 (1.63) | | |
| Student | | 70 | 5.54 (1.58) | | |
| Retired | | 1810 | 2.31 (3.09) | | |
| Marital status | | | | | |
| Single/never been married | 33.7 | 712 | 23.20 (2.08) | Unavailable | |
| Married | 49.5 | 2477 | 57.58 (2.77) | | |
| Divorced/separated | 12.5 | 743 | 12.15 (.69) | | |
| Widowed | 4.3 | 469 | 7.07 (.87) | | |
| Income | | | | | |
| <$15,000 | 9.0 | 411 | 6.88 (1.62) | 13 | 26.00 (9.59) |
| $15,000 - <$35,000 | 14.8 | 535 | 14.01 (1.91) | 11 | 25.04 (12.57) |
| $35,000 - <$50,000 | 11.5 | 350 | 9.54 (1.01) | 11 | 5.5 (3.59) |
| $50,000 - <$75,000 | 17.1 | 513 | 16.41 (.58) | 13 | 13.93 (2.27) |
| ≥$75,000 | 47.6 | 1442 | 53.15 (3.01) | 34 | 29.52 (19.80) |
| Age, *years* | | | | | |
| 18 – 24 (Census: 20-24) | 6.8 | 41 | 5.79 (.60) | 5 | 11.26 (2.68) |
| 25 – 34 | 16.3 | 202 | 15.97 (1.85) | 10 | 23.73 (5.23) |
| 35 – 44 | 15.4 | 392 | 17.98 (1.37) | 14 | 21.74 (1.79) |
| 45 – 64 | 26.8 | 1757 | 36.36 (.76) | 52 | 27.89 (5.62) |
| ≥ 65 | 11.0 | 1892 | 23.91 (2.97) | 47 | 15.37 (1.74) |

*MDCC participants completed a core questionnaire. Among adults who did not consent to full study participation, some opted to complete a shorter survey of demographic information (questions about employment status and marital status were not included in the shortened survey for non-respondents). [†]The MDCC Study used a dual sampling frame of King County adults: (1) A randomly selected community-based sample of adults with and without landline telephones, and (2) a health facility-based sample of adults, with specific chronic condition diagnostic codes, who had attended hospitals, clinics, or received EMS care during the 24 months prior to sampling.

## References


1. Danaei G, Finucane MM, Lu Y, et al. National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2·7 million participants. *Lancet* 2011;378(9785):31-40.

2. Association AD. Economic costs of diabetes in the U.S. in 2012. *Diabetes Care* 2013;36(4):1033-46.

3. Public Health-Seattle & King County. Public Health Data Watch. Diabetes in King County. April 2007. www.kingcounty.gov/healthservices/health/data/~/media/health/publichealth/documents/data/diabetes_April2007.ashx.

4. Behavioral Risk Factor Surveillance System. Centers for Disease Control and Prevention; 2010. http://www.cdc.gov/brfss/. Accessed March 4, 2012.

5. *Improving Equity in Health by Addressing Social Determinants*. World Health Organization; 2011.

6. Diez Roux AV. Conceptual approaches to the study of health disparities. *Annu Rev Public Health* 2012;33:41-58.

7. Carpiano RM. Toward a neighborhood resource-based theory of social capital for health: can Bourdieu and sociology help? *Soc Sci Med* 2006;62(1):165-75.

8. Braveman P, Egerter S, Williams DR. The social determinants of health: coming of age. *Annu Rev Public Health* 2011;32:381-98.

9. Berkman LF, Glass T, Brissette I, et al. From social integration to health: Durkheim in the new millennium. *Soc Sci Med* 2000;51(6):843-57.

10. Schulz AJ, Kannan S, Dvonch JT, et al. Social and physical environments and disparities in risk for cardiovascular disease: the healthy environments partnership conceptual model. *Environ Health Perspect* 2005;113(12):1817-25.

11. Uchino BN. Social support and health: a review of physiological processes potentially underlying links to disease outcomes. *J Behav Med* 2006;29(4):377-87.

12. Brown AF, Ettner SL, Piette J, et al. Socioeconomic position and health among persons with diabetes mellitus: a conceptual framework and review of the literature. *Epidemiol Rev* 2004;26:63-77.

13. Keating DP, Hertzman C eds. Developmental Health and the Wealth of Nations: Social, Biological, and Educational Dynamics. New York, NY: The Guilford Press, 1999.

14. Link BG, Phelan J. Social conditions as fundamental causes of disease. *J Health Soc Behav* 1995;Spec No:80-94.

15. Robert SA. Community-level socioeconomic status effects on adult health. *J Health Soc Behav* 1998;39(1):18-37.

16. Haan M, Kaplan GA, Camacho T. Poverty and health. Prospective evidence from the Alameda County Study. *Am J Epidemiol* 1987;125(6):989-98.

17. Centers for Disease Control and Prevention (CDC). CDC Health Disparities and Inequalities Report - United States, 2011. *MMWR Surveill Summ* 2011;60 Suppl.

18. Auchincloss AH, Diez Roux AV, Brown DG, et al. Association of insulin resistance with distance to wealthy areas: the multi-ethnic study of atherosclerosis. *Am J Epidemiol* 2007;165(4):389-97.

19. Auchincloss AH, Diez Roux AV, Mujahid MS, et al. Neighborhood resources for physical activity and healthy foods and incidence of type 2 diabetes mellitus: the Multi-Ethnic study of Atherosclerosis. *Arch Intern Med* 2009;169(18):1698-704.

20. Burge MR, Lucero S, Rassam AG, et al. What are the barriers to medical care for patients with newly diagnosed diabetes mellitus? *Diabetes Obes Metab* 2000;2(6):351-4.

21. Nelson KM, Chapko MK, Reiber G, et al. The association between health insurance coverage and diabetes care; data from the 2000 Behavioral Risk Factor Surveillance System. *Health Serv Res*. United States, 2005:361-72.

22. Karter AJ, Ferrara A, Liu JY, et al. Ethnic disparities in diabetic complications in an insured population. *JAMA* 2002;287(19):2519-27.

23. Karter AJ, Stevens MR, Herman WH, et al. Out-of-pocket costs and diabetes preventive services: the Translating Research Into Action for Diabetes (TRIAD) study. *Diabetes Care* 2003;26(8):2294-9.

24. Martin TL, Selby JV, Zhang D. Physician and patient prevention practices in NIDDM in a large urban managed-care organization. *Diabetes Care* 1995;18(8):1124-32.

25. Schneider EC, Zaslavsky AM, Epstein AM. Racial disparities in the quality of care for enrollees in medicare managed care. *JAMA* 2002;287(10):1288-94.

26. American Diabetes Association. Standards of medical care in diabetes--2014. *Diabetes Care* 2014;37 Suppl 1:S14-80.

27. Okoro CA, Mokdad AH, Ford ES, et al. Are persons with diabetes practicing healthier behaviors in the year 2001? Results from the Behavioral Risk Factor Surveillance System. *Prev Med* 2004;38(2):203-8.

28. 2012 National Healthcare Disparities Report. Rockville, MD: U.S. Department of Health and Human Services. Agency for Healthcare Research and Quality, May 2013:AHRQ Publication No. 13-0003.

29. Coonrod BA, Betschart J, Harris MI. Frequency and determinants of diabetes patient education among adults in the U.S. population. *Diabetes Care* 1994;17(8):852-8.

30. Barron J, Wahl P, Fisher M, et al. Effect of prescription copayments on adherence and treatment failure with oral antidiabetic medications. *P T* 2008;33(9):532-53.

31. Odegard PS, Capoccia K. Medication taking and diabetes: a systematic review of the literature. *Diabetes Educ* 2007;33(6):1014-29; discussion 30-1.

32. Williams DR. Race, socioeconomic status, and health. The added effects of racism and discrimination. *Ann N Y Acad Sci* 1999;896:173-88.

33. Krieger N, Carney D, Lancaster K, et al. Combining explicit and implicit measures of racial discrimination in health research. *Am J Public Health* 2010;100(8):1485-92.

34. Rees CA, Karter AJ, Young BA, et al. Correlates of Patient-Reported Racial/Ethnic Health Care Discrimination in the Diabetes Study of Northern California (DISTANCE). *J Health Care Poor Underserved* 2011;22(1):211-25.

35. Surwit RS, van Tilburg MA, Zucker N, et al. Stress management improves long-term glycemic control in type 2 diabetes. *Diabetes Care* 2002;25(1):30-4.

36. U.S. Census Bureau, A Compass for Understanding and Using American Community Survey Data: What General Data Users Need to Know. U.S. Government Printing Office, Washington, DC, 2008.

37. U.S. Census Bureau. American Community Survey. Methodology: Sample Size and Data Quality. October 25, 2012.

38. Krieger N, Chen JT, Waterman PD, et al. Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: does the choice of area-based measure and geographic level matter?: the Public Health Disparities Geocoding Project. *Am J Epidemiol* 2002;156(5):471-82.

39. U.S. Census Bureau. Social, Economic, and Housing Statistics Division: Poverty. 2012. (http://www.census.gov/hhes/www/poverty/about/overview/measure.html). (Accessed August 22 2012).

40. U.S. Department of Health & Human Services. 2012 HHS Poverty Guidelines. 2012. (http://aspe.hhs.gov/poverty/12poverty.shtml). (Accessed August 22 2012).

41. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. *Am J Public Health* 1992;82(5):703-10.

42. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *J Epidemiol Community Health* 2001;55(2):111-22.

43. Geronimus AT, Bound J. Use of census-based aggregate variables to proxy for socioeconomic group: evidence from national samples. *Am J Epidemiol* 1998;148(5):475-86.

44. Geyer S, Hemstrom O, Peter R, et al. Education, income, and occupational class cannot be used interchangeably in social epidemiology. Empirical evidence against a common practice. *J Epidemiol Community Health*. England, 2006:804-10.

45. Public Health - Seattle & King County. Data & Reports, Community Health Data: Definitions. 2012. (http://www.kingcounty.gov/healthservices/health/data/indicators/definitions.aspx). (Accessed May 23 2014).

46. Massey D, Fischer M. How segregation concentrates poverty. *Ethnic and Racial Studies* 2000;23(4):670-91.

47. Cowie CC, Rust KF, Ford ES, et al. Full accounting of diabetes and pre-diabetes in the U.S. population in 1988-1994 and 2005-2006. *Diabetes Care* 2009;32(2):287-94.

48. Centers for Disease Control and Prevention. National diabetes fact sheet: National estimates and general information on diabetes and prediabetes in the United States, 2011. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2011. (http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2011.pdf). (Accessed November 2012).

49. Barker LE, Kirtland KA, Gregg EW, et al. Geographic distribution of diagnosed diabetes in the U.S.: a diabetes belt. *Am J Prev Med* 2011;40(4):434-9.

50. Public Health-Seattle & King County. Public Health Data Watch. Diabetes in King County. April 2007. (www.kingcounty.gov/healthservices/health/data/~/media/health/publichealth/documents/data/diabetes_April2007.ashx). (Accessed September 2012).

51. Public Health - Seattle & King County. King County Community Health Indicators. May 2014. (http://www.kingcounty.gov/healthservices/health/data/indicators.aspx). (Accessed 2014).

52. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. 2008. (http://www.health.gov/paguidelines/pdf/paguide.pdf). (Accessed October 2012).

53. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. Washington, DC: U.S. Government Printing Office; December 2010. (http://health.gov/dietaryguidelines/dga2010/DietaryGuidelines2010.pdf). (Accessed October 2012).

54. Walk Score Rankings Methodology. 2012. (http://www.walkscore.com/rankings/ranking-methodology.shtml). (Accessed September 3 2012).

55. California Center for Public Health Advocacy, PolicyLink, and the UCLA Center for Health Policy Research. Designed for Disease: The Link Between Local Food Environments and Obesity and Diabetes. April 2008. (http://www.publichealthadvocacy.org/designedfordisease.html). (Accessed October 2012).

56. Centers for Disease Control and Prevention. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States, 2011. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2011.

57. 2012 National Healthcare Quality Report. Rockville, MD: U.S. Department of Health and Human Services. Agency for Healthcare Research and Quality, May 2013:AHRQ Publication No. 13-0002.

58. National Center for Health Statistics. Health, United States, 2012: With Special Feature on Emergency Care. Hyattsville, MD, 2013.

59. Li R, Barker LE, Shrestha S, et al. Changes Over Time in High Out-of-Pocket Health-Care Burden in U.S. Adults With Diabetes, 2001-2011. *Diabetes Care* 2014.

60. Lindström J, Peltonen M, Eriksson JG, et al. Improved lifestyle and decreased diabetes risk over 13 years: long-term follow-up of the randomised Finnish Diabetes Prevention Study (DPS). *Diabetologia* 2013;56(2):284-93.

61. Gillett M, Royle P, Snaith A, et al. Non-pharmacological interventions to reduce the risk of diabetes in people with impaired glucose regulation: a systematic review and economic evaluation. *Health Technol Assess* 2012;16(33):1-236, iii-iv.

62. Laaksonen DE, Lindström J, Lakka TA, et al. Physical activity in the prevention of type 2 diabetes: the Finnish diabetes prevention study. *Diabetes* 2005;54(1):158-65.

63. van Ryn M, Burgess DJ, Dovidio JF, et al. The Impact of Racism on Clinician Cognition, Behavior, and Clinical Decision Making. *Du Bois Rev* 2011;8(1):199-218.

64. Cooper-Patrick L, Gallo JJ, Gonzales JJ, et al. Race, gender, and partnership in the patient-physician relationship. *JAMA* 1999;282(6):583-9.

65. Smedley B, Stith A, Nelson A eds. Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care. Washington, D.C.: The National Academies Press, 2003.

66. Lin JS, O'Connor E, Whitlock EP, et al. Behavioral counseling to promote physical activity and a healthful diet to prevent cardiovascular disease in adults: a systematic review for the U.S. Preventive Services Task Force. *Ann Intern Med* 2010;153(11):736-50.

67. Yoon U, Kwok LL, Magkidis A. Efficacy of lifestyle interventions in reducing diabetes incidence in patients with impaired glucose tolerance: a systematic review of randomized controlled trials. *Metabolism* 2013;62(2):303-14.

68. Smith AW, Borowski LA, Liu B, et al. U.S. primary care physicians' diet-, physical activity-, and weight-related care of adult patients. *Am J Prev Med* 2011;41(1):33-42.

69. Diez Roux AV. Invited commentary: places, people, and health. *Am J Epidemiol* 2002;155(6):516-9.

70. Hosler AS, Gallant MP, Riley-Jacome M, et al. Relationship between Objectively Measured Walkability and Exercise Walking among Adults with Diabetes. *J Environ Public Health* 2014;2014:542123.

71. Berke EM, Koepsell TD, Moudon AV, et al. Association of the built environment with physical activity and obesity in older persons. *Am J Public Health*. United States, 2007:486-92.

72. Berry TR, Spence JC, Blanchard C, et al. Changes in BMI over 6 years: the role of demographic and neighborhood characteristics. *Int J Obes (Lond)*. England, 2010:1275-83.

73. Moore LV, Diez Roux AV, Evenson KR, et al. Availability of recreational resources in minority and low socioeconomic status areas. *Am J Prev Med* 2008;34(1):16-22.

74. Dong D, Lin B-H. Fruit and Vegetable Consumption by Low-Income Americans: Would a Price Reduction Make a Difference? : U.S. Department of Agriculture, Economic Research Service, January 2009.

75. Moore LV, Diez Roux AV. Associations of neighborhood characteristics with the location and type of food stores. *Am J Public Health* 2006;96(2):325-31.

76. Connor Gorber S, Tremblay M, Moher D, et al. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obes Rev* 2007;8(4):307-26.

77. Rowley WR, Bezold C. Creating Public Awareness: State 2025 Diabetes Forecasts. *Popul Health Manag* 2012.

78. Zhao G, Ford ES, Li C, et al. Compliance with physical activity recommendations in US adults with diabetes. *Diabet Med*. England, 2008:221-7.

79. Zhao G, Ford ES, Li C, et al. Weight control behaviors in overweight/obese U.S. adults with diagnosed hypertension and diabetes. *Cardiovasc Diabetol*. England, 2009:13.

80. Li C, Ford ES, Mokdad AH, et al. Clustering of multiple healthy lifestyle habits and health-related quality of life among U.S. adults with diabetes. *Diabetes Care*. United States, 2007:1770-6.

81. Rautio N, Jokelainen J, Pölönen A, et al. Changes in lifestyle modestly reduce the estimated cardiovascular disease risk in one-year follow-up of the Finnish diabetes prevention program (FIN-D2D). *Eur J Cardiovasc Nurs* 2014.

82. Li G, Zhang P, Wang J, et al. Cardiovascular mortality, all-cause mortality, and diabetes incidence after lifestyle intervention for people with impaired glucose tolerance in the Da Qing Diabetes Prevention Study: a 23-year follow-up study. *Lancet Diabetes Endocrinol* 2014.

83. Renders CM, Valk GD, Griffin SJ, et al. Interventions to improve the management of diabetes in primary care, outpatient, and community settings: a systematic review. *Diabetes Care* 2001;24(10):1821-33.

84. Mokdad AH, Remington PL. Measuring health behaviors in populations. *Prev Chronic Dis* 2010;7(4):A75.

85. National Committee for Quality Assurance. 2014 HEDIS Physician Measures. Available at: http://www.ncqa.org/Portals/0/HEDISQM/HEDIS2014/HEDIS_2014%20_List_of_Physician_Measures.pdf. Accessed June 8, 2014.

86. Bolen SD, Samuels TA, Yeh HC, et al. Failure to intensify antihypertensive treatment by primary care providers: a cohort study in adults with diabetes mellitus and hypertension. *J Gen Intern Med* 2008;23(5):543-50.

87. Perreault L, Pan Q, Mather KJ, et al. Effect of regression from prediabetes to normal glucose regulation on long-term reduction in diabetes risk: results from the Diabetes Prevention Program Outcomes Study. *Lancet* 2012;379(9833):2243-51.

88. Gregg EW, Li Y, Wang J, et al. Changes in diabetes-related complications in the United States, 1990-2010. *N Engl J Med* 2014;370(16):1514-23.

89. Nathan DM, Buse JB, Davidson MB, et al. Medical management of hyperglycaemia in type 2 diabetes mellitus: a consensus algorithm for the initiation and adjustment of

therapy: a consensus statement from the American Diabetes Association and the European Association for the Study of Diabetes. *Diabetologia* 2009;52(1):17-30.

90. Garber AJ, Abrahamson MJ, Barzilay JI, et al. AACE comprehensive diabetes management algorithm 2013. *Endocr Pract* 2013;19(2):327-36.

91. Agency for Healthcare Research and Quality. 2007 National Healthcare Disparities Report. Rockville, MD, February 2008:AHRQ Pub. No. 08-0041.

92. Strine TW, Okoro CA, Chapman DP, et al. The impact of formal diabetes education on the preventive health practices and behaviors of persons with type 2 diabetes. *Prev Med* 2005;41(1):79-84.

93. Hurtado MP, Swift EK, Corrigan JM eds. Envisioning the National Health Care Quality Report. Washington, D.C.: National Academy Press, 2001.

94. Karter AJ, Parker MM, Moffet HH, et al. Effect of cost-sharing changes on self-monitoring of blood glucose. *Am J Manag Care* 2007;13(7):408-16.

95. Li G, Zhang P, Wang J, et al. The long-term effect of lifestyle interventions to prevent diabetes in the China Da Qing Diabetes Prevention Study: a 20-year follow-up study. *Lancet* 2008;371(9626):1783-9.

96. Knowler WC, Fowler SE, Hamman RF, et al. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 2009;374(9702):1677-86.

97. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. Washington, DC: U.S. Government Printing Office, December 2010.

98. Centers for Disease Control and Prevention. State indicator report on fruit and vegetables, 2013. U.S. Department of Health and Human Services, 2013.

99. National Research Council. Eliminating health disparities: Measurement and data needs. Panel on DHHS Collection of Race and Ethnicity Data, Ver Ploeg M and Perrin E (eds). Committee on National Statistics, Division of Behavioral and Social Sciences and Education. WA, DC: The National Academies Press 2004.

100. DiMatteo MR. Variations in patients' adherence to medical recommendations: a quantitative review of 50 years of research. *Med Care* 2004;42(3):200-9.

101. DiMatteo MR, Giordani PJ, Lepper HS, et al. Patient adherence and medical treatment outcomes: a meta-analysis. *Med Care* 2002;40(9):794-811.

102. Hess LM, Raebel MA, Conner DA, et al. Measurement of adherence in pharmacy administrative databases: a proposal for standard definitions and preferred measures. *Ann Pharmacother* 2006;40(7-8):1280-88.

103. Jerant A, DiMatteo R, Arnsten J, et al. Self-report adherence measures in chronic illness: retest reliability and predictive validity. *Med Care*. United States, 2008:1134-9.

104. Voils CI, Hoyle RH, Thorpe CT, et al. Improving the measurement of self-reported medication nonadherence. *J Clin Epidemiol* 2011;64(3):250-4.

105. Lau HS, de Boer A, Beuning KS, et al. Validation of pharmacy records in drug exposure assessment. *J Clin Epidemiol* 1997;50(5):619-25.

106. Osterberg L, Blaschke T. Adherence to medication. *N Engl J Med* 2005;353(5):487-97.

107. Centers for Disease Control and Prevention. The New Ambulatory Care Drug Database System., Last updated: 21 May 2012.

108. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33(1):159-74.

109. Fleiss JL, Levin B, Cho Paik M. *Statistical Methods for Rates and Proportions*. Third ed. Hoboken, NJ: John Wiley & Sons, Inc.; 2003.

110. American Diabetes Association. Standards of medical care in diabetes--2011. *Diabetes Care* 2011;34 Suppl 1:S11-61.

111. Boudreau DM, Daling JR, Malone KE, et al. A validation study of patient interview data and pharmacy records for antihypertensive, statin, and antidepressant medication use among older women. *Am J Epidemiol* 2004;159(3):308-17.

112. Monster TB, Janssen WM, de Jong PE, et al. Pharmacy data in epidemiological studies: an easy to obtain and reliable tool. *Pharmacoepidemiol Drug Saf* 2002;11(5):379-84.

113. Richardson K, Kenny RA, Peklar J, et al. Agreement between patient interview data on prescription medication use and pharmacy records in those aged older than 50 years varied by therapeutic group and reporting of indicated health conditions. *J Clin Epidemiol* 2013;66(11):1308-16.

114. Lyles CR, Karter AJ, Young BA, et al. Provider factors and patient-reported healthcare discrimination in the Diabetes Study of California (DISTANCE). *Patient Educ Couns* 2011;85(3):e216-24.

115. Wagner EH, Austin BT, Von Korff M. Organizing care for patients with chronic illness. *Milbank Q* 1996;74(4):511-44.

116. Torén K, Palmqvist M, Löwhagen O, et al. Self-reported asthma was biased in relation to disease severity while reported year of asthma onset was accurate. *J Clin Epidemiol* 2006;59(1):90-3.

117. Klungel OH, de Boer A, Paes AH, et al. Influence of question structure on the recall of self-reported drug use. *J Clin Epidemiol* 2000;53(3):273-7.

118. West SL, Savitz DA, Koch G, et al. Recall accuracy for prescription medications: self-report compared with database information. *Am J Epidemiol* 1995;142(10):1103-12.

119. White E, Armstrong BK, Saracci R. *Principles of exposure measurement in epidemiology*. Second ed. New York: Oxford University Press; 2008.

120. Guénette L, Moisan J, Préville M, et al. Measures of adherence based on self-report exhibited poor agreement with those based on pharmacy records. *J Clin Epidemiol* 2005;58(9):924-33.

121. Nielsen MW, Søndergaard B, Kjøller M, et al. Agreement between self-reported data on medicine use and prescription records vary according to method of analysis and therapeutic group. *J Clin Epidemiol* 2008;61(9):919-24.

122. van Staa TP, Abenhaim L, Leufkens H. A study of the effects of exposure misclassification due to the time-window design in pharmacoepidemiologic studies. *J Clin Epidemiol* 1994;47(2):183-9.

123. Thompson WD, Walter SD. A reappraisal of the kappa coefficient. *J Clin Epidemiol* 1988;41(10):949-58.

124. Choo PW, Rand CS, Inui TS, et al. A cohort study of possible risk factors for over-reporting of antihypertensive adherence. *BMC Cardiovasc Disord* 2001;1:6.

125. Marcum ZA, Zheng Y, Perera S, et al. Prevalence and correlates of self-reported medication non-adherence among older adults with coronary heart disease, diabetes mellitus, and/or hypertension. *Res Social Adm Pharm* 2013;9(6):817-27.

126. Clark CM, Fradkin JE, Hiss RG, et al. Promoting early diagnosis and treatment of type 2 diabetes: the National Diabetes Education Program. *JAMA* 2000;284(3):363-5.

127. Schmittdiel JA, Uratsu CS, Karter AJ, et al. Why don't diabetes patients achieve recommended risk factor targets? Poor adherence versus lack of treatment intensification. *J Gen Intern Med* 2008;23(5):588-94.

128. Association of Schools of Public Health: Demonstrating Excellence in Academic Public Health Practice. *Public Health Rep* 1999;114(5):480-3.

129. National Quality Forum. Multiple chronic conditions measurement framework. 2012.

130. Robert Wood Johnson Foundation. Chronic Care: Making the Case ForOngoing Care. Princeton, NJ: Robert Wood Johnson Foundation, 2010.

131. Harris MI. Health care and health status and outcomes for patients with type 2 diabetes. *Diabetes Care* 2000;23(6):754-8.

132. Dall TM, Narayan K, Gillespie KB, et al. Detecting type 2 diabetes and prediabetes among asymptomatic adults in the United States: modeling American Diabetes Association versus US Preventive Services Task Force diabetes screening guidelines *Population Health Metrics* 2014;12(12).

133. Jones RG, Trivedi AN, Ayanian JZ. Factors influencing the effectiveness of interventions to reduce racial and ethnic disparities in health care. *Soc Sci Med* 2010;70(3):337-41.

134. Boyle MH, Willms JD. Place effects for areas defined by administrative boundaries. *Am J Epidemiol* 1999;149(6):577-85.

135. Link CL, McKinlay JB. Disparities in the prevalence of diabetes: is it race/ethnicity or socioeconomic status? Results from the Boston Area Community Health (BACH) survey. *Ethn Dis* 2009;19(3):288-92.

136. Gary TL, Safford MM, Gerzoff RB, et al. Perception of neighborhood problems, health behaviors, and diabetes outcomes among adults with diabetes in managed care: the Translating Research Into Action for Diabetes (TRIAD) study. *Diabetes Care* 2008;31(2):273-8.

137. Thackeray R, Merrill RM, Neiger BL. Disparities in diabetes management practice between racial and ethnic groups in the United States. *Diabetes Educ* 2004;30(4):665-75.

138. Freedman VA, Grafova IB, Rogowski J. Neighborhoods and chronic disease onset in later life. *Am J Public Health* 2011;101(1):79-86.

139. Signorello LB, Schlundt DG, Cohen SS, et al. Comparing diabetes prevalence between African Americans and Whites of similar socioeconomic status. *Am J Public Health* 2007;97(12):2260-7.

140. Farmer MM, Ferraro KF. Are racial disparities in health conditional on socioeconomic status? *Social Science & Medicine* 2005;60:191-204.

141. Hayward MD, Miles TP, Crimmins EM, et al. The Significance of Socioeconomic Status in Explaining the Racial Gap in Chronic Health Conditions. *American Sociological Association* 2000;65(6):910-30.

142. King County Equity and Social Justice Annual Report. August 2013. (http://www.kingcounty.gov/exec/equity.aspx). (Accessed June 10 2014).