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THE PREVALENCE OF MULTIMORBIDITY AMONG
FOREIGN-BORN ADULTS IN THE UNITED STATES

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2017

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ABSTRACT

The Prevalence of Multimorbidity Among Foreign-born Adults in the United States

By Lubaba Tasnim

Objective

Although foreign-born adults are a growing population in the United States (US), little is known about the prevalence of multimorbidity, the presence of two or more chronic conditions in an individual, and factors associated with multimorbidity in this population. The objective of this study was to assess the prevalence of multimorbidity involving nine selected chronic conditions among foreign-born adults in the US by socio-demographic factors such as age, sex, and place of origin.

Methods

Data were analyzed on 8,174 adult immigrants from the New Immigrant Survey (NIS), a nationally representative study of adult immigrants with newly acquired legal permanent residence (LPR). Self-reported chronic diseases used to assess multimorbidity in this study were: hypertension, heart problems, stroke, chronic lung disease, asthma, diabetes, cancer, arthritis, and obesity. Descriptive statistics and Pearson's chi-square tests were used to show differences in multimorbidity prevalence across sociodemographic variables. Multinomial regression models were used to evaluate the association of sociodemographic characteristics and covariates such as length of stay in the US and healthcare utilization with multimorbidity. All of the analyses were adjusted by survey-weights, to generate nationally represented estimates.

Results

The overall prevalence of multimorbidity was approximately 6.0% in this study compared to 25% in the native US population. The prevalence of multimorbidity increased with age and was highest among populations from the Latin America and Caribbean region. The most common dyad and triad of chronic conditions among both men and women were hypertension-obesity and diabetes-hypertension-obesity, respectively. The diabetes-hypertension dyad was common among men, whereas the arthritis-hypertension dyad was common among women, especially at older age group. Age, socioeconomic status, health utilization, and length of stay in the US were significant predictors of multimorbidity.

Conclusion

This study found a lower prevalence of multimorbidity among US foreign-born adults (6%) relative to the published literature (9%-38%). Multimorbidity prevalence increased with age, had different patterns in men and women, and varied by place of origin. While these levels of multimorbidity are quite low, an emphasis should be placed on monitoring foreign-born populations particularly among those categories with higher odds of multimorbidity (places of origin; age), identified in this work.

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I. INTRODUCTION

Background

Increases in longevity and social-behavioral changes are contributing to a steady rise in chronic diseases around the world (1-2). As a result, multimorbidity, defined as the co-existence of two, three or more chronic conditions within a person, is also becoming a common phenomenon globally, with an estimated prevalence ranging from 20% to 30% in the all-ages population, increasing significantly with age (3-4). In the United States (US) more than 1 in 4 adults have multimorbidity, with prevalence ranging from 9-26% (4-6). Multimorbidity has major social, health, and economic implications for an individual and society. Multimorbidity is associated with higher rate of disability, high healthcare utilization costs, higher polypharmacy, frequent ER visits, and lower quality of health care in the US (2,4,6).

Multimorbidity trends are also common among foreign-born adults worldwide (7-10). The prevalence estimates of multimorbidity among foreign-born adults in Europe ranged from 9% to 38% in previous studies, often varying by place of origin, sex, and length of stay (1,11-21). However, when it comes to the US, there is a substantial lack of research on multimorbidity prevalence among foreign-born adults even though this population is expanding rapidly. As of 2016, 43.7 million foreign-born individuals lived in the US, accounting for 13.5% of the US population (22). Also, first and second-generation foreign-born adults comprises a quarter of the US population (22). Given that foreign-born adults make up a major portion of the US population, understanding health-related conditions such as chronic diseases and the healthcare needs of this diverse group are critical for policy-making and healthcare reform. Instead of diagnosing and treating

chronic diseases individually, multimorbidity can represent a new approach and paradigm shift to understanding and clinically managing combined chronic diseases (3). Also, multimorbidity is particularly relevant for the health status of foreign-born adults as a consequence of environmental, social, and personal risks (10). Given that the majority of studies on multimorbidity prevalence were conducted outside of the United States, there is a need for substantial research on foreign-born populations in the US. In addition, the prevalence estimates of multimorbidity also vary significantly depending on the various definitions of multimorbidity and chronic conditions considered, population settings, and data collection methods (3-4,14).

Objective and Research Question

The implications of having multimorbidity, defined as the presence of two or more chronic conditions in an individual, is more far-reaching than having one chronic condition for the following reasons: out-of-pocket expenses, greater likelihood of disability, poorer quality of life, inability to work, medication adherence, and higher mortality (3-4,6,23-24). Healthcare expenditures also increase, sometimes exponentially, with each additional chronic condition from more emergency department visits, greater specialist physician access, and hospital admission (3-4,6). While the prevalence is generally higher for individual chronic conditions, the health burden for multimorbidity is more severe (25-27). Given that the social and health consequences of multimorbidity are markedly higher than one chronic condition, identifying the number of multimorbidity cases and its pattern in the US population is crucial. Even though the first and second generation of foreign-born populations represent 25% of the US population, very few studies have characterized the status of multimorbidity and its patterns among this

population (22). Knowing the prevalence and patterns of multiple chronic conditions (multimorbidity) among the US foreign-born population can help recognize the extent of their health-related problems and overall health status (10). To address the gaps in the existing literature and determine the overall health status of foreign-born adults, the objective of this study was to estimate the prevalence of multimorbidity among US foreign-born individuals by age, sex, and place of origin. The data for the study came from the adult sample of the New Immigrant Survey (NIS), which is a nationally representative study of new legal immigrants to the US (28). The primary research question was to estimate what is the overall prevalence of multimorbidity among the foreign-born adults in the US by sociodemographic factors such as age, sex, and place of origin? Additionally, what are the common multimorbidity patterns among US foreign-born adults and how do they differ by age and sex? For this study, multimorbidity was defined as the presence of two or more chronic diseases, self-reported, in the same individual out of a total of 9 conditions: (a) high blood pressure or hypertension; (b) heart problems (heart disease or any cardiac condition); (c) stroke; (d) chronic lung disease; (e) asthma; (f) diabetes (high blood sugar or borderline diabetes); (g) cancer; (h) arthritis; or (i) obesity.

II. LITERATURE REVIEW

Multimorbidity Definitions and Patterns

Multimorbidity Definitions

The definition of multimorbidity varies across literature depending on the study design and setting. Most epidemiologic studies have defined multimorbidity as the number of disease count (commonly two or more) in the same individual, in relation to individual health outcomes and demographic characteristics (3-4). These disease counts can be clinician-rated, self-rated, or drawn from medical records from a pre-defined list of chronic conditions (14). On the other hand, clinical studies have defined multimorbidity through cumulative indices which assess the number and severity of coexisting diseases in an individual. Commonly used indices include the Charlson Comorbidity Index and the Cumulative Illness Rating Scale (CIRS) which studies have often utilized to evaluate the effect of multimorbidity on health outcomes, such as mortality and health care utilization (4,8,10). The Charlson Comorbidity Index is a weighted scoring system (from 1 to 6), developed to categorize the comorbidities of patients according to the severity of the diseases and the risk of mortality (64). Similar to Charlson Comorbidities Index, the CIRS index uses a scoring system (from 1 to 5) which includes 14 body system domains and a severity scale for each domain (29).

Given the diverseness and complexity of the health status of age-related pathologies, no single definition of multimorbidity can fulfill research and clinical purposes effectively. However, the concurrence of several chronic diseases is a common denominator of the majority of the definitions that exist in the literature (3-4). As a result, in this study, multimorbidity is defined as the presence of two or more chronic conditions

in the same individual as most epidemiologic studies have used this definition. (1,4,11-12,30-31). This definition needs to be differentiated from comorbidities, which refer to chronic conditions originating from disorders of primary interest (4). For example, retinopathy, renal failure, and peripheral neuropathy are comorbidities of diabetes and thus form a cluster of interdependent conditions (3).

Multimorbidity Patterns

Given that multimorbidity is the coexistence of several diseases, common patterns of disease clustering are often distinguishable in individuals. Most literature has described the occurrence of chronic disease clusters in dyad or triad (10,32-35). These clusters often develop because of the shared risk factors of the diseases, causation of one by the other, or high prevalence rates of the diseases. Disease clusters can also be concordant (shared disease pathways) or discordant (unrelated conditions) (4). For example, medication for one disease (e.g., tuberculosis) can aggravate the condition of another disease (e.g. diabetes), especially with discordant disease clusters. However, these disease clusters also vary by age and sex as shown in the nationally representative study by Ward et al., which used data from the US National Health Interview Survey (NHIS), 2010 (5). The most common disease cluster identified in the study by Ward et al. was arthritis-hypertension among both men and women of all ages. However, the chronic disease cluster arthritis-asthma were only present among women in the 18-44-year age group. Other studies have also found hypertension-diabetes to be a common disease cluster among individuals with multimorbidity. Other prevalent chronic disease clusters identified in the literature were heart disease-arthritis, and hypertension-obesity (1,5,21,30,32,36).

To estimate the association between disease clusters from a list of chronic conditions, factor analysis, a type of statistical analyses, have been used in literature. A study by Prados-torres et al., found five common chronic disease patterns among adult population through factor analysis which were: cardio-metabolic (notably prevalent among individuals aged 65 or older) , psychiatric-substance abuse (present only among young men 15-45 years old), mechanical-obesity-thyroidal (especially prevalent among women 45-64 years), psychogeriatric (mostly prevalent among women of 65 years or older) and depressive (present only in women among 45 years or older) (35). A narrative review of several studies also found factors comprising of several cardio-metabolic conditions, and factors including pain, and anxiety and depression to be common across studies (34).

Prevalence of Multimorbidity

Prevalence in the United States

Multimorbidity is a growing concern in the United States where over 1 in 4 people have multimorbidity (37). Several studies have examined the prevalence of multimorbidity in the US, but the estimates vary from study to study depending on the number and types of the chronic diseases considered, sources of data (administrative database, surveys, clinical evaluation), settings (primary care vs. self-reported), countries, study design, and study population (3-4). As there are no uniform guidelines to measure the prevalence of multimorbidity, it makes comparability of the prevalence estimates of these studies difficult.

The majority of studies conducted in the United States used a list of 20 chronic conditions classified by the Department of Health and Human Services (HHS) (37).

When 9-10 physical chronic conditions were considered, the prevalence of multimorbidity in the US ranged from 9% to 26% for the overall population and increased up to 81% for those aged 65 years or more (4-5,11-12,31-32). A systematic review by Marengoni et al. found the prevalence of multimorbidity, defined as the presence of two or more concurrent diseases, ranging from 20% to 30% across studies when the whole population (all ages) were considered (3). For people older than 65 years, the prevalence varied from 55% to 98%.

Nationally representative studies have also shown multimorbidity to progress with age. A nationally representative study by Staimez et al. , with data source from National Health and Nutrition Examination Survey, found that the occurrence of multimorbidity increased with age, from 1.5% to 5.9%, 15.0%, and 34.8% for adults aged 18-39, 40-54, 55-64, and 65-79 years, respectively from a list of 4 chronic diseases (31). Another nationally representative study also showed similar findings, using data from NHIS, among non-institutionalized US adults (N=27,157) from a list of 10 chronic conditions, which are presented in Table 1 (5).

Major Findings Across Studies

Even though studies on multimorbidity often vary in estimates, several findings are uniform across the literature. The majority of studies found the prevalence of multimorbidity to increase with age, to be higher among women compared to men, and those with lower socioeconomic status (1,3-6,11,30,32). Although literature shows multimorbidity to be substantial among the older population, the absolute number of people with multimorbidity is higher in those younger than 65 years (1,12-13). Generally, in younger individuals (<55 years) multimorbidity involved mixed mental and physical

conditions whereas in older population multimorbidity was mostly comprised of physical conditions (38).

Studies have also shown the prevalence of multimorbidity to be higher for certain races compared to others (30,32). For example, non-Hispanic Blacks have higher odds of multimorbidity than non-Hispanic Whites, and Whites than Asians (30). Given the global variations in the prevalence of chronic diseases, it is also necessary to estimate the prevalence of multimorbidity among foreign-born people who often have different health and disease profile than that of the native population (33). The prevalence of multimorbidity in the foreign-born population will be discussed in a later section.

Risk Factors for Multimorbidity

The majority of literature shows no established set of universal risk factors for multimorbidity, except for age and low education. A risk factor is any attribute, exposure or aspect of an individual which increases their likelihood of developing a disease or injury (39-40). Although there is a lack of universal risk factors for multimorbidity, some studies have shown several modifiable and non-modifiable factors, to be associated with multimorbidity which are described below:

Modifiable Factors

Modifiable factors such as low physical activity, cigarette smoking, alcohol consumption, and nutrient intake have been found to be individually associated with multimorbidity in the literature. Studies have shown that participants with low physical activity have higher odds of multimorbidity compared to those with high physical activity (41). Same association is observed among smokers who have 20% higher odds of multimorbidity compared to non-smokers (42).

Interestingly, even though alcohol consumption is associated with adverse health outcomes, a study in the United Kingdom (UK) by Gallacher showed less frequent alcohol intake to be associated with higher odds of multimorbidity (43). However, the result of this study should be taken with caution as more studies are needed to confirm the association of alcohol intake with multimorbidity. Moreover, nutrient intake associated with diet has also been shown to be associated with multimorbidity. A Chinese cohort study by Ruel et al. found higher consumption of fruit and vegetables and grain products other than rice and wheat to be significantly associated with the healthier stages in the evolution of multimorbidity (44).

Non-Modifiable Factor

AGE

Age has been established as a major risk factor for multimorbidity across studies (3-4,13,32). A Dutch study by Van den Akker et al. found that compared to 25-39 years old participants, odds of multimorbidity increased consistently with age with the odds of multimorbidity being 2.0 among those aged 40-59 years, 5.9 for 60-79 years, and 10.7 for 80 years or older (11). Another study by Gimeno-Feliu et al. in Spain study found that compared to participants aged 15-44 years old, the odds of multimorbidity was 3.4 for 45-64 years old and 9.3 for those 65 years and older (19).

Socioeconomic Factor

LOW EDUCATION

Low education, which is often an indicator of low socioeconomic status, is a common risk factor for multimorbidity (1,3-4,30,45). In most studies, participants with less than a high school degree were assigned to lower level of education, those with high school degree/some college were in the secondary level of education, and those with at

least a college degree were in the highest educational level. A longitudinal study in Germany by Nagel found the lowest educational category to be significantly associated with increased odds of multimorbidity in both men (OR = 1.43) and women (OR=1.33) compared to the highest educational category (45). Similarly, a cross-sectional study in the U.S. by Johnson-Lawrence found adults with less than a high school degree (OR= 2.21) and those with a high school degree/some college (OR=1.53) had higher odds of multimorbidity compared to those with at least a college degree (30). As shown in previous literature, the above listed modifiable and non-modifiable risk factors can play an essential role in development of primary prevention for individuals at risk of multimorbidity, in turn reducing costs associated with multimorbidity (3-4,46).

Consequences of Multimorbidity

Multimorbidity has major social, health, and economic implications for an individual and society. Multimorbidity is associated with high healthcare utilization cost, disability, higher polypharmacy, frequent ER visits, and lower quality of care (2-3,10,18). In the United States, 66% of the total health care spending is geared towards caring for approximately 27% of the population with multiple chronic conditions (i.e. multimorbidity) which will increase over time (6). The average per capita health care spending is \$2,844 for someone with one chronic condition whereas for those with two or more chronic conditions the cost ranges from \$5,074 to \$14,768 (6). People with multimorbidity are also more likely to be hospitalized and make more annual visits, compared to those with no chronic conditions or one chronic condition. Access to health care is also an obstacle for some patients with multimorbidity (3). They usually face

problems related to health care which may also be exacerbated by language barriers, lack of insurance, and geographic proximity to the providers (3,37).

Migration in the United States

Migration due to political instability, poor socio-economic environment, and other circumstances have become a global phenomenon that entails major health challenges for the foreign-born population. The United States has a long and complicated history of diverse migration patterns. As of 2016, 13.5% of the U.S. population consisted of foreign-born adults (47). The majority of the foreign-born persons in the United States were born in the South and East Asia (30.4%), and Mexico (27.3), followed by other Latin America (16.7%), Europe (10.1%), Central America (8.0), Africa (5.4%), and other countries (2.1%) (22,48). Even though new immigrant arrival has dropped in recent years, if the current trend in immigration continues, first and second-generation foreign-born individuals are estimated to account for 88% of the US population growth until 2065 (22). Given the projected growth of the foreign-born population in the coming years, the health status of foreign-born people and their descendants will play a vital role in shaping the health outcomes of American people (49). As a result, understanding health-related problems and healthcare needs of this diverse population will be critical for policymaking purpose and healthcare reform in the future.

The Health of the Foreign-born Population

To understand the healthcare needs of the foreign-born population, it is essential to determine the individual factors that play a role in shaping the overall health of this diverse population. Generally, foreign-born people tend to be in better health, except for

refugees and asylum seekers, compared to the natives upon arrival to their host countries (10,20). These better health conditions are partly attributable to their lifestyle habits before and post-migration, or health selection through immigrant screening, or to broad social support (10,47). However, with increasing length of residence in the U.S., foreign-born individuals' health become increasingly similar to that of the native-born US population (50). As foreign-born people adopt native lifestyle habits such as low physical activity or unhealthy diet, they develop more health risks leading to an increase in obesity, and high blood pressure (47). Exposure to such detrimental lifestyle habits and environmental risks over time within host countries, causes their health to deteriorate often leading to chronic conditions (51-52).

Despite the gradual deterioration of health, risk of mortality and morbidity for foreign-born people remains lower than that of US-born population (33). Previous literature indicates that across most chronic conditions, foreign-born individuals have lower rates of chronic diseases than native-born individuals (49). A study by Singh et al., which used data from the National Longitudinal Mortality Study, found immigrant men and women had 18% and 13% lower risk of overall mortality, respectively compared to US native-born people (23). This mortality advantage might be attributable to better health upon arrival or the 'salmon bias,' whereby migrants return to their country of origin prior to death (24). The leading causes of mortality among immigrants by place of origin are listed in Table 2 (53-56). Given that chronic diseases are the majority of the leading causes of mortality among the US foreign born-population, estimating the prevalence of multiple chronic diseases or multimorbidity among foreign-born individuals can help identify healthcare needs of this population.

Prevalence of Multimorbidity Among the Foreign-born Population

Prevalence in the United States

Majority of the studies on the prevalence of multimorbidity among foreign-born adults have been conducted in Western Europe (7-10,19-21). The few studies published in the US on foreign-born adults are mostly on chronic diseases prevalence among refugees or asylees and specific ethnic groups. Given the limited studies on multimorbidity in the US, the findings from studies on chronic disease prevalence among foreign-born people are presented below:

Nationally representative studies among foreign-born adults in the US have shown hypertension to be the most prevalent chronic condition across all age groups (25 ,49,57). Other prevalent conditions among foreign-born adults were arthritis, diabetes, obesity, asthma, and heart disease. Asthma and lung disease were more common among those aged 25-44 years whereas heart disease and diabetes were more common among those aged 50 years or above (10,25,50).

Given the variations among the health of the foreign-born individuals by place of origin, previous literature has often presented findings according to the foreign-born population's country of origin (19,25). A nationally representative study found the prevalence of hypertension and arthritis to be highest among foreign-born individuals from Europe, followed by North America and Mexico (58). On the other hand, the prevalence of diabetes was highest among those from Mexico, followed by Europe and South America. Contrasting to these results, another nationally representative study by Oza-Frank et al. found the prevalence of diabetes to be highest (10%) among the foreign-born people from the Indian subcontinent followed by Africa, and Latin America &

Caribbean region, and lowest among those from Europe (3.1%) (25). The study also found the prevalence of multimorbidity to be highest among those from Mexico, followed by Africa and the Middle East.

A population-based study by Dong et al. showed the prevalence of chronic diseases among US Chinese older adults in the Greater Chicago area (59). The study found that 84.3% of adults had one or more chronic condition, 24.6% had two chronic conditions, and 19.5% had three chronic conditions. Out of the nine chronic conditions assessed, high blood pressure was most prevalent (55.2%), followed by high cholesterol (48.4%), osteoarthritis (39.1%), diabetes (22.3%), and heart disease (15.1%). A nationally representative study by Dallo et al. found foreign-born adults from Arab Nations have a significantly higher prevalence of comorbid heart disease (18%), asthma (5%), and obesity (13%) compared to European-born whites. They also had the highest prevalence of comorbid diabetes (8%) compared to both European (5%) and US-born whites (6%) (26).

Among foreign-born adults, refugees often have complex health care needs as a result of their experiences related to marginalization and poverty, displacement, violence or traumatic migration (26). As a result, most literature on the health of foreign-born adults in the US has often focused on the health conditions of refugees (60-62). The findings from these studies are described below:

Nationally representative studies and cross-sectional studies have found obesity, hypertension, and behavioral problems (ex: PTSD and depression) to be most prevalent among refugees in the US (57,62). Other chronic conditions reported in these studies were diabetes, arthritis, anemia, coronary artery disease (CAD) and dyslipidemia (57,63).

A retrospective medical record review by Yun et al. found that among adult refugees in the Northeast, one in 5 adults had two or more chronic non-communicable diseases (i.e., multimorbidity) (62). A cross-sectional study among refugees in Massachusetts also showed that the presence of chronic diseases assessed in the study among refugees or asylees varied significantly according to the place of origin. The study found the prevalence of obesity, hypertension, and coronary artery disease to be highest among refugees from Europe and Central Asia and lowest in East and Southeast Asia. On the other hand, diabetes was most prevalent among refugees from East and Southeast Asia whereas anemia was prevalent among those from Africa (63).

Prevalence of Multimorbidity Outside of the US Among Foreign-born Population

To compare estimates of multimorbidity prevalence of this study with other published literature, findings from studies outside of the US have been described below as there have been limited studies in the US.

MAJOR FINDINGS

Even though prevalence estimates for multimorbidity vary depending on the type of study, most studies in Europe have found the prevalence to range from 9%-38%. For cross-sectional studies, the prevalence of multimorbidity ranged from 9% to 35% where the total number of chronic diseases considered ranged from 16-18 (9-10). On the contrary, a retrospective study based on medical records found multimorbidity prevalence to be 14.2% whereas clinical studies in a general practitioner (GP) setting showed multimorbidity prevalence to range from 20% to 38% (8,19,21).

Previous literature also suggests odds of multimorbidity to be higher for women and older age groups for both foreign-born and natives (7-10, 19-21). The most prevalent chronic conditions listed in the majority of studies among foreign-born adults were

cardiovascular disease, diabetes, and arthritis (1,10). Foreign-born people also had lower odds of multimorbidity, except for refugees, compared to the native-born population in host countries across studies (10,19).

PREVALENCE ACCORDING TO LENGTH OF STAY AND COUNTRY OF ORIGIN

Previous research assessing the prevalence of multimorbidity among foreign-born persons have found the odds of multimorbidity to increase after a five-year stay in the host country (33-60). A cross-sectional study in Spain found multimorbidity prevalence to be 23.2% and 31.0% for men and women respectively among those with less than five years of residence in the host country. The prevalence increased to 25.5% for men and 35.5% for women when the length of residence was higher than five years (19). A register-based study in Norway found odds of multimorbidity to double after a five-year stay in Norway among foreign-born adults (7). A cross-sectional study by Gimeno-Feliu et al. in Spain showed differences in the prevalence of multimorbidity according to the place of origin (19). The prevalence of multimorbidity was highest among those from Western Europe and North America (21.2%), followed by Latin America (18.5%), Africa (11.7%), and lowest for Asia (10.0%) and Eastern Europe (10.4%).

Conceptual Framework

Study Significance

Foreign-born adults in the US are heterogeneous in terms of social and cultural identity as well as health behaviors and health risks. As a result, their health care needs and health outcomes are usually different than those of the native population. As of 2016, the first and second generation of foreign-born adults represent 25% of the US population

(33). As foreign-born adults are a considerable proportion of the US population, there is a need to focus on the health of this diverse group.

Multimorbidity, defined as the presence of two or more chronic diseases, can provide a comprehensive framework in assessing the health status and chronic diseases pattern among foreign-born adults as it is often a manifestation of an individual's social, environmental, and personal risks that accumulate over the years (3-4). However, few studies have focused on the prevalence of multimorbidity in the US foreign-born adults with most research done in Europe (51). Considering the social and economic implications of multimorbidity, and the limited research in this area for foreign-born adults in the US, understanding the extent of multimorbidity among this population can indicate their overall health outcomes as well as minimize the research gap that exists in the literature. Keeping this in mind, the goal of this study is to estimate the prevalence of multimorbidity among foreign-born adults in the United States.

Factors Associated with Multimorbidity

To assess the prevalence of multimorbidity one needs to determine and evaluate individual and collective factors that lead to multimorbidity among the foreign-born adults in the US in the first place, following chronic diseases. Previous literature has suggested several sociodemographic factors such as age, sex, country of origin, length of stay in the US, and socioeconomic status to be associated with chronic diseases (1,4,12,7,9,19-20,64-65). Additionally, the development of chronic diseases from these sociodemographic factors may also occur via lifestyle and other factors among foreign-born adults (1,3-4,17,9-10,64-68). Lifestyle factors refer to smoking, alcohol consumption, physical inactivity, and dietary patterns whereas other factors include health utilization and social support (67).

For foreign-born individuals, age is an essential component in developing multiple chronic conditions, or multimorbidity, as with aging adults progressively lose resilience and homeostasis needed to regulate multiple organ systems (68). Sex also plays a role in the development of chronic conditions as the risk of chronic conditions in an individual often varies by sex (1,3-4,9). Previous literature has consistently shown both age and sex to be associated with chronic diseases where the odds of multiple chronic diseases increased with age and was generally higher among women than men (1,3-4,9). Socioeconomic status has also been demonstrated in the literature to be associated with multiple chronic diseases where individuals with low income and education level had higher odds of multimorbidity than those with high income and education level (4,12,65).

Another pathway through which age, sex, and socioeconomic status are associated with chronic diseases are through lifestyle and other factors. Studies have indicated the adoption of lifestyle behaviors to differ by age and sex among adults, where men and older age group are often engaged in a higher number of risky lifestyle behaviors (64,66-67). Health care utilization and social support also vary by age and sex among foreign-born adults, where women are more likely to be married or see a doctor in the past year than men (64,67). Furthermore, individuals with high education level have been shown in the literature to adopt healthy lifestyle factors, except for smoking, and utilize healthcare more than those with low education level. People with higher education are also more likely to be married or living together with another adult (65-66,69).

Country of origin and migration are other socio-demographic factors that have been identified in the literature to be associated with chronic diseases. Given the observational nature of the majority of the studies, a causal association is difficult to

establish for place of origin and migration with chronic diseases. However, the risk of certain chronic diseases among foreign-born adults often differs according to their region of origin (10,19-20,64). For example, the risk of diabetes is often higher among foreign-born adults from Asia, and the risk of obesity is elevated among individuals from Latin America and the Caribbean region compared to those from other regions (25). Length of stay in the US, a component of migration, has also been shown in the literature to be positively associated with chronic diseases among foreign-born adults in the US (7,19-20).

As described earlier for age, sex, and socioeconomic status; country of origin and migration can also lead to chronic conditions through lifestyle and other factors in foreign-born adults. Studies have shown the adoption of lifestyle, and other factors to vary by country of origin among foreign-born adults, which might explain the variations in chronic disease prevalence by country of origin (15,46). Even though foreign-born adults are healthier than native-born upon arrival, with increasing length of stay in the host country, they often adopt detrimental lifestyle behaviors such as diets high in sugar and fat, and physical inactivity which increase risks of certain chronic diseases (10,51). Length of stay in the US for foreign-born adults is also associated with higher health utilization as those with a higher length of stay tend to utilize healthcare more frequently (7,16,19). Social support has also been shown to be associated with length of stay where acculturation to western society with increasing length of stay has been associated with a decrease in social support (70). However, it should be reminded that foreign-born adults might also have access to resources and health benefits, and more favorable health behaviors which can lower their risk for certain chronic diseases (71).

Adoption of certain lifestyle factors among foreign-born individuals, which might or might not arise from the sociodemographic factors mentioned above, often increases risks for the development of certain chronic diseases (43,40,45,70). Lifestyle factors such as physical inactivity, unhealthy diet, alcohol consumption, and smoking have all been previously shown in the literature to increase the risk of chronic diseases among foreign-born adults by introducing more intermediary risk factors such as raised blood pressure and glucose levels along with abnormal blood lipids (39). Other health-related behaviors such as health utilization and social variables like social support have also been associated with chronic diseases among foreign-born individuals (1,3-4). Foreign-born individuals who utilize health care more such as visit doctors regularly, generally have higher odds of chronic diseases as they get diagnosed more often than those who do not visit as regularly. Individuals might also visit a doctor more frequently if they are already diagnosed with a chronic disease (19,64). In addition to increased health utilization, a component of social support such as being married or living with another adult has also been associated with lower odds of chronic diseases in the literature (1).

Chronic Disease to Multimorbidity

Given the variations of multimorbidity definitions in the literature as described earlier in the literature review, this study only captures one definition of multimorbidity: the presence of two or more chronic diseases in the same individual, without taking the severity of each chronic diseases and mental disorders into account (3). Of note, multimorbidity is not a clinically diagnosed condition, instead, it is a count of self-reported physical chronic conditions by study participants. Several components such as number, duration, and interrelatedness of chronic conditions, in addition to time, play a role in the transition from chronic disease to multimorbidity (4). For example, for an

individual to progress from chronic disease to multimorbidity, the number of chronic conditions and the duration of the condition has to be taken into account as these factors determine whether someone can be defined as having multimorbidity or just a single chronic condition (3-4). Also, often one chronic condition leads to the development of other chronic conditions (e.g., obesity leading to stroke or diabetes), which results in an individual transitioning from a single chronic disease to a multimorbidity status (3). However, this study did not take into account the interrelatedness and duration of chronic diseases. Only the total number of simultaneous chronic diseases per individual were considered in this study. The time component in the conceptual framework represents the time it usually takes for the development of an individual chronic disease, and multimorbidity from a single chronic disease. The time component is partly accounted for in this study by incorporating age and the length of stay in the US for foreign-born adults, which is often responsible for the transition from one chronic disease to multiple chronic diseases (multimorbidity) (3-4,10,51).

Study Variable Selection Based on Conceptual Framework

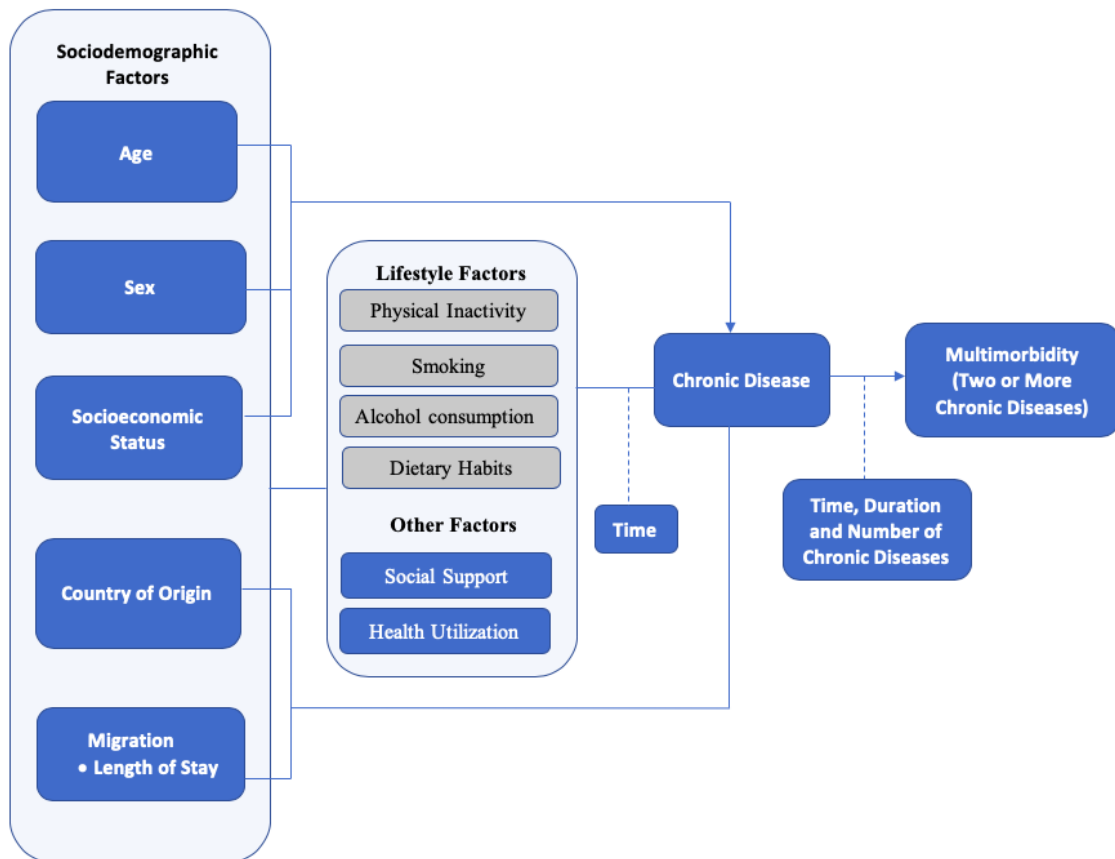
Given the cross-sectional nature of this study, a causal association between the factors listed in the conceptual framework and multimorbidity, two or more chronic diseases, cannot be established. Instead, this study will focus on assessing the prevalence of multimorbidity by age, sex, and place of origin among the foreign-born adults in the US within the context of factors presented in the framework. The association of multimorbidity with sociodemographic and other factors will also be assessed in the study. The rationale for selecting the various factors presented in the conceptual framework is listed below:

Age is one of the main exposures of this study as multiple studies have demonstrated the association of increasing age with multimorbidity (1,3-4,9,17,19). Also, most analyses performed in this study are done separately for men and women as previous studies have shown multimorbidity prevalence estimates to vary by sex (9,12). Because differences in genetic background exist among foreign-born adults due to their country of origin, place of origin of participants is taken into account when assessing multimorbidity prevalence in the analyses (19-20). Place of origin was categorized into 5 groups in the study: Latin America and Caribbean; East Asia, South Asia, and the Pacific; Middle East and North Africa; African Sub-Saharan; Europe, Central Asia, and North America as previous studies using the NIS dataset have used these categories (49). Other covariates in the study included the length of stay in the US, years of education, marital status, and health care utilization. Length of stay in the US was dichotomized into "less than five years" and "more than five years," as significant changes in health, as a result of acculturation, are often noticeable after five years (7,20). A dichotomous variable for healthcare utilization among foreign-born adults was also created as previous literature has indicated a positive association between healthcare utilization and multimorbidity (46). Years of education of participants is also used in the study to describe the socioeconomic component of the framework as education is a strong determinant of employment and income and has often been used as a generic to measure the socioeconomic status of an individual (49). To account for the social support factor described in the conceptual framework, the marital status of participants was used as previous studies have often utilized marital status as a small component of social support (20). Lifestyle factors mentioned in the framework such as alcohol intake, smoking, and

physical inactivity were not considered for analysis in this study as they were not part of the study objective.

Given that multimorbidity is the coexistence of chronic conditions, several health outcome variables were constructed in the study from the NIS dataset for analysis of chronic diseases. To be consistent with the framework outlined in the Department of Health and Human Services (HHS) Initiative on Multiple Chronic Conditions (MCC), following conditions were examined to measure multimorbidity: (a) high blood pressure or hypertension; (b) heart problems (such as coronary heart disease, heart attack, angina, congestive heart problem or other heart problems); (c) stroke; (d) chronic lung disease (chronic bronchitis or emphysema) ; (e) diabetes (high blood sugar or borderline diabetes; (f) cancer; (g) asthma; or (h) rheumatoid arthritis if they lasted for at least a year (37). Even though HHS does not include obesity as a chronic disease in its' MCC framework, this study incorporated obesity as a chronic disease as the World Obesity Federation defines obesity as a chronic, relapsing disease as it “fits the epidemiological model of a disease process except that the toxic or pathological agent is diet-related rather than a microbe” (54).

Representation of Conceptual Framework



III. DATA AND METHODS

Study Background

Data Source

The data for this study came from the New Immigrant Survey (NIS). The NIS is a nationally representative survey of new legal immigrants and their children to the US. The sampling frame of the NIS was based on administrative records compiled by the United States Citizenship and Immigration Services and consisted of foreign-born adults admitted to lawful permanent residence (LPR) between May and November 2003 (28). The sampling frame was also stratified by four immigrant visa categories: employment principals, diversity principals, spouses of US citizens, and other immigrants; the first two strata were oversampled. Employment principals and diversity principals were oversampled in the NIS dataset as they were sampled at about two and three times their natural occurrence, respectively (28). Given that these groups, particularly employment principals tend to be among the most socioeconomically advantaged immigrants, the results presented here will likely underestimate the difficulties faced by the immigrant population. The dataset represents new legal immigrants and their children who became legal permanent residents in the US in 2003. Individuals who were new arrivals to the US, as well as those who were already in the US with a temporary nonimmigrants visa and have adjusted to LPR were also included in the sample (29). This analysis uses the adult sample, which was restricted to individuals who were at least 18 years old at the time of admission.

Data Collection

The survey (NIS-2003-1) was in the field from June 2003 to June 2004. Because the sample was drawn from a list of all green card recipients at that time, the majority of countries in the world were represented. Survey instruments including consent forms were translated into ten languages. The interview was conducted in the language of the respondents' choice as soon as possible after they were granted legal permanent residency. Sixty percent of the adult sample interviews were administered by phone and the remainder was administered in-person. All of the data collected were self-reported (28).

Variables

Independent Variables of Interest

The independent variables of interest for this study are place of origin, age, and sex. To determine the place of origin of the respondents, NIS asked the following question: "In what country were you born?" In the NIS dataset, the place of origin was combined into eight regions: Europe & Central Asia, East Asia, South Asia & the Pacific, other North America, Latin America & the Caribbean, Africa sub-Saharan, Middle East and North Africa, Oceania, and Arctic region, except for the countries that had a substantial number of immigrants. Using the regional classification provided by the NIS data, the participant's place of origin was categorized into five groups in this study: Latin America and the Caribbean; East Asia, South Asia, and the Pacific; the Middle East and North Africa; African Sub-Sahara; Europe, Central Asia, and North America. For the analysis of this study, any individually listed countries in the dataset were assigned to one of the five place of origin groups previously identified. Countries that were assigned to

Latin America & the Caribbean region included Columbia, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Jamaica, Mexico, and Peru. Countries such as China, India, Korea, Vietnam, and the Philippines were part of East Asia, South Asia, and the Pacific Region. Ethiopia and Nigeria were included in the African Sub-Saharan region, and Poland, Russia, Ukraine, and the United Kingdom were assigned to the Europe and Central Asia region. Canada was designated to the North America region. Because of limited data, North America was combined with Europe and Central Asia region, and Oceania and Arctic region were aggregated to East Asia, South Asia, and the Pacific region in this study.

Variables listing the participant's birth year and interview year in the NIS data were used to construct the continuous variable age for analyses. Age was created by subtracting the year of participants' birth from the year of the interview. Then a categorical variable for age was generated to categorize age into 3 groups: 18-44, 45-64, and ≥ 65 . The rationale for distributing age into these 3 levels came from previous studies which used the same categories in nationally representative data (5). The variable for sex was already included in the NIS data and did not require further classification.

Other Independent Variables

Additional study variables that were used as covariates in the models were years of education and marital status. Using the responses from the NIS question, "How many years of schooling in total you have completed?", years of education was categorized into two groups in this study: less than 12 years and 12 years or more. For marital status, NIS had it categorized into six groups: married, living together in a marriage-like relationship but not married, separated, divorced, widowed, and never married, not living with someone in a marriage like relationship. For analyses purpose, marital status was

categorized into two groups in this study: married/living together and not married/living together, from the NIS variable on marital status. For this analysis, participants who were single, separated, divorced, or widowed were combined into the ‘not married or living together’ category whereas those who were married or living together in a marriage like relationship but not married were combined in the ‘married or living together category’.

Additional covariates included in the study were length of stay in the US and healthcare utilization of foreign-born adults in the US. In this study, length of stay in the US was defined as the years since the first migration to the US for foreign-born adults. Length of US stay was calculated from several variables in the NIS data: interview year and the year individuals first left their country of birth or another country to move to the United States. Then the year of first US arrival was subtracted from the interview year to calculate the length of stay in the US. Length of stay was categorized into two groups in the analyses: less than five years and more than five years in the US. The variable for healthcare utilization was dichotomized into categories of “yes” or “no” in this study, where “yes” constituted affirmative response to the following NIS question, “Aside from any hospital stays, have you seen or talked to a medical doctor about your health, including emergency room or clinic visits in the last 12 months?”

Dependent Variables

The outcome variables in the analyses are multimorbidity and the individual chronic conditions used to assess multimorbidity from the NIS questionnaire. Affirmative response to the NIS question “Has a doctor ever told you that you have” regarding any of the chronic diseases listed below was considered disease positive: (a) high blood pressure or hypertension; (b) heart problems (such as coronary heart disease, heart attack, angina, congestive heart problem or other heart problems); (c) stroke; (d) chronic lung disease

(chronic bronchitis or emphysema); (e) diabetes (high blood sugar or borderline diabetes); (f) cancer; (g) asthma; (h) rheumatoid arthritis. All the chronic conditions were self-reported in the NIS dataset. In our study, an individual was considered to have a chronic condition only if they were clinically diagnosed with the condition for a year or more. This duration was determined from the response to the NIS question, which asked respondents, “How long have you had this condition?” after they confirmed having a chronic condition. However, for stroke and heart problems the duration of the conditions was not taken into account as they were not available in the dataset. The variable for the chronic condition obesity was created based on self-reported weight and height, following the Centers for Disease Control guidelines: underweight ($BMI < 18.5 \text{ lb/in}^2$), normal weight ($18.5 \text{ lb/in}^2 \leq BMI < 25 \text{ lb/in}^2$), overweight ($25 \text{ lb/in}^2 \leq BMI < 30 \text{ lb/in}^2$), and obesity ($BMI \geq 30 \text{ lb/in}^2$) (73). To account for implausible values, BMI values less than 10 or greater than 60 were excluded from the analysis. For each chronic condition, a dichotomous variable was created indicating the presence or absence of the condition. An individual was considered to have multimorbidity if they had ever been diagnosed with two or more of the nine chronic conditions: hypertension, heart problems, stroke, chronic lung disease, diabetes, cancer, asthma, arthritis, or obesity. If individuals did not meet these criteria, they were considered as not having multimorbidity.

Data Preparation

Sample Creation

For purpose of analyses, the adult sample was used; it consists of individuals who were at least 18 years old at the time of admission to legal permanent residence and have visas as principals or as accompanying spouses (28). The adult sample size was 8,753

with a response rate of 70%. Observations that were missing data on independent variables such as age, sex or place of origin, were excluded from the analysis. In addition, subjects who had missing data on all 9 chronic health conditions, were also excluded from the analyses. The final analytical sample included 8,174 adult immigrants aged 18 and older. The missing counts were as follows: place of origin, 39; age, 40; years of education, 29; marital status, 6; length of stay in US, 642; healthcare utilization, 348; cancer, 346; hypertension, 464; diabetes, 388; arthritis, 390; chronic Lung Disease, 347; stroke, 337; heart Problem, 339; asthma, 359; and obesity, 876.

Data Filtering and Variable Selection

For this study, all the variables listed in the NIS dataset were examined for inclusion in the analyses. Variables were chosen based on their relation to the conceptual framework described earlier. As presented in the framework, variables were classified into one of three groups: sociodemographic factors associated with chronic conditions, other factors that are associated with chronic conditions, and individual chronic conditions which will be evaluated to assess multimorbidity. The first group, variables that represented sociodemographic factors associated with chronic conditions, included age (18-44, 45-64, 65 years and above), sex (men and women), place of origin (Latin America and Caribbean; East Asia, South Asia, and the Pacific; Middle East and North Africa; African Sub-Saharan; Europe, Central Asia, and North America), years of education (less than 12 years and 12 years or more), and length of stay in the US (less than 5 years and more than 5 years). Other factors associated with chronic conditions included current marital status (married or living together and not married or living together) and healthcare utilization (yes and no). The third group that included variables on individual chronic conditions to assess multimorbidity were: high blood pressure or

hypertension, heart problems, stroke, lung disease, diabetes, cancer, obesity, asthma, or arthritis (yes, no, and missing).

Creation of Chronic Diseases Dyad and Triad Variable

To find the most prevalent chronic disease dyad and triad, an empty string variable was created for hypertension, heart problem, stroke, lung disease, diabetes, cancer, obesity, asthma, and arthritis through ‘foreach’ loop. Then the string variables were replaced with the name of their respective chronic diseases if a subject had one or more chronic disease present. These newly created variables were concatenated into a new variable called “allcond” which listed the name of the chronic diseases if an individual had any chronic conditions present.

Data Cleaning and Coding

After the selection of data variables, data were cleaned and recoded for analyses purpose. This process involved the elimination of any implausible values. Univariate analyses were conducted for all the variables whether they were continuous or categorical to make sure there was no error in data entry. For categorical variables, the variables arrived coded in the format: “yes”, “no”, “missing”, “do not know”, and “refusal to answer”. For our analyses, any observations with “don’t know” or “refusal to answer” were considered missing values. For better interpretation of the variables, the following were recoded to 1 for “yes” and 0 for “no”. Categorical values with more levels were coded accordingly.

All the variables with specific chronic conditions asthma, arthritis, cancer, chronic lung disease, diabetes, hypertension, heart problem, stroke, and obesity were coded as yes, no, and missing where yes indicated the presence of the chronic diseases, no indicated absence of the chronic disease, and missing was assigned for anyone missing

data on the chronic condition. The outcome variable called multimorbidity was also coded in the yes, no, and missing format where ‘yes’ indicated the presence of multimorbidity (two or more chronic diseases) and ‘no’ indicated absence of multimorbidity (presence of one or no chronic disease).

Statistical Analyses

All analyses were conducted using STATA version 15.1. Chi-square analyses assumptions included independent sample and individual cell counts > 5 . For all analyses, sampling weights were taken into account to adjust for the probabilities of selection in this study. After using survey weights, the study is representative of foreign-born adults in the US who obtained legal permanent residence in the US in 2003.

Descriptive Analyses

The association of each of the socio-demographic variables with multimorbidity was evaluated with a chi-square test as shown in Table 3. For Table 4, cross-tabulations were used to estimate the number of chronic conditions by age and sex among foreign-born adults. The prevalence of individual chronic disease by place of origin was also measured via cross-tabulation, and the differences in the prevalence estimates of chronic diseases across place of origin and the overall population were tested using ‘lincom’ statement in STATA (Table 5). Cross-tabulations were also used to show the most prevalent dyads and triads by sex and age group (Table 6 and 7). Dyads and triads were considered separately; therefore, a person with three of the eight chronic conditions was considered to have three distinct dyads and one triad. For example, a person with hypertension, diabetes, and arthritis generated three distinct dyads: hypertension and diabetes, hypertension and arthritis, and diabetes and arthritis.

Modelling

The association of each independent variables and other covariates with multimorbidity, categorized by number of chronic conditions, was examined from the odds ratio and their 95% confidence interval through multinomial logistic regression (Table 8). Participants who had no chronic conditions were treated as the base outcome for the regression model. For the unadjusted model, bivariate logistic regression was performed for sex, age, years of education, place of origin, current marital status, health utilization, and length of stay with multimorbidity as the outcome variable. The equation for the unadjusted multinomial logistic regression model is listed below:

$$\ln \left[\frac{P(G = g | X)}{P(G = 0 | X)} \right] = a_g + \beta_{g1} * X_i$$

In this model, a_g represents the intercept, β_g stands for regression coefficients corresponding to outcome G, and X_i is the vector of explanatory variables describing observation i (1 to 7). The outcome G has 3 categories, where two or more chronic conditions=2, one chronic condition=1, and no chronic condition (reference category) =0. The lowercase g (1,2) subscript refers to the specific comparison being made to the reference category (0).

In the adjusted model, multivariate logistic regression was conducted for each variable with multimorbidity as the outcome while adjusting for other variables listed in the full model. Full model included sex, age, place of origin, years of education, marital status, health utilization (consulted with a doctor in the past year), and length of stay in the US. The equations for the adjusted multinomial regression models are listed below:

$$\ln \left[\frac{P(G=g | age)}{P(G=0 | age)} \right] = a_g + \beta_{g1} * Age + \gamma_{g1} * sex + \gamma_{g2} * region + \gamma_{g3} * \\ education + \gamma_{g4} * maritalstatus + \gamma_{g5} * healthutilization + \\ \gamma_{g6} * lengthofstay$$

$$\ln \left[\frac{P(G=g | sex)}{P(G=0 | sex)} \right] = a_g + \beta_{g1} * sex + \gamma_{g1} * age + \gamma_{g2} * region + \gamma_{g3} * \\ education + \gamma_{g4} * maritalstatus + \gamma_{g5} * healthutilization + \\ \gamma_{g6} * lengthofstay$$

$$\ln \left[\frac{P(G=g | region)}{P(G=0 | region)} \right] = a_g + \beta_{g1} * region + \gamma_{g1} * age + \gamma_{g2} * sex + \gamma_{g3} * \\ education + \gamma_{g4} * maritalstatus + \gamma_{g5} * healthutilization + \\ \gamma_{g6} * lengthofstay$$

$$\ln \left[\frac{P(G=g | education)}{P(G=0 | education)} \right] = a_g + \beta_{g1} * education + \gamma_{g1} * age + \gamma_{g2} * sex + \gamma_{g3} * \\ region + \gamma_{g4} * maritalstatus + \gamma_{g5} * healthutilization + \gamma_{g6} * \\ lengthofstay$$

$$\ln \left[\frac{P(G=g | maritalstatus)}{P(G=0 | maritalstatus)} \right] = a_g + \beta_{g1} * maritalstatus + \gamma_{g1} * age + \gamma_{g2} * sex + \\ \gamma_{g3} * region + \gamma_{g4} * education + \gamma_{g5} * healthutilization + \gamma_{g6} * \\ lengthofstay$$

$$\ln \left[\frac{P(G=g | healthutilization)}{P(G=0 | healthutilization)} \right] = a_g + \beta_{g1} * healthutilization + \gamma_{g1} * age + \gamma_{g2} * \\ sex + \gamma_{g3} * region + \gamma_{g4} * education + \gamma_{g5} * maritalstatus + \\ \gamma_{g6} * lengthofstay$$

$$\ln \left[\frac{P(G=g | lengthofstay)}{P(G=0 | lengthofstay)} \right] = a_g + \beta_{g1} * lengthofstay + \gamma_{g1} * age + \gamma_{g2} * sex + \\ \gamma_{g3} * region + \gamma_{g4} * education + \gamma_{g5} * maritalstatus + \gamma_{g6} * \\ healthutilization$$

In the adjusted models above, a_g represents the intercept, β_g betas (β) are the regression coefficients for the main exposure and gammas (γ) are regression coefficients for other variables that are adjusted for in the models. The outcome G has 3 categories, where two or more chronic conditions=2, one chronic condition=1, and no chronic condition=0 (reference category). The lowercase g (1,2) subscript refers to the specific comparison being made to the reference category (0).

IV. RESULTS

Descriptive Statistics Results

Univariate Analyses

Table 3 presents the sample characteristics of the overall study population, also stratified by multimorbidity status. In the overall analytical sample, 56.2% of respondents were women, and more than 72% were younger than 45 years old. By place of origin, the two largest groups of foreign-born adults were from the Latin America & the Caribbean region (44.2%) and East Asia, South Asia, & the Pacific region (29.5%). The majority of the foreign-born adults completed > 12 years of education (64.1%), did not consult with a doctor in the past year (62.3%), and had been in the US for less than five years (55.2%). Generally, foreign-born people with multimorbidity were most often women ($p < 0.05$) and came from Latin America & the Caribbean ($p < 0.01$) region compared to those without multimorbidity. A higher proportion of population with multimorbidity had less than 12 years of education, were in the 45-64 years age group, married, and consulted with a doctor in the past year (P-value < 0.001) than those without multimorbidity. Also, the majority of the foreign-born population with multimorbidity had been in the US for less than five years compared to those without multimorbidity ($p > 0.05$). The prevalence of multimorbidity by age group is shown in Figure 1.

Prevalence of Chronic Diseases

The number of chronic conditions among US foreign-born adults stratified by sex and age is shown in Table 4. Overall, the majority of the population had no chronic conditions (75.5%), followed by one chronic condition (18.6%). Among both men and women, the prevalence of the number of chronic conditions differed across age groups.

The prevalence of the number of chronic conditions increased with age, especially among women. Women overall had a higher number of one, two, and three or more chronic conditions compared to men, particularly among those in the >65 years age group. However, among women who had two chronic conditions this trend was reversed (women: 16.2%; men:17.3%). Similarly, among women in the 18-44 years age group, the percentage of individuals with two or three chronic conditions were slightly lower compared to men in the same group. Also, women in the 45-64 age group had a lower percentage of one chronic disease than men of the same group (women: 25.2%; men: 28.8%).

Prevalence of Individual Chronic Diseases

The prevalence of individual chronic diseases among foreign-born adults in the United States by place of origin is presented in Table 5. Among the total nine chronic diseases evaluated, the most prevalent chronic disease in foreign-born adults was obesity (12.7%), followed by hypertension (8.1%), and arthritis (3.9%). The percentage of obesity was highest among those from Latin America and the Caribbean (19.7%) and the prevalence in this region was also significantly different from the overall prevalence of obesity ($P<0.05$). Compared to other regions, people from East Asia, South Asia, & the Pacific were diagnosed with hypertension the most (8.7%) and had the highest proportion of stroke (0.6%). Foreign-born adults from East Asia, South Asia, & the Pacific had the lowest prevalence of obesity (4.7%) than in other regions. For the majority of the chronic conditions listed in Table 5, the highest chronic condition prevalence was among those from Europe and Central Asia region. Foreign-born adults from Europe and Central Asia had the highest prevalence of arthritis (4.5%), heart problem (2.7%), chronic lung disease (1.2%), and cancer (0.8%) relative to foreign-born populations from other regions. The

Middle East and North Africa foreign-born population had the highest diabetes prevalence (4.3%) and the lowest hypertension prevalence (3.8%) compared to other regions. The lowest prevalence of arthritis (2.8%), heart problem (0.6%), and chronic lung disease (0.3%) were among those from Sub-Saharan Africa where the proportion of people with a heart problem was also significantly different than the overall prevalence of heart problem ($P < 0.05$). The prevalence of multimorbidity, two or more chronic diseases, was highest among foreign-born adults from Latin America & the Caribbean (7.1%), followed Europe, Central Asia, & North America (5.7%), and was lowest Sub-Saharan Africa foreign-born population (4.3%), also shown in Figure 2.

Prevalent Chronic Disease Dyads and Triads

Table 6 and 7 show the most common dyads and triads of chronic conditions by age and sex among foreign-born adults in the US. The patterns of chronic disease dyads and triads varied by age group and were similar in men and women. Among those with two chronic conditions, the hypertension-obesity dyad was the most prevalent among both men and women across the majority of age groups (women: 25.3.5%; men: 20.5%). However, in the overall analytical sample, only 1.0% had the hypertension-obesity dyad. Following the hypertension-obesity dyad, the next most frequent dyad was diabetes-hypertension among men, whereas, arthritis-hypertension dyad was more common among women. Asthma and chronic lung diseases were common across dyads and triads in the 18-44 years age group who had two or three chronic conditions. The most common chronic diseases triad among both men and women with three chronic conditions were diabetes-hypertension-obesity (women: 25.3%; men: 24.8%). Again, when compared to the overall analytical sample, only 0.3% had the diabetes-hypertension-obesity triad. People in the age group 65 years or above had dyads and triads which included heart

problem more frequently than other age groups. Men overall experienced heart problems more frequently than women.

Bivariate and Multivariate Association of Sociodemographic Factors with Multimorbidity

Table 8 shows the odds ratio and 95% Confidence Intervals (CI) for the multinomial logistic regression analysis with multimorbidity as the outcome, categorized by the number of chronic conditions. Bivariate (unadjusted) and multivariate analyses (adjusted) were performed for sociodemographic factors with multimorbidity as the outcome. All variables were adjusted for each other in the multivariate analyses where the full model included sex, age, place of origin, years of education, marital status, consulted with a doctor in the past year, and length of stay in the US.

Sociodemographic Factors and One Chronic Condition

In the unadjusted model, age, place of origin, years of education, and length of stay in the US were significantly associated with the development of one chronic condition compared to no chronic conditions. The odds of having one chronic condition increased significantly with age. For place of origin, foreign-born adults from East Asia, South Asia, & the Pacific, Sub-Saharan Africa, and Europe, Central Asia, & North America had significantly lower odds of having one chronic disease than those from Latin America & the Caribbean region. People with ≥ 12 years of education had 40% lower odds of one chronic condition than those with < 12 years of education (OR 0.6, 95% CI: 0.5-0.7). On the contrary, foreign-born adults who had lived in the US for ≥ 5 years had 50% higher odds of one chronic condition than those who have been in the US for < 5 years (OR 1.5, 95% CI: 1.4-1.8).

For the adjusted model, the odds of having one chronic condition was 2.6 times higher among people in the age group 45-64 years and 4.7 times higher among those aged 65 or older (age group 45-46: OR 2.6, 95% CI: 2.2-3.0; age group > 65: OR 4.7, 95% CI: 3.7-6.0). Foreign-born adults from East Asia, South Asia, & the Pacific, and Europe, Central Asia, & North America had significantly lower odds of developing one chronic condition than those from Latin America & the Caribbean region. Also, those with 12 years or more education had significantly lower odds of one chronic disease (OR 0.6; 95% CI: 0.5-0.7) whereas those who were in the US for five years or more had significantly higher odds of one chronic disease (OR 1.5; 95% CI: 1.4-1.8).

Sociodemographic Factors and Multiple Chronic Conditions

In the unadjusted model, the odds of multimorbidity (two or more chronic conditions) increased significantly with age (age group 45-46: OR 7.0, 95% CI: 5.4-9.0; age group \geq 65: OR 23.8, 95% CI: 17.6-32.0) compared to those with no chronic conditions. For place of origin, foreign-born adults from East Asia, South Asia, & the Pacific, and Sub-Saharan Africa had significantly lower odds of multimorbidity than those from Latin America & the Caribbean region. Also, being married or living together and having \geq 12 years of education were significantly associated with lower odds of multimorbidity whereas those consulting a doctor in the past year had significantly higher odds of multimorbidity (OR 1.3; 95% CI: 1.1-1.6).

After adjusting for sex, place of origin, years of education, marital status, doctor consultation, and length of stay, the odds of multimorbidity increased significantly with age (age group 45-46: OR 8.0, 95% CI: 6.0-10.5; age group \geq 65: OR 25.7, 95% CI: 18.1-36.4), varying by place of origin. When adjusted for other variables in the full model, participants from Sub-Saharan Africa had higher odds of multimorbidity than the

unadjusted model; even though the association was not significant (OR 0.7, 95% CI: 0.4-1.3). This might imply that given the same sociodemographic distribution as other regions, individuals from Sub-Saharan Africa have higher odds of multimorbidity. Years of education, consultation with a doctor, and length of stay were also significantly associated with multimorbidity in the study. Individuals with ≥ 12 years of education had 40% lower odds of multimorbidity than those with less than 12 years of education (OR 0.6, 95% CI: 0.4-0.8). Also, Foreign-born adults who consulted a doctor in the past year were more than twice as likely to have multimorbidity than those who did not consult a doctor in the adjusted model and this association was statistically significant (OR 2.4; 95% CI: 1.9,3.0). Similar odds of multimorbidity was found for foreign-born populations who were in the US for more than five years (OR 2.3; 95% CI: 1.8,2.9).

V. DISCUSSION

This study uses data from the New Immigrant Survey (NIS) which is a nationally representative study of adult immigrants who have recently become legal permanent residents in the US. The aim was to assess the prevalence of multimorbidity, two or more chronic conditions in an individual, among foreign-born adults in the US by sociodemographic factors such as age, sex, and place of origin. The study also focused on finding common multimorbidity patterns (dyads and triads) by age and sex among study participants. The overall prevalence of multimorbidity, the presence of two or more chronic diseases in an individual, was approximately 6.0% in the study population, ranging from 2.3% in the 18-44-year-old age group to 27.3% in subjects aged 65 or older. The prevalence of multimorbidity was higher in women than men and was the highest among foreign-born people from Latin America and the Caribbean region (7.1%); consistent with findings from previous studies (11-14,17,19,21). The combination of hypertension with obesity, diabetes, arthritis, and heart problem were the most commonly occurring disease pairs and triplets in both sexes. Age, socioeconomic status, and length of stay in the US were the most important measured predictors of the multimorbidity status in the study.

The estimates of the prevalence of multimorbidity in this study are relatively lower compared to previous cross-sectional studies among foreign-born adults in Europe which have ranged from 9% to 35% (9-10). The prevalence estimates of multimorbidity among US foreign-born adults in this study was also lower than the US native-born population, which ranged from 9% to 26% in previous studies for a total of 9-10 disease count (4-5,31-32). Several factors might help explain the low prevalence of

multimorbidity in this study, such as total disease count, the measure of multimorbidity, and length of stay in the US. This study included only nine chronic conditions to assess multimorbidity as they were the most relevant in the published literature and were available in the NIS dataset (3-4,12,28,31,37). The inclusion of only nine chronic conditions might result in a lower prevalence of multimorbidity in the study as research has shown prevalence estimates to generally increase with higher disease count (1,9,12,14). The majority of the studies included more chronic conditions to assess multimorbidity which ranged from 16-40 depending on the study design (1,10-11). Some of the chronic conditions listed in other studies were sleep apnea, depression, anxiety, dementia, chronic pain, hyperlipidemia, hepatitis, human immunodeficiency virus (HIV), osteoporosis, gastrointestinal disease, and chronic kidney disease (1,10-11). However, these chronic conditions listed in other studies, except for depression, were not taken into account in this study as data were not available on these conditions. Even though data were available to diagnose depression, depression was not used to assess multimorbidity in the study as majority of the studies only included chronic physical conditions to evaluate multimorbidity (4-5,30-31,34,51,58). In addition, all chronic conditions in this study were self-reported which can lead to lower diagnosis of chronic diseases among foreign-born adults, resulting in lower multimorbidity prevalence. Literature has previously shown multimorbidity prevalence to increase substantially when chronic diseases were clinically measured compared to self-reported (measured: 56.3% vs. self-reported: 34.8%) (14).

Age, sex, and socioeconomic status were hypothesized to be associated with multimorbidity in this study, consistent with the literature (1,4-5,10-11,14). As

hypothesized, age and socioeconomic status were significantly associated with multimorbidity in this study; however, sex was not. Also consistent with the literature, health utilization was significantly associated with higher odds of multimorbidity (2,4,7,19-20). Individuals who use healthcare frequently are diagnosed with chronic diseases more often than those who have low healthcare utilization which might explain the higher odds of multimorbidity among individuals with high healthcare utilization (4-5).

Length of stay in the host country has also often been shown in the literature as a significant predictor of health-related outcomes among foreign-born adults (7,19-20). Generally, foreign-born adults are often healthier than their native counterparts on arrival to the host country and this phenomenon is often rereferred to as the ‘healthy migrant effect’ (9-10,19-20). However, with increasing length of stay, foreign-born adults often converge to the health status of the host population due to changes in lifestyle (e.g., reduced physical activity, dietary patterns, smoking, alcohol consumption), social (healthcare utilization, family support structure), and other environmental factors (e.g., toxicant exposures, air pollution) (15,72,81-82). As a result of these lifestyles, social, and environmental factors, foreign-born populations face increasing health risks, which often lead to risk factors for chronic diseases such as elevated blood pressure, high BMI, and increased glucose level (51,80). The healthy migrant effect among foreign-born individuals might also partly explain the low multimorbidity prevalence in this study, as the majority of the study participants did not live in the US long enough at the time of the data collection to experience a gradual decline in health. The rise in multimorbidity with

increasing length of stay could also be attributed to increased healthcare utilization in the host country over time as confirmed by other studies (20).

The prevalence of individual chronic diseases and multimorbidity also varied by place of origin in agreement with previous studies (19-20). Obesity followed by hypertension and arthritis were the most prevalent chronic conditions among the nine chronic conditions in this study. The prevalence of obesity was highest in the Latin American and Caribbean region, and the prevalence of hypertension was highest among those from East Asia, South Asia, and the Pacific region; these findings are compatible with prior studies (58). The prevalence estimates for individual chronic diseases were also comparable to previous studies that have utilized the NIS dataset (74). However, it should be noted that the prevalence of single chronic disease among foreign-born adults is generally lower than native US population (33-49). The study also found that the odds of multimorbidity decreased among foreign-born adults with increasing geographic distance from the United States. For example, the prevalence of multimorbidity was highest among those from Latin America and the Caribbean, followed by those from Europe, Central Asia, and North America, and lowest among East Asia, South Asia, and the Pacific. These findings are in agreement with previous literature which has shown long-distance migrants were less likely to suffer long term illnesses, followed by short-distance and non-migrants (75). Given that the majority of the study population had been in the US for less than five years and became legal permanent residents at the time of data collection, this study confirms that individuals who are in good health are often more likely to move long distance than those who are in poor health conditions (76).

The most common dyads and triads of conditions varied with age and were different in men and women as shown in previous studies (18,32). Some of the most common dyads or triads observed in the study population were hypertension-obesity, diabetes-hypertension, arthritis-hypertension, and diabetes-hypertension-obesity. These combinations were expected given the high frequency of the individual conditions and have already been recognized in other studies (4,17-18,31-32,75). Both diabetes and hypertension have been shown in the literature to share common pathways, in which one condition may develop after the other for the same individual, as a result of a metabolic syndrome caused by obesity (77-78). Some of these combinations of chronic conditions were different in men and women. For example, dyads and triads including arthritis were more common in women and dyads and triads including heart problem were more common in men. These findings are also consistent with other studies which have attributed high incidences of heart diseases among men due to psychosocial (e.g., social isolation, vital exhaustion) and behavioral risk factors (e.g., excessive alcohol consumption and smoking) whereas high occurrence of arthritis in women are often due to genetic factors and hormonal aspects (79-80).

Very few studies have published reports on multimorbidity patterns among younger foreign-born adults. In this study for the age group 0-44 years, some of the most common dyads and triads included respiratory diseases such as asthma and chronic lung disease, especially among women. These findings are consistent with earlier studies, which have shown asthma and chronic obstructive pulmonary diseases (COPD) to be common among young adults and women (30). Among women with two chronic diseases in the 18-44-year age group, 9.1% had asthma and chronic lung disease dyad in this

study. This particular group is noteworthy to mention as the coexistence of asthma and COPD appear to identify cases with unusually high severity, mortality risk, and economic burden. Asthma has also been shown in the literature to increase the risk of developing COPD by 8 to 12 times (30).

Strengths and Limitations

A central strength of this study is that it is among the few to draw on nationally representative data to report the prevalence of multimorbidity – the presence of two or more chronic diseases in the same individual- among US foreign-born adults. This data source contributes to the generalizability of the study findings. In addition, examining the prevalence of multimorbidity among foreign-born adults by sociodemographic factors such as age, sex, and place of origin allows for important identification of multimorbidity patterns in this population and can serve as a platform for future research.

However, there are several limitations to note. Given the cross-sectional nature of the NIS-2003 baseline data, any inferences regarding causality cannot be made in this study. In addition, the sampling method of selecting new immigrants for the NIS study resulted in a disproportionate number of immigrants who have resided in the US for less than 5 years. Also, NIS samples only immigrants with newly acquired legal permanent residence status, who may be different from immigrants without legal permanent residence status (23). Given that countries of birth were already pre-categorized in the NIS data, this did not allow the examination of differences within regions (e.g., East Europeans vs. West Europeans). This study was also a secondary analysis, and therefore there was no control over the data collection process. Lastly, chronic disease status to assess multimorbidity was self-reported, thereby leading to potential recall and misreporting bias (102). Moreover, all chronic disease variables used to assess

multimorbidity were dichotomous variables. Because the data were not continuous, the severity of each chronic disease were not accounted for in the study.

Conclusion

In this study, multimorbidity prevalence among foreign-born population was approximately 6% compared to 25% among the overall US native-born population (37). This comparison suggests that multimorbidity may be lower, or potentially underreported among foreign-born adults, potentially due to cultural and language barriers, low health care utilization, and other sociodemographic factors. The study also found disease dyads and triads involving hypertension, obesity, and diabetes to be common across both men and women of all age groups. The prevalence of multimorbidity increased steeply with age, was higher among women than men, and varied by place of origin. These findings provide important insights into the health care needs of the foreign-born adults and are expected to enhance the evidence base on co-occurring chronic conditions among this group to inform health planning and promotion.

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VII. TABLES AND FIGURES

Table 1. Prevalence of Chronic Conditions Among US Adults by Age and Sex (N=27,157)

Type of study	Age Group	Men			Women		
		Number of Chronic Conditions					
		1	2-3	≥4	1	2-3	≥4
Nationally representative study (NHIS)	18-44	93.9	6.3	0.4	91.1	8.0	0.8
	45-64	67.2	28.1	4.7	65.2	28.1	6.7
	≥65	37.5	45.4	17.1	38.2	47.4	14.5

*Reference (5)

Table 2. Leading Causes of Mortality Among US Foreign-born Population

Place of Origin	Leading Causes of Mortality
Europe	1. Cardiovascular disease 2. Cancer 3. Chronic obstructive pulmonary disease
Asia	1. Cancer 2. Heart disease 3. Stroke
Africa	1. Heart disease 2. Cancer 3. Unintentional injuries (Men) Stroke (Women)
Latin America	1. Heart disease 2. Cancer 3. Unintentional injuries

*References (53-56)

Table 3. Sample Characteristics of Foreign-born Adults in the US (N=8,174)

	Overall	No Multimorbidity % (95% CI)	Multimorbidity^a % (95% CI)	P-value
Sample Size	N = 8,174	n = 7,706	n = 468	
Sex				<0.05*
Men	43.8 (42.6-45.1)	44.1 (42.8-45.4)	39.1 (34.5-43.9)	
Women	56.2 (54.9-57.4)	55.9 (54.6-57.2)	61.0 (56.1-65.5)	
Age, years				<0.001***
18-44	72.3 (71.2-73.3)	75.1 (74.0-76.1)	27.9 (23.5-32.6)	
45-64	21.3 (20.3-22.3)	20.0 (19.0-21.0)	42.7 (38.0-47.6)	
65 and above	6.4 (5.9-7.0)	5.0 (4.5-5.5)	29.4 (25.2-34.0)	
Place of Origin				<0.01**
Latin America & the Caribbean	44.2 (43.0-45.5)	43.7 (42.4-45.0)	52.7 (47.8-57.5)	
East Asia, South Asia, & the Pacific	29.5 (28.4-30.7)	29.8 (28.7-31.0)	24.6 (20.8-28.9)	
Sub-Saharan Africa	6.6 (6.0-7.2)	6.7 (6.1-7.3)	4.7 (3.0-7.4)	
Middle East & North Africa	4.4 (3.9-4.9)	4.4 (3.9-5.0)	3.3 (2.0-5.2)	
Europe, Central Asia & North America	15.3 (14.4-16.2)	15.3 (14.4-16.3)	14.7 (11.5-18.6)	
Highest Level of Education				<0.001***
<12 years of education	35.9 (34.7-37.1)	34.4 (33.2-35.6)	59.0 (54.2-63.7)	
≥ 12 years of education	64.1 (62.9-65.3)	65.6 (64.3-66.8)	41.0 (36.3-45.8)	
Current Marital Status				<0.001***
Married or living together	76.5 (75.5-77.5)	77.0 (76.0-78.0)	68.1 (63.5-72.3)	
Not married or living together	23.5 (22.5-24.5)	23.0 (22.0-24.0)	31.9 (27.7-36.5)	
Consulted with a Doctor in the Past year				<0.01**
Yes	37.7 (36.5-38.9)	36.7 (25.4-37.9)	54.3 (49.5-59.2)	
No	62.3 (61.1-63.5)	63.3 (62.1-64.6)	45.6 (40.8-50.5)	
Length of Stay in the US				>0.05
Less than 5 years	55.2 (53.9-56.5)	55.5 (54.1-56.8)	50.9 (45.8-56.0)	
5 years or more	44.8 (43.5-46.1)	44.5 (43.2-45.9)	49.0 (44.0-54.2)	

*** Significant at the .001 level, **significant at the .01 level, *significant at the .05 level

^aTo assess multimorbidity, following chronic diseases were included in the analyses: obesity, hypertension, arthritis, diabetes, asthma, heart problem, chronic lung disease, cancer, and stroke

Survey weighted; Source: New Immigrant Survey, 2003

Table 4. Prevalence of Number of Chronic Diseases* Among Foreign-born Adults in the US within Each Sex by Age Group (N=8,174)

	Prevalence, % (95% CI)			
	Number of Chronic Conditions			
	0	1	2	≥ 3
	n = 6,229	n = 1,477	n = 347	n = 125
Overall	75.5 (74.4-76.5)	18.6 (17.6-19.6)	4.4 (3.9-4.9)	1.5 (1.3-1.9)
Men				
All ages	76.4 (74.8-77.9)	18.3 (16.9-19.8)	4.3 (3.6-5.1)	1.1 (0.7-1.5)
18-44 y	82.9 (81.2-84.5)	14.6 (13.1-16.3)	2.2 (1.6-2.9)	0.3 (0.1-0.7)
45-64 y	61.1 (57.3-64.9)	28.8 (25.4-32.5)	8.1 (6.2-10.5)	2.0 (1.1-3.5)
≥ 65 y	48.6 (41.8-55.6)	27.5 (21.8-34.1)	17.3 (12.6-23.2)	6.6 (3.9-11.0)
Women				
All ages	74.8 (73.3-76.2)	18.8 (17.5-20.1)	4.5 (3.9-5.2)	1.9 (1.6-2.4)
18-44 y	82.5 (80.9-84.0)	15.4 (13.9-16.9)	2.0 (1.4-2.6)	0.2 (0.1-0.5)
45-64 y	61.6 (58.2-64.8)	25.2 (22.4-28.2)	9.2 (7.5-11.4)	4.0 (2.9-5.5)
≥ 65 y	36.4 (30.9-42.2)	34.0 (28.6-39.8)	16.2 (12.2-21.2)	13.4 (9.9-18.0)

*Chronic diseases included in the analyses were obesity, hypertension, arthritis, diabetes, asthma, heart problem, chronic lung disease, cancer, and stroke

Row totals may not equal to 100, due to rounding

Survey weighted

Source: New Immigrant Survey, 2003

Table 5. Prevalence of Chronic Diseases by Place of Origin among Foreign-born Adults in the US (N=8,174)

Chronic Conditions	Prevalence, % (95% CI)					
	Overall	Latin America & the Caribbean	East Asia, South Asia, & the Pacific	Sub-Saharan Africa	Middle East & North Africa	Europe, Central Asia, & North America
Obesity	12.7 (0.4-11.9)	19.7 (18.1-21.4) *	4.7 (3.8-5.8) *	11.4 (8.6-15.1)	14.1 (10.3-19.0)	9.3 (7.6-11.4) *
Hypertension	8.1 (0.3-7.4)	8.5 (7.5-9.6)	8.7 (7.6-10.0)	6.1 (4.3-8.7)	3.8 (2.3-6.4) *	7.5 (6.0-9.3)
Arthritis	3.9 (0.2-3.4)	3.7 (3.0-4.5)	4.1 (3.3-5.0)	2.8 (1.6-4.9)	3.7 (2.1-6.2)	4.5 (3.4-5.9)
Diabetes	3.1 (0.2-2.7)	4.0 (3.3-4.7) *	2.9 (2.3-3.6)	2.3 (1.3-4.0)	4.3 (2.5-7.2)	1.2 (0.7-1.9) *
Asthma	2.5 (0.2-2.1)	2.6 (2.0-3.2)	2.3 (1.7-3.1)	2.7 (1.5-4.9)	0.6 (0.2-2.0)	3.1 (2.2-4.6)
Heart Problem	1.7 (0.2-1.4)	1.3 (0.9-1.8) *	2.1 (1.6-2.8)	0.6 (0.2-1.9) *	1.9 (0.9-4.0)	2.7 (1.9-3.9)
Chronic Lung Disease	0.6 (0.1-0.4)	0.6 (0.4-0.9)	0.4 (0.2-0.8)	0.3 (0.1-1.1)	0.5 (0.1-2.0)	1.2 (0.6-2.1)
Cancer	0.5 (0.1-0.4)	0.5 (0.3-0.9)	0.6 (0.3-1.1)	-- ^a	0.2 (0.1-1.4)	0.8 (0.4-1.5)
Stroke	0.4 (0.1-0.3)	0.4 (0.3-0.7)	0.6 (0.3-1.0)	0.3 (0.1-1.4)	0.3 (0.1-2.1)	0.3 (0.1-0.8)
Multimorbidity	5.9 (5.4-6.5)	7.1 (6.2-8.1) *	5.0 (4.1-6.0) *	4.3 (2.7-6.7)	4.4 (2.8-7.1)	5.7 (4.4-7.3)

* Significant at the 0.05 level- compared to the overall prevalence

^a Not enough data

Survey weighted

Source: New Immigrant Survey, 2003

Table 6. Most Prevalent Dyads of Chronic Diseases by Sex and Age among Foreign-born Adults in the US with 2 Chronic Conditions (N=387)

Chronic Condition Dyads	Prevalence, % (95% CI)
Men (n=154)	
Overall	
Hypertension-Obesity	20.5 (14.5-28.1)
Diabetes-Hypertension	17.2 (11.8-24.4)
Arthritis-Hypertension	10.5 (6.4-16.8)
18-44 y (n=59)	
Hypertension-Obesity	28.7 (17.7-42.9)
Asthma-Obesity	11.1 (4.0-27.5)
Diabetes-Obesity	11.1 (4.7-24.2)
45-64 y (n=60)	
Hypertension-Obesity	20.2 (11.5-32.9)
Diabetes-Hypertension	18.1 (10.2-30.0)
Arthritis-Hypertension	13.2 (6.3-25.4)
≥ 65 y (n=35)	
Diabetes - Hypertension	25.2 (13.1-42.9)
Arthritis- Hypertension	14.4 (6.1-30.6)
Heart Problem-Hypertension	12.1 (4.6-28.4)
Women (n=193)	
Overall	
Hypertension-Obesity	25.3 (19.2-32.5)
Arthritis-Hypertension	11.5 (7.7-16.7)
Diabetes-Hypertension	10.3 (6.6-15.6)
18-44 y (n=55)	
Asthma-Obesity	23.4 (13.3-37.8)
Hypertension-Obesity	18.4 (10.0-31.4)
Asthma-Chronic Lung Disease	9.1 (3.6-21.3)
45-64 y (n=91)	
Hypertension-Obesity	30.3 (21.0-41.5)
Arthritis- Hypertension	12.1 (6.9-20.4)
Diabetes- Hypertension	11.3 (6.0-20.2)
≥ 65 y (n=46)	
Hypertension-Obesity	20.2 (13.9-41.3)
Arthritis- Hypertension	21.3 (11.6-35.7)
Diabetes-Hypertension	15.6 (7.7-29.0)

*Prevalence estimates for each group does not add up to 100 as some dyads were not listed in the table due to low sample size

Survey weighted

Source: New Immigrant Survey, 2003

Table 7. Most Prevalent Triads of Chronic Conditions by Sex and Age among Foreign-born Adults in the US with 3 Chronic Conditions (N=98)

Chronic Condition Triads	Prevalence, % (95% CI)
Men (n=31)	
Overall	
Diabetes- Hypertension-Obesity	24.8 (12.4-43.3)
Heart Problem- Hypertension-Obesity	13.2 (3.7-38.1)
18-44 y (n=7)	
Heart Problem- Hypertension-Obesity	32.1 (5.3-79.9)
Asthma- Hypertension-Obesity	15.7 (3.2-51.4)
45-64 y (n=13)	
Diabetes- Hypertension-Obesity	21.3 (6.6-51.0)
Arthritis- Hypertension-Obesity	16.8 (2.5- 61.0)
≥ 65 y (n=11)	
Diabetes- Hypertension-Obesity	28.7 (9.2-61.3)
Arthritis-Heart Problem-Hypertension	17.4 (4.3- 49.6)
Women (n=67)	
Overall	
Diabetes- Hypertension-Obesity	25.3 (16.1- 37.4)
Arthritis-Heart Problem-Hypertension	14.0 (7.4- 25.0)
18-44 y (n=5)	
Diabetes- Hypertension-Obesity	59.7 (19.7- 89.9)
Arthritis- Chronic Lung Disease-Obesity	20.8 (2.8- 70.3)
45-64 y (n=33)	
Diabetes- Hypertension-Obesity	34.2 (9.7- 52.3)
Arthritis- Hypertension-Obesity	11.2 (3.9-28.1)
≥ 65 y (n=28)	
Arthritis-Heart Problem-Hypertension	23.9 (11.6- 42.9)
Arthritis- Hypertension-Obesity	12.9 (4.9-30.2)

*Prevalence estimates for each group does not add up to 100 as some triads were not listed in the table due to low sample size

Survey weighted

Source: New Immigrant Survey, 2003

Table 8. Results of the Multinomial Logistic Regression Analysis (Sociodemographic and Other Characteristics), Multimorbidity Being the Dependent Variable Categorized by Number of Chronic Conditions (N=8,174)

	One Chronic Condition		Multimorbidity (≥ 2 chronic Conditions)	
	Base Outcome: No Chronic Conditions			
	Unadjusted Model ^a OR (95% CI)	Adjusted Model ^b OR (95% CI)	Unadjusted Model ^a OR (95% CI)	Adjusted Model ^b OR (95% CI)
Sex (Men)				
Women	1.1 (0.9-1.2)	1.1 (0.9-1.2)	1.2 (1.0-1.5)	1.1 (0.9-1.4)
Age, years (18-44)				
45-64	2.4 (2.1-2.8) *	2.6 (2.2-3.0) *	7.0 (5.4-9.0) *	8.0 (6.0-10.5) *
65 and above	4.2 (3.3-5.2) *	4.7 (3.7-6.0) *	23.8 (17.6-32.0) *	25.7 (18.1-36.4) *
Place of origin (Latin America & the Caribbean)				
East Asia, South Asia & the Pacific	0.6 (0.5-0.7) *	0.6 (0.5-0.7) *	0.6 (0.5-0.8) *	0.6 (0.4-0.8) *
Sub-Saharan Africa	0.6 (0.5-0.8) *	0.7 (0.5-1.0)	0.5 (0.3-0.9) *	0.7 (0.4-1.3)
Middle East & North Africa	0.7 (0.5-1.0)	0.9 (0.7-1.3)	0.6 (0.3-1.0)	0.9 (0.5-1.6)
Europe, Central Asia & North America	0.6 (0.5-0.8) *	0.7 (0.6-0.9) *	0.7 (0.5-1.0)	1.0 (0.7-1.4)
Years of Education (<12 Years of Education)				
≥ 12 years of education	0.6 (0.5-0.7) *	0.8 (0.7-0.9) *	0.3 (0.3-0.4) *	0.6 (0.4-0.8) *
Current Marital Status (Not Married or Living Together)				
Married or living together	0.9 (0.8-1.0)	1.0 (0.8-1.1)	0.6 (0.5-0.8) *	0.9 (0.7-1.2)
Consulted with a Doctor in the Past Year (No)				
Yes	1.1 (1.0-1.3)	1.2 (1.0-1.4)	2.1 (1.7-2.6) *	2.4 (1.9-3.0) *
Length of Stay in the US (< 5 years)				
5 years or more	1.5 (1.4-1.8) *	1.5 (1.3-1.8) *	1.3 (1.1-1.6) *	1.6 (1.2-2.0) *

^a Bivariate analysis was performed for each variable listed in the table

^b Multivariate analysis was performed where each variable was adjusted for all other variables presented in the table. Full model included sex, age, place of origin, education, marital status, health utilization, and length of stay

Reference categories are shown in parenthesis

Survey weighted; Source: New Immigrant Survey, 2003

Figure 1. Prevalence of Multimorbidity^a by Age Group Among Foreign-born Adults in the US (N=8,174)¹

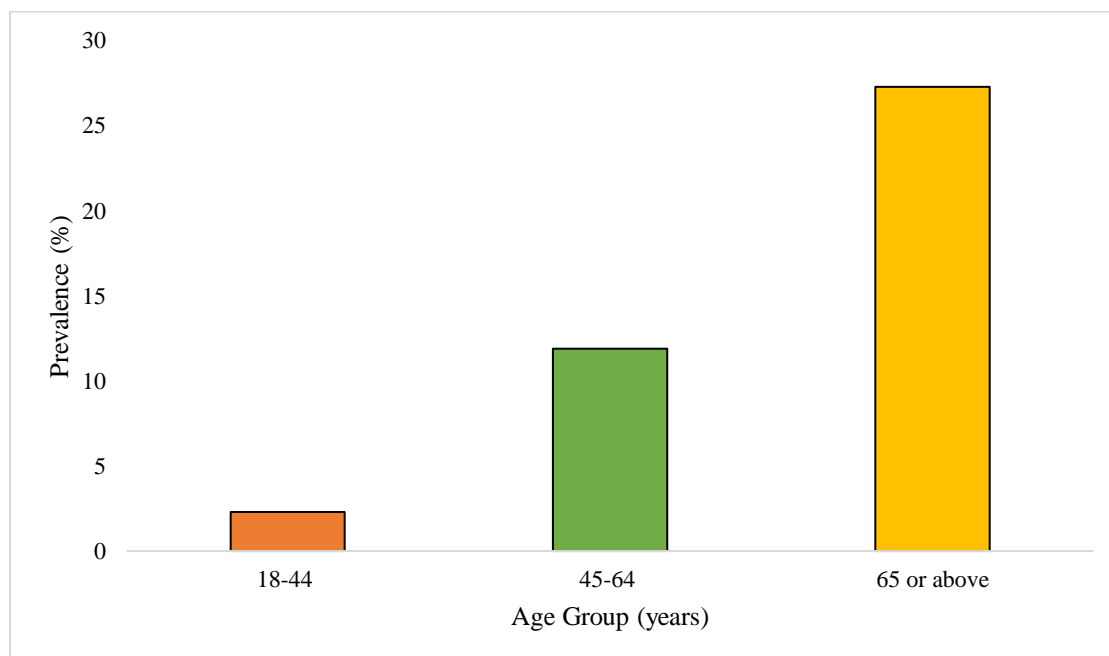
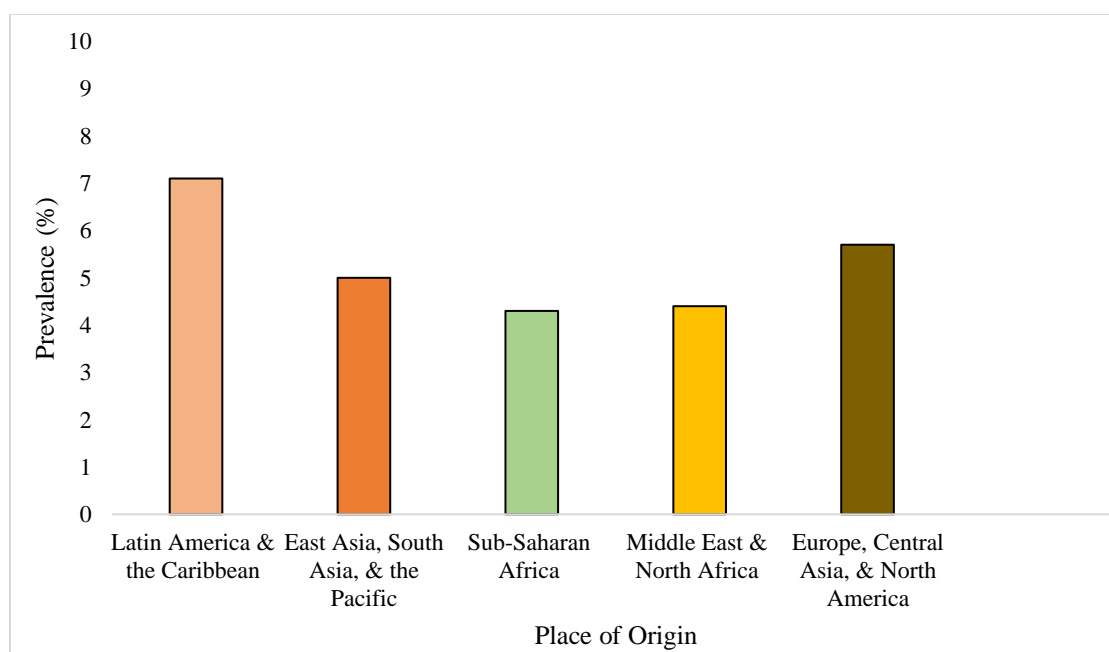


Figure 2. Prevalence of Multimorbidity by Place of Origin Among Foreign-born Adults in the US (N=8,174)¹



¹ Survey weighted, Source: New Immigrant Survey, 2003. To assess multimorbidity, following chronic diseases were included in the analyses: obesity, hypertension, arthritis, diabetes, asthma, heart problem, chronic lung disease, cancer, and stroke

VIII. APPENDICES

Table 1. Prevalence of Multimorbidity Among US Foreign-born Adults by Sex, Age, and Place of Origin (N=8,174)

Place of Origin	Prevalence, % (95% CI)			
	Men (n= 3,964)			
	All ages ^b	18-44 y	45-64 y*	≥ 65 y
Overall	5.3 (4.6-6.2)	2.5 (1.9-3.2)	10.1 (8.0-12.7)	23.9 (18.4-30.3)
Latin America & the Caribbean	5.8 (4.7-7.2)	2.3 (1.5-3.3)	15.5 (11.3-20.9)	26.1 (17.5-37.1)
East Asia, South Asia & the Pacific	5.7 (4.3-7.4)	2.0 (1.1-3.6)	7.9 (5.0-12.1))	21.3 (14.1-30.9)
Sub-Saharan Africa	3.7 (1.8-7.5)	3.0 (1.1-7.6)	8.1 (2.8-21.3)	-- ^a
Middle East & North Africa	3.0 (1.4-6.5)	0.97 (0.2-4.2)	4.7 (1.0-19.0)	62.1 (21.1-91.0)
Europe, Central Asia & North America	4.8 (3.2-7.3)	3.9 (2.1-7.0)	4.6 (2.2-9.1)	24.2 (10.4-46.8)
Women (n= 4,210)				
Overall	6.4 (5.7-7.3)	2.2 (1.6-2.8)	13.3 (11.2-15.7)	30.0 (24.5-35.4)
Latin America & the Caribbean	8.1 (6.9-9.6)	3.7 (2.7-5.0)	16.3 (12.8-20.5)	28.3 (20.9-37.2)
East Asia, South Asia & the Pacific	4.5 (3.5-5.8)	0.7 (0.3-1.6)	7.7 (5.3-11.0)	28 (20.2-37.4)
Sub-Saharan Africa	4.9 (2.8-8.5)	1.2 (0.3-4.5)	14.6 (7.0-27.8)	22.9 (7.3-53.0)
Middle East & North Africa	6.1 (3.3-11.0)	-- ^a	27.9 (15.1-45.7)	20.0 (2.6-68.9)
Europe, Central Asia & North America	6.5 (4.7-8.9)	1.7 (0.7-4.0)	15.1 (9.5-23.1)	43.8 (28.1-60.9)

^a Not enough data

Survey weighted

Source: New Immigrant Survey, 2003