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# Chronic Conditions Profiles and Cardiometabolic Risk Factor Control Among a Diverse Sample of Older Adults With Type 2 Diabetes Mellitus

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# CHRONIC CONDITIONS PROFILES AND CARDIOMETABOLIC RISK FACTOR CONTROL AMONG A DIVERSE SAMPLE OF OLDER ADULTS WITH TYPE 2 DIABETES MELLITUS

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# ABSTRACT

**Background:** Multiple chronic condition is common in older adults with diabetes. Several prior studies have shown that having multiple chronic condition impact cardiometabolic risk factor controls (i.e., blood pressure, High-density lipoprotein (HDL) cholesterol level, and high glycated hemoglobin (HbA1c). However, it is not clear whether these results extend to a multiethnic sample of older adults.

**Objectives:**

1). Examine the association between Comorbidity profile and ABCs goals achievement.

2). Examine whether the association between comorbidity profile and ABCs goals achievement is moderated by race/ethnicity.

**Methods:** A sample of 3532 participants from Health and Retirement Study (HRS) years 2010 and 2012 and corresponding HRS Biomarker data were included in this analysis. Individual without complete diabetes status and those with missing value of all outcome variables were excluded. The main outcome measures were three cardiometabolic risk factor controls (blood pressure control, glycated hemoglobin (HbA1c) control and HDL cholesterol control), which measured based on guideline-defined threshold. Explanatory variables were a participant's comorbidity profile, characterized by the presence of specific chronic condition types (none, concordant only, discordant only, and both concordant and discordant). Analyses included logistic regression adjusted for survey years, socio-demographic, clinical and lifestyle characteristic factors.

**Results:** In the final study sample, (66%) were had both concordant and discordant condition, 19% were had only concordant condition, 9% were had only discordant condition, and only 6% were had no other chronic condition beside diabetes. We did not find significant associations between comorbidity profile and Blood pressure control (for concordant: OR: 0.9; 95% CI: (.05- 1.7), discordant: OR: 1.2; 95% CI: (0.6 – 2.1), and both condition: OR: 1.0; 95% CI: (0.6 – 1.8)). Diabetes patient with only discordant chronic condition or both concordant and discordant chronic condition were more likely to have HbA1c controlled than those with no chronic condition beside diabetes (for discordant: OR: 2.37; 95% CI: (1.30 – 4.33) and both condition: OR: 2.15; 95% CI: (1.18 – 3.93). The association between HDL cholesterol and comorbidity profile were modified by race/ethnicity. Having concordant conditions was negatively associated with HDL cholesterol control among Hispanic (OR: 0.36; 95% CI; (0.14 – 0.92). The association was not significant among whites or blacks.

**Conclusions:** This study shows that Comorbidity profile is associated with ABCs goals achievements among older adults with diabetes. Having discordant chronic conditions makes HbA1c goal achievement more likely. However, having concordant conditions makes HDL cholesterol goal achievement less likely: an effect that varies by race/ethnicity. Future study should further examine the association by using comprehensive set of chronic conditions.

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# LIST OF ABBREVIATIONS

ABCs ..... A1C, Blood pressure and Cholesterol level

BMI ..... Body Mass Index

BP ..... Blood pressure

F2F ..... Face to Face doctor visit

HbA1c ..... Glycated hemoglobin

HDL ..... High-density lipoprotein

LDL ..... Low-density lipoprotein

T2DM ..... Type 2 diabetes mellitus

# CHAPTER 1

# INTRODUCTION

Type 2 diabetes mellitus (T2DM) is the seventh leading cause of death in the United States [1]. Aging is one of the risk factor for developing T2DM[2]. Approximately 26% of older adults have diabetes[2–4] and it is projected that, in 2050, the prevalence of diabetes in older adults will increase by 4.5 fold[3]. Recent studies estimated that 90% of older adult with diabetes have one or more comorbid condition [5] , and 40% have at least four or more conditions[4–6]. These multiple chronic conditions may impact diabetes care prioritization, health care utilization, and self-management ability[5]. Despite a dramatic improvement in diabetes treatment and quality of care, older adults with multiple chronic conditions are more likely to have uncontrolled of A1C, Blood pressure and Cholesterol level (ABCs goals) [7]. Suboptimal ABCs goals were associated with a higher risk of diabetes related complications and mortality[7–9].

Improving diabetes care management may require greater attention to the type of comorbid chronic condition. Increasingly, studies are differentiating between concordant and discordant conditions[6,10–14]. Concordant conditions refer to "illnesses that overlap with diabetes in their pathogenesis and share care goals with diabetes (e.g., heart disease, hypertension, stroke)[6]." Discordant conditions are "illnesses with unrelated pathogenesis to diabetes or that do not share care goals or underlying predisposing factors with diabetes (e.g., mental health illnesses, cancer, arthritis)[6]." There is some evidence to

suggests that among older adults with diabetes, concordant conditions are associated with better diabetes care outcomes [6,12,13] and discordant conditions are associated with poorer diabetes care outcomes [10–12,15]. However, most of these studies did not include diverse racial/ethnic populations or the study had a crude measure of race/ethnicity (i.e., white versus non-white).

Racial disparities in ABCs goals achievement among older adult with diabetes have been documented [7,16,17]. For example, African Americans and Hispanics with diabetes typically have worse control of ABCs goals than whites[16]. Although several explanations for observed racial/ethnic disparities are attributed to lower socioeconomic status, inadequate health care access, poorer visit time management, fewer interactions with the health care system, few studies have examined whether differences in comorbidity profile can help further explain the observed differences[18]. A study by Pentakota, found that discordant conditions are observed to be high in non-white groups, but their effect on the racial disparity in ABCs goals achievement is not well investigated[12]. Over all the role of comorbidity profiles in racial/ethnic disparities in diabetes outcomes remains unclear. To address these gaps, we propose to use data from the Health and Retirement Study (waves 2010 and 2012), to examine the association between comorbid chronic condition profile on ABCs goals achievement among a racially diverse sample of older adults with type 2 diabetes mellitus.

# CHAPTER 2

# LITERATURE REVIEW

## Diabetes Burden and Public Health Significance

Type 2 diabetes mellitus (T2DM) is the seventh leading cause of death in the United States [1]. Aging is one of the risk factor for developing T2DM[2]. Approximately 26% of older adults have diabetes[2–4] and it is projected to increase by 4.5 fold that, in 2050[3]. Complications due to diabetes is a major cause of disability, reduced quality of life and death among older[5,8,19]. A study by Caspersen et.al[20] reported that diabetes can result in 8 years reduction in life expectancy among people aged 55 to 64. This means a 57 years old diabetic person may have an equivalent biological age to that of a 65 years old person without diabetes[20]. The study by Kalyani et.al[8] also demonstrated that older adults with diabetes have a high prevalence of disabilities than older adult without diabetes. More than 50% of older adult with diabetes reported difficulty performing daily physical tasks[21]. Diabetes imposes a profound economic cost in the health care system due to routine care for it and hospital care to treat diabetes related complications. For example, diabetes care accounts for a total of $245 billion every year, out of this $176 billion is direct medical costs and the remaining $69 billion is for indirect cost due to disability, work loss and premature death[2].

**Cardiometabolic risk factor control among older adults with diabetes**

Diabetes patient with optimal ABCs goals are associated with a reduction in risk of diabetes related complications [7,19,22]. Results in a study by Stratton et.al.[23] found that a 1% reduction in HbA1c was associated with reductions in diabetes related outcomes - 21% in deaths related to diabetes, 14% in myocardial infarction, and 37% in microvascular complications [23]. In another study, similar results were found among older adults with diabetes who achieved blood pressure control goal - 32 % reduction in death related to diabetes, 44% in stroke, and 37% in micro- vascular disease[24]. Currently, the American Diabetes Association recommends control goals for adults with diabetes which includes:- HbA1c<7.5%, BP <140/90mmHg, and LDL cholesterol <100 mg/dL[25]. However, most older adult with diabetes are unable to achieve the clinical guideline goals for controlling cardiometabolic risk factors such as blood pressure and cholesterol[7,26]. A study by Casagrande et.al [7] found that 80% of people with diabetes did not achieve ABCs goals and the prevalence of achieving blood pressure(BP) < 130/80 mmHg decreased with increasing age. Findings suggest that, to achieve a better outcome and reduce diabetes related complications, diabetes care quality should focus and integrate on ABCs goals achievement, treatments and prevention.

Racial/ethnic differences in the prevalence of diabetes are well documented[2,27] . Blacks and Hispanics experience a two times higher burden of diabetes. According to previous studies, non-Hispanics blacks (13.2%) and Hispanics (12.8%) have higher prevalence in comparison to non-Hispanic whites (6%)[2]. Due to this higher burden of diabetes, blacks and Hispanics are disproportionately affected by diabetes related complications, which may in part be explained by poorer ABCs goals achivements[18]. For

example, glycemic control is lower among Hispanics and blacks (35% and 37% respectively) compared to whites (49%)[28]. Improving cardiometabolic risk factor control among blacks and Hispanics may help to reduce the racial disparities in diabetes outcomes. Differences in access to health care, diabetes prevention and control programs, socioeconomic status, and neighborhood context are factors that help to explain some of the variations observed in ABCs goals achivements[16,28].However, a limited number of studies have explored the role of multiple chronic conditions as a key factor in contributing to disparities.

**Multiple chronic conditions and burden in older adults with type 2 diabetes mellitus**

In the United States, multimorbidity (or multiple chronic conditions), the presence of two or more co-occurring chronic conditions, is common and one-third of the older population is affected by it[29]. Several different approaches have been used to examine multimorbidity. The most common way is to sum the total number of chronic conditions[6,30]. However, there is no consensus regarding the number of conditions that should be included. The type and number of conditions may depend on the data source that is used. For example, studies that are using medical records can include about 5-62 conditions[11,30]. On the other hand, studies that have used nationally representative population-based datasets that rely on self-reports such as the National Health and Nutrition Examination Survey (NHANES), Behavioral Risk Factor Surveillance Study (BRFSS), and the Health and Retirement Study (HRS) have used up to 8 conditions to characterize multimorbidity[6,31].

**Multiple chronic conditions and type 2 diabetes mellitus**

Multiple chronic conditions are common in older adult with diabetes. Studies by Guneir et.al[5] estimates that 90% of older adults with diabetes have one or more chronic conditions, and 40% have five or more conditions [5]. Having multiple chronic conditions can impact the quality of life and health care utilization[5] . For example, emergency visits and hospitalizations were four times higher among older adults with five or more comorbid conditions compared to those without chronic conditions[5]. In addition, multiple chronic conditions are associated with less engagement in diabetes self-management activities [6,10]. For example, the presence of cancer or arthritis may eclipse the priority of diabetes care and make its self-management much more difficult.

There is a lack of evidence-based guidelines to care for type 2 diabetes mellitus patients with specific disease clusters[32,33]. To our knowledge, there is no clear guidance in placed on how to manage, integrate and prioritize care for multiple chronic conditions and only little is known how diabetes management affected by the presence of comorbid conditions[31,32,34]. To achieve better health outcomes among diabetes patients with multiple chronic conditions, furthering our understanding of the types of multiple chronic conditions may improve diabetes management outcomes.

Piette and Kerr[6] discusses how multimorbidity profiles may have a great impact on diabetes care outcomes. In their typologies for comorbid chronic conditions, they suggested to classify chronic condition based on their characteristic (concordant/discordant). Concordant conditions are those that have related management and pathogenesis with diabetes e.g. hypertension heart failure and cerebrovascular diseases. When the condition is concordant the provider may be able to provide more

integrative and synergistic care. Discordant conditions are those have unrelated management and pathogenesis with diabetes e.g. arthritis and cancer. In the presence of discordant conditions, it is difficult for providers to integrate care and may also encounter drug-drug interactions[34].

Data from a limited number of studies support this concepts [6,12,13,] For example, a retrospective cohort study by Pentakota et.al[12] examined veterans with new onset of diabetes to evaluate the relationship between diabetes care and the type of comorbidity (i.e. whether comorbidities were discordant or concordant). In this study, diabetes care was measured by number of visits per year (face to face visit), level of HbAc1 and LDL cholesterol. The findings suggested that patients with concordant conditions had better or similar quality of cares (Magnan et.al). For example, the odds of getting tested for HbA1c as per guideline is 17% higher in patients with concordant condition compered to patient with no comorbidity (OR: 1.17; 95%CI: (1.09 -1.25) ; whereas, patients with discordant conditions had poorer quality of care (the discordant group had 12% lower odds of meeting the guideline)[12]. Another study found inconsistence care response for diabetes with discordant condition, observed both better and worse diabetes cares[13]. However, the study has limitations, first the study excluded patients with limited life expectancy or terminal conditions (e.g metastatic cancer) that limited examination of the impact of total number of discordant condition including serious conditions that might have a greater impact on diabetes care. Second, the study was conducted in the VA, which serves mainly male elderly patients population, and had limitation on its generalizability. The other study also used data from a Midwest population that is not racially diverse as general population. The present study proposed to use data from HRS that is as racially

diverse as the general us population, which offers an excellent opportunity to examine racial/ethnic disparity in diabetes care.

# CHAPTER 3

# METHODS

## Study Aim

The main aim of this study was to examine the association between chronic condition profiles on ABCs goals achievement among a diverse sample of older adults with type 2 diabetes mellitus. Specifically, the objective was to analyze the association between comorbidity profile type and ABCs goals achievement by race/ethnicity among older adults with type 2 diabetes.

## Study design

This study is a cross- sectional study design employing data from the Health and Retirement Study (HRS).

## Data Source

Data from Health and Retirement Study (HRS), year 2010 and 2012 database were used for this study. More specifically we combined data from the core interviews, the biomarker dataset, and the RAND HRS datafiles (cleaned, processed, and streamlined collection of variables from HRS). HRS is biennial longitudinal panel survey that is nationally representative of Americans age 50 and older. The HRS over-samples Hispanic and Black individuals and sampling weights are provided. Interview is conducted every two years by telephone or in person. The study is funded by the National Institute of Aging and conducted by the Institute for Social Research at the University of Michigan. Detail about the study can be found in (http://hrsonline.isr.umich.edu/).

## Study Population

Our sample was limited to individuals who have type 2 diabetes mellitus. Participants included in this study are those who have been told by a doctor that they had the disease. If participant reports not having diabetes at the time of interview, they were consider not having diabetes and were exclude from this study (n= 11,311). Individuals who were missing all three outcome variables (blood pressure, HbA1c and LDL cholesterol; n= 3) were excluded. In addition, individual who were self-reported race/ethnicity as other or missing race/ethnicity variable (n=142) were excluded yielding analytic samples of 3567 individuals.

## Definition of variables

### Dependent variable

This study assessed three outcome variables: HbA1c, HDL and blood pressure. HDL and HbA1c was collected using dried bold spot technique. In 2010 wave, the Heritage Laboratory was used to assay total cholesterol and HbA1c. In 2012 wave, the University of Washington was used to assay both total cholesterol and HbA1c level[36].

Blood pressure was measured by using an automated device that has been validated against manual measurement[36]. The measurement was taken from the respondent's left arm and data recorded for systolic and diastolic pressure. Respondents were instructed to sit down with both feet on the floor and their left arm comfortably supported with the palm facing up. Then cuff was adjusted approximately half an inch above the elbow and made direct contact with the skin. Three measurements were taken at different time. The average of the three measurements were used for the analysis.

Although these three variables are continuous, we categorized them as a dichotomous variable. The cutoff point was based on American Diabetes Association guideline-recommended diabetes control care goals and guidelines for improving the care of the older person with diabetes mellitus[25,37] : HbA1c: $\geq$ 7.5% = uncontrolled; HDL level: for female < 40 mg/dl and male < 50 mg/dl = uncontrolled; BP level: diastolic/ systolic greater than 140/90 mmHg. These three variables reflect how well cardiometabolic risk factor control was achieved.

**Independent variable**

Multimorbidity were assessed based on a total of 8 chronic conditions (hypertension, cancer, chronic lung disease, heart disease, stroke, Alzheimer's/dementia**,** psychiatric problems, and arthritis) collected in HRS. In HRS each condition was measured by asking the respondents whether the doctor has ever told him/her has the condition.

**Cancer:** was assessed by asking: "Has a doctor ever told you that you had a cancer or a malignant tumor, excluding minor skin cancer?"

**Chronic lung disease:** was assessed by asking: "Has a doctor ever told you that you had chronic lung disease such as chronic bronchitis or emphysema?"

**Heart disease:** was assessed by asking: "Has a doctor ever told you that you had a heart attack, coronary heart disease, Angina, congestive heart failure, or other heart problems?"

**Hypertension:** was assessed by asking: "Has a doctor ever told you that you have Hypertension?"

**Stroke:** was assessed by asking: "Has a doctor ever told you that you have a stroke?

**Arthritis:** was assessed by asking: "Has a doctor ever told you that you had arthritis or rheumatism?"

**Alzheimer's/Dementia:** was assessed by asking: "Has a doctor ever told you that you had Alzheimer disease or dementia.?"

**Psychiatric problem:** was assessed by asking: "Has a doctor ever told you that you had emotional, nervous, or psychiatric problems?"

Concordant conditions included hypertension, heart disease, and stroke. Discordant conditions included: cancer, psychiatric problems, chronic lung disease, arthritis, and Alzheimer's disease. Based on previous research[12,38], participants was grouped into the following categories: none chronic conditions; concordant only; discordant only; concordant and discordant conditions.

**Effect modifier**

Race/ethnicity: was assessed by two different questions. Respondents were asked: "Do you consider yourself primarily White or Caucasian, Black or African America, American Indian, or Asian, or something else" and grouped into three different classification: white or Caucasian, Black or African American and other. Second, they were asked: "Do you consider yourself Hispanic or Latino?". Single variable for race/ethnicity was created based on the responses to the two questions. Then participant was assigned in to three mutually exclusive categories (Non-Hispanic White, Non-Hispanic Black and Hispanic). Those participants reported other or have missing value was excluded in the present study.

**Confounders/covariates**

Based on prior studies[6,12,13] the following variables was included as confounders: age, sex educational level, marital status, health insurance status, number of hospital visit, self-rated health status, diabetic medication type (oral vs insulin), hypertension medication, and physical activity. The same question was asked in 2010 and 2012 wave and the variable was a result of both waves.

Age**:** collected as a continuous variable and utilized as continuous variable in this study

Sex**:** was used the same way categorized in the data set female and male

Educational level: education was measured by the years of education from 0 to 17 that the participant had finished and categorized as 1 = less than high school, 2 = high school graduate/GED, 3 = some college, and 4 = college and above.5. In the percent study education status, were measured by three categories, “less than high school”, “high school” and “some college or above”.

Marital Status: were coded married if respondents report “married” and unmarried if they report “single”, “never married”, “divorced”, “widowed”, and “separated”. If the response was “other”, “don’t know”, “refused”, or blank it was coded as missing.

Self-rated health status**:** Participant were asked “Would you say your health is excellent, very good, good, fair, or poor?” Answer options ranged from 1 (excellent) to 5 (poor). In the percent study, participant was grouped based on their response: excellent or very good grouped as “excellent”, fair or good grouped as “good” and poor grouped as “poor”.

Diabetic medication type (oral vs insulin): this variable was created by combining a response from two different questions, “Do you now use insulin?” and “Do you currently take any diabetes medication that you take by mouth?” For both question the response variable is “yes”, “no” or “Don’t know”. Participant was grouped in to four groups based on their answer: oral medication, insulin, both, and neither.

BMI: calculated from weight divided by square height. Participants provided their weight in pounds and converted to kilogram in the BMI calculation. The same way participant asked about their height in feet and inches and converted to meters for BMI calculation. BMI is continuous variable and was categorized in to three groups: Under/Normal weight (<25 $kg/m^2$); Over weight (25 $kg/m^2$ to 30 $kg/m^2$); Obese (>=30 $kg/m^2$).

Physical activity: was assessed by asking three questions; "We would like to know the type and amount of physical activity involved in your daily life? How often do you take part in sports or activities that are vigorous, moderate or light physical activity?” The possible responses included every day, more than once per week, once per week, one to three times per month, or never. For the present study participant was dichotomized into “Physically active” if the participant answer, every day, more than once per week, once per week in one of the three physical activities, and “not physically active “if the participant answer one to three times per month, or never in all three activities that is intensive, moderate and light physical activities.

Health insurance status: was assessed by asking three different questions which included, “Are you currently covered by Medicare health insurance?”; “Are you currently covered by (Medicaid/STATE NAME FOR MEDICAID)?”; “We’d like to ask about all

the other types of health insurance plans you might have, such as insurance through an employer or a business, coverage for retirees, or health insurance you buy for yourself, including Medigap or) other supplemental coverage. If the participant answer was yes for one of the above question they were categorized as insured and if their answer was no they was categorized as uninsured.

Doctor Visit: participant asked to report number of doctor visit in the last two years and it was collected as a continuous variable and recoded as a categorical variable. Based on the previous literature the participant was grouped [12] into four groups <7, 7-12,13-24 and >24 visits per year.

Medication for blood pressure: participants were asked to report if they are taking any medication to lower their blood pressure." To lower your blood pressure, are you now taking any medication?". The response variables are "yes", "no" or "Don't know". Participant were grouped in to two groups based on their answer: "Yes" or "no". If a Participant respond was "don't know" it was coded as missing.

**Statistical Analysis**

All analyses were conducted using SAS version 9.4 software. Descriptive analysis was used to assess all study variables by comorbidity profiles. For continuous variable means and standard deviation were reported and for categorical variable percentages and frequencies were reported. To test for significant differences between groups we used t-test (for continuous variables) and chi-square test (for categorical variables).

We used logistic regression analyses to examine the association between comorbidity type and each dependent variable: HbAlc, BP and HDL. Three different

logistic regression models were constructed regardless of the ABCs goal variable being analyzed:

Model 1: unadjusted model, it only had comorbidity type and adjusted for wave.

Model 2: model 1 + additionally adjusted for demographic characteristics (age, educational level, marital status, income, health insurance status).

Model 3: Model 2 +additionally adjusted for self-rated health status, diabetes medication type, BMI, physical activity, and number of doctor visits.

Model 4: Model 3 +, additionally adjusted for interaction term between comorbidity profile and race/ethnicity. The sample was divided in the basis of race/ethnicity and model 3 was fit and multiple logistic regression was performed.

**Sensitivity Analysis**

1. To examine whether there is a systematic difference in the distribution of study variables between 2010 and 2012 year. The frequency of each study variable was compared (Table A.1). Over-all there were no systematic difference in the distribution of the study variables between 2010 and 2012 years, however, few variables show significant difference. The average age was significantly differed (2010: 68.9; 2012: 67.9; p-value = .0024). We observe significant difference in the distribution of diastolic blood pressure (2010: 79.2mmHg; 2012: 78.0mmHg; P-value = 0.004) and systolic blood pressure (2010: 133.7mmHg; 2012: 131.8; P-value = 0.007). Considering these results, we adjusted for survey year in the analysis.

2. To assess the association between the number of concordant or discordant chronic conditions and ABCs goals achievement (Table A.2). We categorized the number of chronic conditions in to three different groups: 0, 1-2, 3+ conditions for both

concordant and discordant separately. There were no significant associations between ABCs goals achievement and number of concordant chronic condition. Similarly, there were no significant associations between HDL control and number of discordant chronic conditions. However, having 1-2 or 3+ numbers of discordant chronic condition were associated with greater odds of achieving HbA1c control (OR: 1.35; 95% CI: 1.08 – 1.69; OR: 1.75; 95% CI: (1.21 – 2.53) respectively), than no having any discordant chronic condition. Individuals with 3+ numbers of discordant chronic condition were more likely to have blood pressure control (OR: 1.73; 95% CI: (1.07 – 2.80) than individuals who have no chronic condition. No other significant difference was noted.

3. To assess whether the association between comorbidity profile and HbA1c control would change if HbA1c level was categorized based on different cut point = 8.0mmol/mol (Table A.4) A guidelines of American Diabetes Association (ADA) recommend a cut point for HbA1c of 8.0mmol/mol for older adults with complex multiple coexisting chronic condition, high treatment burden and shorter remaining life expectancy. In other hand, older adults with longer remaining life expectancy and fewer coexisting chronic condition can use a cut point of 7.5mmol/mol, which was used for our main analysis. The result from a cut point 8.0mmol/mol, found no significant association between comorbidity profile and HbA1c control. This result is different from the result form main analysis (cut point 7.5mmol/mol). This result discussed in the result section.

4. To assess whether the association between comorbidity type and blood pressure control would change if blood pressure level was categorized based on different cut point = 130mmHg systolic and 80mmHg diastolic (Table.A.3). For cut points 130/80mmHg, there were no significant association between blood pressure control and

comorbidity profile. This result was similar with the result from the original cut point (140/90 mmHg).

# CHAPTER 4

# RESULTS

## Descriptive Analysis

Our sample has 3532 individuals with diabetes. The highest proportion of sample (66%) had both concordant and discordant condition besides diabetes. About 19% of sample had only concordant condition, 9% had only discordant condition, and only 6% of them were free of other chronic condition except diabetes (Table 4.3).

Sociodemographic characteristics by comorbidity types are presented in Table 4.1. Almost all variables were significantly associated with comorbidity profiles (P-value<.05). The sample average age was 67 years old and composed of 52% female, 72% white and 61% married. Individuals with both concordant and discordant chronic condition were significantly older (68 years) than individual with no chronic condition (62 years) (p-value = <0.0001). The percentage of non-Hispanic white was significantly higher among group who have only discordant chronic conditions (81%) or both concordant and discordant chronic condition (74%) than group with no chronic condition (66%). Among the group with both chronic condition, 55% were females, 74% were whites, 57% were married and 61% were physically inactive. Obesity is slightly higher among the group with both chronic condition than the group with only concordant or with only discordant chronic conditions. The prevalence of blood pressure medication intake was disproportionately higher in individuals with only concordant chronic conditions

(85%) and individual with both discordant and concordant (86%) chronic conditions compered to individuals with only discordant chronic condition (5%).

Table 4.2 illustrated the percentage of those who achieved their ABCs goals. For the HbA1c goal, approximately, 79% of the sample met the HbA1c target of less than 7.5mmol/mol. When we look by comorbidity profile, 67% of those who have no chronic conditions, 77 % of those who have only concordant chronic conditions, 84% of those who have only discordant chronic conditions and 80% of those who have both chronic conditions met the HbA1c target of less than 7.5mmol/mol. On the other hand, slightly over half (58%) of the sample met HDL cholesterol target of < 40 mg/dl for female and < 50 mg/dl for male. When we look HDL cholesterol level control 68% of those with no chronic condition beside diabetes, 62% of those who have only concordant chronic conditions, 66% of those who have only discordant chronic conditions and 55% of those who have both chronic conditions were achieved HDL cholesterol goal. Only 32 % of the sample met all three ABCs goals (cholesterol, blood pressure and HbA1c) together. When we look by comorbidity profile 43% of those who have only discordant condition achieved all three targets. Among those who have only concordant chronic condition 32% of those achieved all three targets. Among those who have both chronic condition 30% of those achieved all three targets.

Table 4.3 illustrated the prevalence of comorbidity profile by race/ethnicity. The proportion of having only concordant chronic conditions were greater among blacks (20%) than whites (17%) however, proportion of having only discordant chronic conditions were smaller among blacks (4%) than whites (10%). Proportion of having both concordant and discordant chronic conditions were greater among blacks (71%) than

whites (68%). Proportion of having only concordant chronic conditions were highest among blacks (20%) comparing to Hispanics (13%) and whites (17%). The Proportion of having both concordant and discordant chronic conditions were smaller among Hispanics (55%) than whites (71%) and blacks (68%).

**Statistical Analysis**

The results from unadjusted and adjusted logistic regression model for each cardiometabolic risk factor control was presented in table 4.4.

**HbA1c models:** When only adjusting for survey year (model 1) having only concordant, only discordant, or both chronic conditions were associated with significantly increased odds of HbA1c control compared to having no chronic conditions, (for concordant: OR: 1.61; 95% CI: (1.05-2.47), discordant: OR:2.54; 95% CI: (1.42 – 4.53), and both condition: OR: 1.97; 95% CI: (1.28 – 3.03)). Similarly after adjusting for socio-demographic variables, having only concordant chronic conditions, only discordant chronic conditions, or both chronic conditions were associated with significantly increased odds of HbA1c control, (for concordant: OR: 1.66; 95% CI: (1.13 - 2.45), discordant: OR:2.11; 95% CI: (1.22 – 3.64), and both condition: OR: 1.61; 95% CI: (1.08 – 2.40)). Finally, after adjusting for clinical factors and lifestyle characteristic variables the association was slightly higher and remained significant (for concordant: OR: 1.88; 95% CI:(1.08 – 3.27), discordant: OR: 2.37; 95% CI: (1.30 – 4.33), and both condition: OR: 2.15; 95% CI: (1.18 – 3.93). An interaction term between race/ethnicity and comorbidity profile was assessed in the fully adjusted model; but was not significant (P =0.52).

**HDL Cholesterol model.** When only adjusting for survey year, having both (concordant and discordant) chronic conditions were negatively associated with HDL control (OR: 0.58; 95% CI:( **0.41 – 0.82**). However, having only concordant or only discordant chronic conditions were not significantly associated with HDL cholesterol control. After controlling for socio-demographic variable, the result was remained the same, having both (concordant and discordant) chronic conditions were less likely to achieving HDL control comparing to those with no chronic conditions (OR: 0.7; 95% CI: (0.49 - 0.99). However, after adjusting for clinical factors and lifestyle characteristic variables there were no significant association noted between chronic condition profiles and HDL control. Lastly, by using fully adjusted model, race/ethnicity was assessed as modifiers of the association between HDL control and comorbidity profiles. The interaction between race/ethnicity and comorbidity profile were significant (p-value =0.03). Table 5 illustrates the association between comorbidity type and HDL control level by race/ethnicity. For white and black no association was observed between comorbidity profile and HDL cholesterol control. Similarly, there were no significant association between having discordant or both (concordant and discordant) chronic conditions and HDL cholesterol control among Hispanics. However, Hispanics with concordant chronic conditions were less likely to control their HDL cholesterol level than those Hispanic with no chronic condition beside diabetes (OR: 0.39; 95% CI: (0.16 – 0.95).

**Blood pressure model.** For all three model (model 1, model 2 and model 3) there were no significant associations between blood pressure control and comorbidity profiles. Interaction term between race/ethnicity and comorbidity profile was assessed in

fully adjusted model as modifiers of the association between blood pressure control and comorbidity profiles however, it was not significant (P = 0.28).

**All ABCs Target Model.** For model 1(unadjusted model) and model 2 (after adjusting for socio-demographic variables) we found no significant association between comorbidity profile and all three targets achievements. In model 3, having only discordant, or both chronic conditions were associated with significantly increased odd of controlling all three targets compared to having no chronic conditions, (for discordant: OR: 2.07; 95% CI: (1.15 – 3.70), and both condition: OR: 2.05;95% CI: (1.16 – 3.62)) (Table 4.6).

Table 4.7 illustrated a detail of results from the final adjusted model. After adjusting for all covariates. Sex was associated with HDL control, compared to females, males were significantly more likely to have a higher odd of HDL control (OR: 2.54; 95% CI: (2.02 – 3.20). Age, marital status, education, health insurance, physical activity, face to face doctor visit and taking blood pressure medication were not significantly associated with HDL cholesterol control. Blacks were significantly more likely to control their HDL cholesterol level compared to whites (OR: 1.63; 95% CI:(1.26 – 2.13). Similarly, Hispanics have a higher odds of HDL control compared to whites, it was marginally significant (OR:1.33; 95% CI: (1.03 – 1.70). Individuals who intake oral diabetes medication or those who intake both oral and insulin diabetes medications were less likely to control their HDL cholesterol level compared to those with no diabetes medication (OR:0.54; 95% CI: (0.36 - 0.84) and OR: 0.60; 95% CI: (0.43 - 0.80) respectively. Similarly, individual with poor self-rate health status less likely to control their HDL cholesterol level compared to those with good self-rate health status (OR:

0.78; 95% CI: (0.63 – 0.96). Overweight or obese were related to lower odds of HDL cholesterol control compared to normal weight (OR: 0.64; 95% CI: (0.52 - 0.82) and OR: 0.54; 95% CI: = (0.40 - 0.37) respectively.

Blacks were significantly less likely to control their HbA1c level compared to whites (OR: 0.67; 95% CI: (0.46 - 0.98). Sex, age, marital status, BMI, self-rate health status, education, health insurance, physical activity and face to face doctor visit were not significantly associated with HbA1c control. Individual who take any kind of diabetes medication were less likely to control their HbA1c level compared to those who do not take any diabetes medication. In other hand individual with poor self-rate health status less likely to control their HbA1c level compared to those with good self-rate health status (OR: 0.74; 95% CI:(0.56 – 0.96). Individual with high school diploma were less likely to control their blood pressure level compared to individual with some college degree or higher education status (OR:0.71; 95% CI: (0.54 - 0.95). Like HbA1c control, blacks were significantly less likely to control their blood pressure compared to whites (OR:0.58; 95% CI: (0.44 – 0.77). Hispanics were less likely to control their HbA1c level compared to whites, (OR:0.71; 95% CI:(0.53 – 0.93). Finally, sex, marital status, BMI, self-rate health status, health insurance, physical activity, diabetes medication intake, and face to face doctor visit were not significantly associated with blood pressure control. (Table 4.7)

Table 4.1. Characteristic of participant by comorbidity profile, Health and Retirement Study, 2010 and 2012

| Characteristic | Total ($N^e$ =3532) | None ($n^e$= 185) | Concordant only ($n^e$=657) | | Discordant only ($n^e$=266) | | Both ($n^e$= 2424) | |
|---|---|---|---|---|---|---|---|---|
| | % | %, | % | p-value [a] | % | p-value [b] | % | p-value [c] |
| Age (Mean) years | 67.3 | 62 | 64 | **<0.001** | 65 | **<0.001** | 68 | **<0.001** |
| Sex (%) | | | | | | | | |
| Female | 52 | 46 | 39 | 0.15 | 55 | 0.14 | 55 | **0.09** |
| Male | 48 | 54 | 61 | | 45 | | 45 | |
| Race/ethnicity (%) | | | | | | | | |
| Non-Hispanic White | 72 | 66 | 66 | 0.64 | 81 | 0.0007 | 74 | **0.0005** |
| Non-Hispanic black | 14 | 12 | 15 | | 6 | | 15 | |
| Hispanic | 14 | 22 | 19 | | 13 | | 11 | |
| Marital status (%) | | | | | | | | |
| Married | 61 | 70 | 65 | 0.46 | 72 | 0.74 | 57 | **0.02** |
| Not married | 40 | 30 | 35 | | 28 | | 43 | |
| Vigorous physical activity (%) | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Active | 45 | 63 | 49 | 0.002 | 62 | 0.79 | 39 | **<.0001** |
| Not active | 55 | 37 | 51 | | 38 | | 61 | |
| Total face to face visits (%) | | | | | | | | |
| <7 per 2 years | 54 | 80.5 | 69 | 0.06 | 59 | **<.0001** | 46 | **<.0001** |
| 7 -12 per 2 years | 24 | 13 | 19 | | 22 | | 27 | |
| 13-24 per 2 years | 2 | 0.5 | 2 | | 2 | | 3 | |
| 24+ per 2 years | 20 | 6 | 11 | | 17 | | 24 | |
| Diabetes medication (%) | | | | | | | | |
| Oral | 55 | 56 | 63 | **0.01** | 49 | **0.04** | 54 | **0.007** |
| Insulin | 8 | 10 | 5 | | 6 | | 9 | |
| Both | 13 | 5 | 10 | | 10 | | 15 | |
| Non | 24 | 29 | 22 | | 35 | | 22 | |
| BMI (%) | | | | | | | | |
| Normal | 15 | 30 | 17 | **0.0029** | 20 | 0.11 | 13 | **<.0001** |
| Over weight | 31 | 31 | 35 | | 36 | | 29 | |
| Obese | 54 | 39 | 48 | | 44 | | 58 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Self-rate health status (%) | | | | | | | | |
| Poor | 51 | 27 | 39 | **0.03** | 33 | 0.3 | 58 | **<.0001** |
| Good | 49 | 73 | 61 | | 67 | | 42 | |
| Health insurance (%) | | | | | | | | |
| Insured | 93 | 88 | 86 | 0.6 | 96 | **0.03** | 95 | **0.03** |
| Uninsured | 7 | 11 | 14 | | 4 | | 5 | |
| Education (%) | | | | | | | | |
| <high school | 27 | 20 | 23 | | 21 | | 29 | |
| High school | 28 | 19 | 28 | 0.09 | 26 | 0.34 | 30 | **<.0001** |
| >some college | 45 | 61 | 29 | | 53 | | 41 | |
| Blood pressure medication (%) | | | | | | | | |
| Yes | 74 | 1 | 85 | **<.0001** | 5 | 0.19 | 86 | **<.0001** |
| No | 26 | 99 | 14 | | 97 | | 14 | |

**a.** P-value represents the comparison of variables between individuals who do have concordant chronic condition and those who do not have chronic condition except diabetes; **b.** P-value represents the comparison of variables between individuals who do have discordant chronic condition and those who do not have chronic condition except diabetes; **c.** p-value represents the comparison of variables between individuals who do have both concordant and discordant chronic condition and those who do not have chronic condition except diabetes; d. Bold font represents a significant p-value.; **e**. HRS consider weighted percentage in account

Table 4.2. Percentage of participant who achieved each ABCs goal by comorbidity profile, Health and Retirement Study, 2010 & 2012.

| ABC goals achievement | Total (N, %) | None (N, %) | Concordant (N, %) | Discordant (N, %) | Both (N, %) |
|---|---|---|---|---|---|
| HbA1c [a] | | | | | |
| Control | 2743 (79) | 121 (67) | 479 (77) | 213 (84) | 1930 (80) |
| Uncontrolled | 789 (21) | 64 (33) | 178 (23) | 53 (16) | 494 (20) |
| HDL Cholesterol [b] | | | | | |
| Control | 2054 (58) | 123 (68) | 398 (62) | 176 (66) | 1357 (55) |
| Uncontrolled | 1478 (42) | 62 (32) | 259 (38) | 90 (34) | 1067 (45) |
| Blood pressure [c] | | | | | |
| Control | 2337 (69) | 131 (71) | 400 (64) | 209 (77) | 1597 (69) |
| Uncontrolled | 1195 (31) | 54 (29) | 257 (36) | 57 (23) | 827 (31) |
| All three goals | | | | | |
| Control | 1080 (32) | 61 (33) | 190 (32) | 110 (43) | 719 (30) |
| Uncontrolled | 2452 (68) | 124 (67) | 467 (68) | 156 (57) | 1705 (70) |

a. HbA1c control <7.5 mmol/mol
b. HDL control for female <50 mg/dL and for male < 40 mg/dL
c. Blood pressure control systolic <140/90 mmHg

Table 4.3. Distribution of comorbidity profiles by race/ethnicity, Health and Retirement Study, 2010 & 2012

| Comorbidity type (%) | Total, N (%) | Black, N (%) | Hispanic, N (%) | White, N (%) |
|---|---|---|---|---|
| Concordant | 657 (19) | 176 (20) | 170 (13) | 311 (17) |
| Discordant | 266 (9) | 37 (4) | 53 (8) | 176 (10) |
| Both | 2424 (66) | 618 (71) | 358 (55) | 1448 (68) |
| None | 185 (6) | 39 (5) | 60 (10) | 86 (5) |

Table 4.4. Crude and adjusted association between comorbidity profiles and each ABCs goal achievement, Health and Retirement Study ,2010 & 2012

| | **HDL Cholesterol** | | | **HbAc1** | | | **Blood Pressure** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Type** | **Model 1[a]** | **Model 2[b]** | **Model 3** | **Model 1** | **Model 2** | **Model 3** | **Model 1** | **Model 2** | **Model 3** |
| | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95%CI) | OR (95%CI) | OR (95% CI) |
| Concordant | 0.77 (0.50 – 1.16) | 0.71 (0.46 – 1.08) | 1.03 (0.64–1.66) | **1.61 (1.05 – 2.47)** | **1.6 6 (1.13 – 2.45)** | **1.88 (1.08–3.27)** | 0.73 (0.4 – 1.3) | 0.8 (0.4 – 1.4) | 0.9 (0.5 – 1.7) |
| Discordant | 0.91 (0.58 – 1.41) | 1.00 (0.63 – 1.57) | 1.27 (0.77–2.11) | **2.54 (1.42 – 4.53)** | **2.11 (1.22 – 3.64)** | **2.37 (1.30 –4.33)** | 1.3 (0.7 – 2.4) | 1.3 (0.7 – 2.4) | 1.2 (0.6 – 2.1) |
| Both | **0.58 (0.41 – 0.82)** | **0.62 (0.43 – 0.89)** | 1.06 (0.67–1.66) | **1.97 (1.28 – 3.03)** | **1.61 (1.08 – 2.40)** | **2.15 (1.18 – .93)** | 0.89 (0.5 – 1.4) | 1.0 (0.6 – 1.6) | 1.0 (0.6 – 1.8) |
| None[d] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

a. Model 1: Unadjusted model

b. Model 2: Model 1 and additionally adjusted for Socio-demographic covariates: - age, gender, race/ethnicity, marital status, education status, health-insurance

c. Model 3: model 2 and additionally adjusted for BMI, self-rated health, physical activity, smoking status, medication for hypertension, medication for diabetes, face to face doctor visits

d. Reference group

e. Bold font represents significant 95% CI

Table 4.5. Adjusted association between comorbidity profiles and HDL control by race, Health and Retirement Study, 2010 & 2012

| HDL | | | | | | |
|---|---|---|---|---|---|---|
| Comorbidity type | Non-Hispanic white | | Non-Hispanic black | | Hispanic | |
| | OR | (95% CI) | OR | (95% CI) | OR | (95%CI) |
| Concordant | 1.63 | 0.85 – 3.14 | 0.44 | 0.11 – 1.76 | **0.39** | **0.16 – 0.95** |
| Discordant | 1.76 | 0.89 – 3.48 | 0.71 | 0.19 – 2.69 | 0.80 | 0.26 – 2.43 |
| Both | 1.48 | 0.80 – 2.75 | 0.50 | 0.15 – 1.63 | 0.51 | 0.23 – 1.13 |
| None [b] | 1 | | 1 | | 1 | |

a. Adjusted for wave, comorbid condition, age, gender, race/ethnicity, marital status, education status, health insurance, BMI, self-rated health, physical activities, smoking status, medication for hypertension, medication for diabetes, face to face doctor visits

b. Reference group

c. Bold font represents significant 95% CI

Table 4.6. Crude and adjusted association between comorbidity profiles and all ABCs goals achievement, Health and Retirement Study ,2010 & 2012

| | **All three goals** | | |
|---|---|---|---|
| **Comorbidity Type** | **Model 1[a]** | **Model 2[b]** | **Model 3[c]** |
| | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Concordant | 0.97 (0.59 – 1.58) | 1.03 (0.64 – 1.64) | 1.79 (0.98 – 3.28) |
| Discordant | 1.59 (0.91 – 2.76) | 1.66 (0.98 – 2.82) | **2.07 (1.15 – 3.70)** |
| Both | 0.91 (0.58 – 1.40) | 1.04 (0.69 – 1.56) | **2.05 (1.16 – 3.62)** |
| None[d] | 1 | 1 | 1 |

a. Model 1: Unadjusted model

b. Model 2: Model 1 and additionally adjusted for Socio-demographic covariates: - age, gender, race/ethnicity, marital status, education status, health-insurance

c. Model 3: model 2 and additionally adjusted for BMI, self-rated health, physical activity, smoking status, medication for hypertension, medication for diabetes, face to face doctor visits

d. reference groups

e. Bold font represents significant 95% CI

Table 4.7. Results from the final model examining association between comorbidity profiles and ABCs goals achievement, Health and Retirement Study, 2010 & 2012

| Variable | HDL Cholesterol | HbAc1 | Blood Pressure |
|---|---|---|---|
| | OR (95% Confidence Interval) | OR (95% Confidence Interval) | OR (95% Confidence Interval) |
| Concordant | 1.03 (0.64 – 1.66) | 1.8 (1.0 – 3.2) | 0.9 (0.5 – 1.7) |
| Discordant | 1.27 (0.77 – 2.11) | **2.3 (1.3 – 4.3)** | 1.2 (0.6 – 2.1) |
| Both | 1.06 (0.67 – 1.66) | **2.1 (1.1 – 3.9)** | 1.0 (0.6 – 1.8) |
| None | 1 | 1 | 1 |
| Age (Mean) years | 0 .99 (0.98 – 1.01) | 1.88 (1.08 – 3.27) | **0.97 (0.96 -0.99)** |
| Sex (%) | | | |
| Female [a] | 1 | 1 | 1 |
| Male | **2.54 (2.02 – 3.20)** | 1.11 (0.82 – 1.50) | **0.71 (0.59 – 0.86)** |
| Race/ethnicity (%) | | | |
| Non-Hispanic White [a] | 1 | 1 | 1 |
| Non-Hispanic black | **1.63 (1.26 – 2.13)** | **0.67 (0.46 – 0.98)** | **0.58 (0.44 – 0.77)** |

| | | | |
|---|---|---|---|
| Hispanic | 1.33 (1.03 – 1.70) | 0.74 (0.48 – 1.13) | **0.71 (0.53 – 0.93)** |
| Marital status (%) | | | |
| Married [a] | 1 | 1 | 1 |
| Not married | 0.86 (0.70 – 1.07) | 1.06 (0.82 – 1.37) | 1.13 (0.91 – 1.39) |
| Education (%) | | | |
| Less than high school | 0.88 (0.71 – 1.11) | 0.91 (0.68 – 1.22) | **0.71 (0.54 – 0.95)** |
| High school | 1.08 (0.81 – 1.44) | 0.78 (0.57 – 1.08) | **0.70 (0.54 – 0.92)** |
| Some college or greater [a] | 1 | 1 | 1 |
| Health insurance (%) | | | |
| Insured [a] | 1 | 1 | 1 |
| Uninsured | 0.82 (0.51 – 1.33) | **0.56 (0.39 – 0.82)** | 0.74 (0.54 – 1.06) |
| Physical activity (%) | | | |
| Active [a] | 1 | 1 | 1 |
| Not active | 0.95 (0.78 – 1.17) | 0.74 (0.54 – 1.03) | 1.03 (0.85 – 1.24) |
| Total F2F visits (%) | | | |
| <7 per 2 years | 0.84 (0.62 – 1.13) | 0.82 (0.56 – 1.21) | **0.70 (0.52 – 0.95)** |

| | | | |
|---|---|---|---|
| 7 -12 per 2 years | 0.75 (0.57 – 1.00) | 1.00 (0.71 – 1.42) | 0.89 (0.69 – 1.14) |
| 13-24 per 2 years | 0.99 (0.46 – 2.10) | 0.75 (0.34 – 1.67) | 0.67 (0.38 – 1.19) |
| 24+ per 2 years [a] | 1 | 1 | 1 |
| Diabetes medication (%) | | | |
| Insulin | 0.93 (0.72 – 1.20) | **0.39 (0.26 – 0.60)** | 1.45 (1.09 – 1.98) |
| Oral | **0.54 (0.36 – 0.84)** | **0.11 (0.07 – 0.18)** | 1.27 (0.81 - 1.98) |
| Both | **0.60 (0.43 – 0.80)** | **0.12 (0.07 – 0.19)** | 1.49 (1.09 – 2.03) |
| None [a] | 1 | 1 | 1 |
| BMI (%) | | | |
| Normal [a] | 1 | 1 | 1 |
| Over weight | **0.64 (0.52 – 0.82)** | 0.59 (0.40 – 0.88) | 1.11 (0.78 – 1.58) |
| Obese | **0.54 (0.40 – 0.73)** | 0.72 (0.48 – 1.10) | 1.08 (0.80 – 1.46) |
| Self-rate health status (%) | | | |
| Poor | **0.78 (0.63 – 0.96)** | **0.74 (0.56 – 0.96)** | 0.95 (0.77 – 1.18) |
| Good [a] | 1 | 1 | 1 |
| Blood pressure medication (%) | | | |

| | | | |
|---|---|---|---|
| Yes | 0.84 (0.65 – 1.08) | 1.13 (0.75 – 1.70) | **0.73 (0.55 – 0.96)** |
| No [a] | 1 | 1 | 1 |

Abbreviation: BMI, Body mass index; F2F, face to face doctor visit: [a.] Reference group

[b.] OR from final model adjusted for wave, age, gender, race/ethnicity, marital status, education status, health-insurance, BMI, self-rated health, physical activity, smoking status, medication for hypertension, medication for diabetes, face to face doctor visits

[d.] Bold font represents significant p-value (<.05); [e.] BMI group Under/Normal weight (<25); Over weight (25 to 30); Obese (>=30)

# CHAPTER 5

# DISCUSSION

We found that, the distribution of comorbidity profiles differed by race/ethnicity. Hispanics had the highest percentage of individuals with no chronic condition beside diabetes when compared with black and whites. On the other hand, the percentage of discordant condition was higher among Hispanics and whites than blacks.

This study assessed whether there was an association between comorbidity profile and cardiometabolic risk factor control among older adults with diabetes. Also, the study was examined whether race/ethnicity modified the association between comorbidity profile and cardiometabolic risk factor control. Our results show that individual with only discordant chronic conditions are more likely to control their HbA1c level than those with no chronic condition beside diabetes. Similarly, having both concordant and discordant chronic conditions were associated with greater odds of HbA1c control. In general, our results suggest that diabetes patient with discordant chronic conditions have a better chance to control their HbA1c level than those with no chronic condition beside diabetes. Also, we did find race/ethnicity as effect modifier between HDL control and comorbidity profile.

## Cardiometabolic risk factor control by both concordant and discordant chronic condition

Our result also showed that diabetes patient with both discordant and concordant chronic conditions were more likely to control their HbA1c level than patients with no

chronic condition beside diabetes. This result is supported by another study, that reported that diabetes patients with both concordant and discordant chronic conditions were more likely to have better ABCs goals achievement than those of with no chronic condition beside daiabetes[39]. The possible explanation for this result could be a difference in lipid lowering medication intake among groups. The literature shows that individual with multiple chronic condition or those with polypharmacy were more likely to receive statins or other lipid lowering medication as compared to those with no chronic condition beside diabetes[40]. Further, those taking statins was also related with lowering A1c levels, however we were unable to capture satin medication intake in our data. Another explanation could be because patients with more chronic conditions had more frequent primary and specialty care visits than other patients, which may increase relationship between provider and patients. Greater effort by health care providers such as pay attention and examine all aspects of the patient conditions, accordingly individualize achievement goals and the lifestyle changes help patients to achieved good HbA1c control[39,41]. This suggests that having more chronic condition does not necessarily make diabetes patents vulnerable to receiving poorer cardiometabolic risk factor control.

**Cardiometabolic risk factor control by discordant chronic condition**

Our results showed that diabetes patients with only discordant chronic conditions was associated with better control of HbA1c level compared with those with no chronic condition beside diabetes. This finding did not support our hypothesis that those with discordant chronic conditions will have much worse ABCs goals achievement compared to those with no chronic condition beside diabetes. However, our result is supported by previous literature showing the same impact of discordant chronic conditions on diabetes

care. For example, the result from Woodard et al., shows that diabetes patient with only discordant chronic conditions were more likely to have better control of glucose and lipids than patients with no chronic condition beside diabetes. The possible explanation might be that individuals who had much more challenging conditions may receive better care with frequent medication and life style changes and do better self-care than individuals with no chronic condition beside diabetes. Another explanation could be a difference in diabetes medication intake, we found that the prevalence of insulin intake was greater among individual with on chronic condition beside diabetes (10%) than individual with only discordant chronic condition (5%). This finding was further supported by the finding from other literatures, suggested that insulin intake is associated with lower HbA1c control[7,22].

However, our result is in contradict with the Pentakota et al.[12] study, suggests that discordant condition reduced quality of diabetes care. This inconsistent result may be due to the fact the Pentakota study excluded patients with life threatening conditions which other study show high risk patients received better provider attention and increased a chance to received better care[11].

**Cardiometabolic risk factor control by concordant chronic condition**

Our results found no association between having concordant chronic conditions and ABCs goal achievements. We found no difference on achieving ABCs goals between those who have concordant chronic conditions compared to those with no chronic condition. Possible explanation could be attributed to the fact we only included a limited number of concordant chronic conditions (n= 3). In addition to that patients with this conditions (stroke, hypertension and heart disease) mostly gives much less attention to

goal achievement prioritizations and lifestyle changes than patients who has other concordant chronic condition (e.g renal disease & diabetes eye disease) which was not capture in our data[6]. Therefore, it may possible this may buffer the effect of concordant chronic conditions on ABCs goals achievement. However, research has found having concordant chronic condition was associated with better ABCs goals achievements[13].

Race/ethnicity does not appear to modify the association between HbA1c control and comorbidity profile or blood pressure control and comorbidity profile. A possible explanation to our null findings were a small sample size for Hispanic and black participants by comorbidity profiles (Hispanic discordant n = 53 and black discordant n = 37). Furthermore, race/ethnicity modified the association between HDL control and comorbidity profiles. We found Hispanics with concordant chronic conditions less likely to control their HDL level than Hispanic with no chronic condition (OR: 0.39; 95% CI: (0.16 – 0.95)).

**Strengths and Limitations**

The present study has several strengths. First, it uses HRS data, which is a nationally representative sample of persons 50 years of age. In addition to the nationally-representative, multi-stage area probability sample, it over sampled black and Hispanic populations to increase generalizability. Second, all outcome variables, blood pressure, HDL cholesterol, and HbA1c were from HRS biomarker dataset, which are measured objectively. Finally, we assessed association between ABCs goals achievement and comorbid chronic condition by using comorbidity profile (concordant and discordant), rather than just looing the number of chronic conditions, which ignores a potentially

important consideration; whether the comorbidity has similar or opposite management to diabetes.

However, there are several limitations in the present study. The first limitation is, the fact that it is a cross-sectional study, it is possible that increased numbers of comorbid conditions are the result of, rather than the cause of, poor cardiometabolic risk factor control. Therefore, we can only suggest association, not causality. Second, except for the cardiometabolic risk factor variables (BP, HbA1c and HDL), type 2 diabetes and other chronic condition were assessed based on self-report information and not verified by medical records review. This, make the information less reliable and bias may occur due to the misclassification of diabetes and other chronic condition variables. However, study suggest that although strength of agreement varied by conditions, there is good agreement between validated evidence of chronic condition and self-report of chronic disease[42]. Fourth, recall bias could weaken the true effect of comorbidity on ABCs goals achievements. Fifth, while we examine the effect of comorbidity by their type (concordant/ discordant) we looked for presence or absence of condition, and we were not able to assess chronic severity level that might influence ABCs goals achievement[11]. Sixth, we included small numbers of common chronic conditions to classify patients into comorbid chronic condition groups; however, the condition may not reflect all existing chronic conditions and it may lead to underestimating the impact of comorbidity profiles in our outcome. Finally, physical activity was poorly measured, and diet was not measured. Furthermore, even if the present study adjusted for so many covariant, it is plausible to acknowledge that there may be unmeasured confounders (e.g., polypharmacy

and diabetes duration and medication adherence) for which we could not make adjustments.

**Conclusion**

Our study indicates that diabetes patients with multiple chronic conditions have a better or similar ABCs goals achievement compared to individuals with no chronic condition beside diabetes, particularly those with discordant chronic conditions regardless of race/ethnicity. However, the impact of concordant chronic conditions differed by race/ethnicity. Hispanics with concordant chronic conditions were less likely to achieve HDL cholesterol goals but no association was found among whites or blacks. These findings suggest the need for strategies that focus on identifying patients who might be at high risk of controlling their ABCs goals and the development of interventions that account for individuals' comorbidity profiles and race/ethnicity. Future studies should further examine the association longitudinally and use a comprehensive set of chronic conditions.

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# APPENDIX. A SENSITIVITY ANALYSIS

Table A.1. Comparison of socio-demographic and clinical variables for 2010 and 2012 Health and Retirement Study

| Variables | 2010 wave | | 2012 wave | | P-value [a] |
|---|---|---|---|---|---|
| | N, Means | %, SD | N, means | %, SD | |
| Exposure (%) | | | | | |
| None | 95 | 6.0 | 90 | 5.8 | |
| Concordant | 313 | 18 | 344 | 19 | |
| Discordant | 127 | 7 | 139 | 10 | 0.11 |
| Both | 1,313 | 68 | 1,111 | 64 | |
| Outcome (mean, SD) | | | | | |
| Systolic blood pressure | 133.7 | 21.1 | 131.8 | 20.1 | 0.0075 |
| Diastolic blood pressure | 79.2 | 12.3 | 78 | 12 | 0.004 |
| HbA1c | 6.8 | 1.5 | 6.8 | 1.4 | 0.89 |
| HDL | 49.9 | 14.3 | 49.6 | 14.3 | 0.56 |
| Covariant | | | | | |
| Age (Mean) years | 68.9 | 10.2 | 67.6 | 9.8 | 0.0024 |
| Sex (%) | | | | | |
| Female | 1034 | 53 | 898 | 51 | 0.33 |
| Male | 814 | 47 | 786 | 49 | |
| Race/ethnicity (%) | | | | | |
| None Hispanic White | 1087 | 73 | 934 | 71 | |
| None Hispanic black | 440 | 14 | 430 | 15 | 0.5 |
| Hispanic | 321 | 13 | 320 | 14 | |
| Marital status (%) | | | | | |
| Married | 1104 | 61 | 1004 | 61 | 0.9 |
| Not married | 744 | 39 | 680 | 39 | |

| | | | | | |
|---|---|---|---|---|---|
| Vigorous physical activity (%) | | | | | |
| Active | 721 | 44 | 678 | 45 | |
| Not active | 974 | 56 | 969 | 55 | 0.7 |
| Diabetes medication (%) | | | | | |
| Insulin | 995 | 54 | 970 | 56 | |
| Oral | 162 | 8 | 148 | 8 | |
| Both | 237 | 13 | 247 | 13 | |
| None | 454 | 25 | 319 | 21 | 0.4 |
| BMI (%) | | | | | |
| Normal | 315 | 16 | 262 | 15 | |
| Over weight | 602 | 17 | 511 | 29 | |
| Obese | 931 | 52 | 911 | 56 | 0.24 |
| Self-rate health status (%) | | | | | |
| Poor | 989 | 51 | 909 | 50 | |
| Good | 859 | 49 | 775 | 50 | 0.66 |
| Health insurance (%) | | | | | |
| Insured | 1700 | 93 | 1542 | 92 | |
| Uninsured | 141 | 7 | 137 | 8 | 0.61 |
| Education (%) | | | | | |
| <high school | 560 | 25 | 560 | 29 | |
| High school | 562 | 30 | 459 | 26 | |
| >some college | 726 | 45 | 665 | 45 | 0.05 |
| Blood pressure medication (%) | | | | | |
| Yes | 1392 | 74 | 1291 | 74 | |
| No | 456 | 26 | 393 | 26 | 0.96 |

***** P-value represents the comparison of variables between wave 2010 and wave

**-** Bold font represents a significant p-value

Table A.2. Impact of the number of discordant and concordant condition on cardiometabolic risk factor control

| Number of concordant Condition | HbAc1control | HDL Cholesterol Control | Blood pressure control |
|---|---|---|---|
| | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Concordant | | | |
| 0[a] | 1 | 1 | 1 |
| 1 - 2 | 1.29 (0.80 – 2.08) | 0.91 (0.66 – 1.25) | 0.97 (0.67 – 1.42) |
| 3+ | 1.16 (0.60 – 2.24) | 1.05 (0.68 – 1.62) | 0.93 (0.48 – 1.80) |
| Discordant | | | |
| 0 [a] | 1 | 1 | 1 |
| 1-2 | **1.35 (1.08 – 1.69)** | 1.06 (0.81 – 1.39) | 1.10 (0.80 – 1.51) |
| 3+ | **1.75 (1.21 – 2.53)** | 0.93 (0.64 – 1.35 | **1.73 (1.07 – 2.80)** |

[b] Adjusted for wave, age, gender, race/ethnicity, marital status, education status, health insurance, BMI, self-rated health, physical activities, smoking status, medication for hypertension, medication for diabetes, face to face doctor visits

[a] Reference groups

-Bold font represents significant 95% CI

[c] This group has a very small number and interpretation for result should be with caution

Table A.3. The association between comorbidity type and Blood pressure level with cut-point 130/80 and 140/90, Health and Retirement Study, 2010 & 2012

| | Cut-point=130/80 mmHg | | Cut-point=140/90mmHg | |
|---|---|---|---|---|
| Comorbidity type | OR [b] | 95% CI | OR | 95% CI |
| Concordant | 0.89 | 0.47 - 1.69 | 0.9 | 0.5 – 1.7 |
| Discordant | 1.03 | 0.64 – 1.63 | 1.2 | 0.6 – 2.1 |
| both | 1.12 | 0.65 – 1.93 | 1.0 | 0.6 – 1.8 |
| None [a] | 1 | | 1 | |

[a] Adjusted for wave, age, gender, race/ethnicity, marital status, education status, health insurance, BMI, self-rated health, physical activities, smoking status, medication for hypertension, medication for diabetes, face to face doctor visits

[b] Reference groups

[c] Bold font represents significant 95% CI

Table A.4. The association between comorbidity type and HbA1c level with cut-point 7.5 and 8.0, Health and Retirement Study, 2010 & 2012

| Comorbidity type | Cut-point = 8.0 | | Cut-point = 7.5 | |
|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI |
| Concordant | 1.62 | 0.77 – 3.41 | 1.8 | 1.0 – 3.2 |
| Discordant | 1.73 | 0.83 – 3.61 | **2.3** | **1.3 – 4.3** |
| both | 1.86 | 0.88 – 3.91 | **2.1** | **1.1 – 3.9** |
| None [a] | 1 | | 1 | 1 |

[b] Adjusted for wave, age, gender, race/ethnicity, marital status, education status, health insurance, BMI, self-rated health, physical activities, smoking status, medication for hypertension, medication for diabetes, face to face doctor visits

[a] Reference groups

-Bold font represents significant 95% CI