

**Migration and The Left Behind: The Puerto Rican Exodus and The
Health of Non-Migrant Older Adults**

by

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Dedication

To life, to family, and friends. This research work is inspired by the many Puerto Rican lives who strive for a better Puerto Rico. I dedicate this research work to my mother, María Del Carmen Moreno Fraderas, to my grandmother, Elba Matos Pérez, and to my wife, Yabetza Vivas Irizarry.

“Gracias a la vida por ustedes y por su esencia. Las Amo”

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Abstract

The combined effects of emigration, increased life expectancy, and low birth rate has accelerated the aging of the Puerto Rican population and resulted in increased burdens associated with age-related diseases and risk factors. Previous studies suggest that out-migration affects not only the migrant itself but those left behind in the sending country through the reduction of social ties and, consequently, increased isolation. Studies in China, Mexico, Thailand, among others, have estimated the positive and detrimental consequences of out-migration on the health and well-being of older adults left behind. However, there are no such studies in Puerto Rico. This dissertation examined the impact of migration and psychosocial factors on the health and well-being of older adults left behind in Puerto Rico in three separate aims.

In the first aim, using a multilevel approach, we estimated the initial consequences of net migration rate on depression and all-cause mortality of older adults. We found that there were urban-rural disparities in the effect of out-migration on depressive symptoms. As the municipal net migration rate changes from negative to positive among urban municipalities the levels of depressive symptoms decrease ($\beta = -0.08$; p value < 0.05). Older adults in urban municipalities who experienced high negative net migration rates had a higher average of depressive symptoms. We found no association between net migration rate and all-cause mortality.

In the second aim, we examined the association between adult-children migration, parental depression, and prevalent disability among older adults residing in Puerto Rico and found that older adults with migrant adult-children were more likely to report a history of depression than older adults with no children residing outside of Puerto Rico (PR=1.20; CI:0.99-1.46). However, we incorporated an Instrumental Variable (IV) analysis and did not find a causal relationship between depression and adult-children migration.

In the third aim, we examined the prospective relationship between social support, living alone, and incident physical disability among older adults. Results indicate a significant association between both psychosocial measures and incident disability. Receiving more social support (OR=1.17; CI:1.02-1.35) and living alone (OR=1.58; CI:1.01-2.46) were both associated with higher odds of developing a disability.

Taken together, the results from this dissertation suggest there may be some negative consequences of out-migration on the mental health of older adults in Puerto Rico. It also highlights the uncertainty of the impact of out-migration on the physical health of non-migrant older adults. With the accelerating pace of out-migration over the last 14 years, it is essential to continue monitoring the effect migration has on the physical and mental health of older Puerto Ricans. This dissertation represents a first attempt to understand migration as a social determinant of health for older adults left behind.

Chapter I: Introduction

Human migration is an age-old phenomenon that stretches back to the earliest periods of human history. From the times of Neanderthals and Homo sapiens, humans have sought new lands and invented innovative tools to settle in new territories. Although migration has an enormous presence in history, it has not been studied until recent decades. Researchers in demography and sociology have started looking at the intertwined determinants of migration, and the impact migration has on developing new social and political environments, and consequently, on the population's health. Since the 1990s, researchers have linked the process of migration to the migrant's health. Acculturation, ethnic variation at the place of arrival, social support, remittances, socioeconomic status, dietary factors, and other social determinants have been associated with the migrant's health and well-being. However, few studies have estimated the impact migration has on the health of those left behind.

In the following sections, I present the concepts and theories associated with migration and health. In the first section, I dwell on the association between migration and health, the mechanisms and theories developed to explain the association, and recent findings on migration's effect on the left behind. Then, in section two, I present the socio-political context of Puerto Rico, the ubiquitous effect of increased out-migration, and an epidemiological view of older adults in Puerto Rico.

Migration and Health

In our globalized world, there is constant population movement between developed and developing countries. In 2015, the international organization for migration (IOM) estimated a global international migration of 244 million migrants, increasing 71 million since the year 2000 (IOM, 2018). Furthermore, 740 million were estimated to

migrate within their own country, also known as internal migration. An average of 14% of the total population in the world moves each year between geographical locations (internationally and internally). Although population movement affects the migrant in many ways, it also directly affects many millions more; as social networks extend within and across national borders and labor markets and service providers become increasingly entangled within the broader global political economy (F. Thomas, 2016).

Because of migration, a more diverse and unique social context has developed in various world regions. Countries like China, United States, Mexico, and many others, experience internal migration (population movement within geopolitical boundaries) and external migration (population movement between geopolitical boundaries) by the millions (F. Thomas, 2016). Geographic locations are "updated" constantly with an influx of people and customs (IOM, 2018). However, countries like Nepal (Ghimire, Singh, Nath, Jeffers, & Kaphle, 2018) and Puerto Rico (Mora, Dávila, & Rodríguez, 2017) experience negative net migration, which means that the number of people emigrating is greater than those entering the country. These changes in the countries' political and social contexts could have positives and negatives effects on population health for the migrants themselves and those in the sending and receiving regions.

Recent decades have seen considerable literature emerging across a range of academic disciplines, which focuses on the importance of understanding how best to conceptualize and respond to the demands of migration (Ingleby & Kotsioni, 2012; Felicity Thomas & Gideon, 2013). Experts recognize that migration does not constitute a risk for the migrant. However, weak and uncoordinated policies and hostile receptivity can leave

many migrants facing vulnerabilities, such as poor living and working conditions, social and cultural isolation, and discrimination (F. Thomas, 2016).

With a constant increase of global migration and urbanization in developed and developing countries, migration, both moving within and across national boundaries, has become an unprecedented phenomenon in the modern world. Given the impact that migration has on a country's political and social environment, it is increasingly recognized as an essential social determinant of health and well-being. Scientific evidence suggests that internal and external migration play an important role in the well-being of particular subgroups of a population (Song, 2017; F. Thomas, 2016; Felicity Thomas & Gideon, 2013). Migration can disrupt the physical and social environments where migrants and non-migrants cohabit, resulting in behavioral and demographic changes. These changes positively and negatively impact the health and well-being of the population. Experts have delineated three explanatory mechanisms and pathways through which migration is interconnected with health: health selection of migration, the effect of migration on health for migrants, and the effect of migration on health for people left behind.

The decision to migrate is influenced by many factors which are not necessarily distributed equally within the population. Depending on the country under scrutiny, migrants are more likely to be from specific income levels, gender, educational level and be healthier than the sending country's population. Markides and Coreil (Markides & Coreil, 1986) found that despite having lower education and socioeconomic status, Hispanic immigrants in the United States are generally healthier than the native population. They called this the "epidemiological paradox" because of the unexpected low levels of cardiovascular disease and other health outcomes among the Hispanic

population in the United States compared to Whites and African Americans (Markides & Coreil, 1986). In recent years, it has been proven that hispanics are not the only ethnic group experiencing this paradox (Ueshima, 2007).

Many researchers have investigated possible explanations for the epidemiological paradox. There are two main hypotheses. First, individuals may be differentially selected into migration by pre-migration health conditions due to the physical and psychological stress resulting from the process of migration. This is known as the "healthy migrant bias." People who successfully migrate and can settle at the receiving destination may have superior health before migration than non-migrants at the community of origin (F. Thomas, 2016). Second, migrants may return to their country of origin because of health deterioration (the salmon bias). People at the age of retirement who cannot participate in the labor force due to a physical or mental disability may migrate back to the country of origin where they have the needed social and financial support that often comes from family members. Both hypotheses explain how the process of migration impacts age-associated disease estimates among Hispanics in the United States.

The second mechanism is considered the main effect of migration on health and migration research's primary focus. The process of migration may affect the migrant's health directly through changes in the physical environment or indirectly through socioeconomic, psychosocial, or behavioral pathways (Arevalo, Tucker, & Falcon, 2014; Arévalo, Tucker, & Falcón, 2015; Castañeda et al., 2015; Jorge Duany, 2011). A growing body of research has focused on international migration and examined mechanisms contributing to differential health outcomes between immigrants and the native-born population. Xu and colleagues conducted a systematic review to present a general

conceptual framework of the linkages between migration and cognitive function (Xu et al., 2018). They identified five pathways between migration and the migrant's cognitive function: socioeconomic status, psychosocial, behavioral, environmental factors, and physical and psychological health status. Other studies agree with Xu's findings regarding the many intertwined factors involved in the impact migration has on the migrant's health (Aggleton, Bell, & Kelly-Hanku, 2014; Dykxhoorn et al., 2018; Gushulak, Weekers, & MacPherson, 2009). Although there is a need for more research in this area, most migration research focuses on the migrant itself and not the impact of migration on the community of origin.

The third mechanism between migration and health focuses on the people affected by migration other than the migrant: the left behind. Improved income and familial separation that commonly arise from out-migration affect the health of the migrants themselves. They have important and mixed implications for the health of those left behind. On the one hand, there are some benefits to the family members of the migrant who stay behind: remittances. Money transfers sent back from migrant family members provide additional sources of income and improve living standards for those in the sending country.

Conversely, although acknowledging the positive impact of remittances on socioeconomic status, various studies have found that the impact of remittances may not offset the loss of labor supply in rural households and the loss of social and emotional support from family separation (Abas et al., 2009; Davis & Lopez-Carr, 2010; Hamilton & Choi, 2015; Kanaiaupuni & Donato, 1999). These familial power dynamics and family structure changes may lead to stress and deterioration of psychological health for those

who stay in the community of origin. A study focusing on population migration at the community level reported higher infant mortality rates in Mexican communities with higher levels of U.S migration by any household member (Kanaiaupuni & Donato, 1999). Although remittances reduced the adverse effect, they did not account for all the excess in infant mortality.

In contrast, other studies in Mexico have found that children in households with emigrants had a lower risk of low birth weight and infant mortality (Frank & Hummer, 2002). There is no definitive hypothesis for why these studies have contradictory results. However, some researchers attribute these differences to specific limitations. These studies do not distinguish the different relationships between migrants and children. Studies on parental relationships suggest that familial separation from parents, especially mothers, is more detrimental to the children's health than other relatives.

There is also limited empirical research focusing on the older adult population left behind. Like other subgroups of the population, there is no consensus on the consequences of adult-children's migration on their older parents' health and well-being. As the young population moves away and adult children migrate, elderly parents who are left behind may enjoy socioeconomic benefits from remittances. However, the absence of their children as caregivers may be affecting the older parents (F. Thomas, 2016). Kuhn's study in Bangladesh showed a strong positive effect of adult-children's migration on their parents' physical functioning and survival (Kuhn, Everett, & Silvey, 2011). Using a counterfactual approach, those older adults with a higher propensity of having a migrant child had a lower risk of mortality and lower difficulties with activities of daily living (ADL). However, Antman's study in Mexico also used a counterfactual approach and found that

older adults with at least one child outside of Mexico have poorer self-reported physical and mental health and a higher risk of suffering from a heart attack (F. Antman, 2010).

These contradictory findings may suggest mediating effects of the familial power dynamics and remittances in the migration and health relationship. Parreñas mentions that those left behind may experience beneficial effects on emotional health by restructuring power dynamics within the family (Parreñas, 2005). The psychosocial consequences of out-migration on those left behind are likely to be multifaceted with competing channels of influence. Existing studies have not established the pathways through which adult-children's migration affects the level of caregiving and emotional support received by the elderly parents left behind. Lu and colleagues demonstrated the detrimental effect of migration on the psychosocial health of those left behind in Indonesia. Adults in households with labor out-migrants were more likely to report depressive symptoms than those in households without out-migrants. However, monetary remittances from labor migrants buffered out-migration's mental health costs (Y. Lu, Hu, & Treiman, 2012). The authors suggest that heterogeneity in the underlying causes of migration between internal and external migrants and the different family structures and social norms for old-age support may also have contributed to the disagreement.

Lu also suggests that extended family members' emotional and social support provides a buffer against the stress created by separation from adult-children. As family members left behind adapt to the separation from the migrant, they will likely develop better coping mechanisms that diminish the impact of migration. However, another study by Lu found that the detrimental effect of migration on health for people who were left behind tended to accumulate over time (Yao Lu, 2012). The initial psychosocial impact

was relatively small and increased with prolonged separation. For example, older adults left behind in Indonesian migrant households experienced an increased probability of developing hypertension and depression. When a laborer migrated for work, parents left behind were especially vulnerable to developing hypertension and depression compared to spouses. There were also gender differences in the migration impact. Even though women were more likely to experience depressive symptoms, men were more likely to develop hypertension. Women were also more effective in mobilizing social networks and emotional support than men.

Experts agree on the moderating role place and time have on the migration and health association. Although migration and health studies can provide evidence on the different important factors that influence population health, every association is pertinent to the specific cultural norms and political and social environment. Studies in Nepal, Indonesia, Mexico, the Philippines, and other countries have provided evidence on the positive and negative effect migration has on self-reported health, hypertension, stroke, heart attacks, depressive symptoms, mortality, and other health outcomes. However, these results cannot be extrapolated to countries with different cultural norms and societal environments.

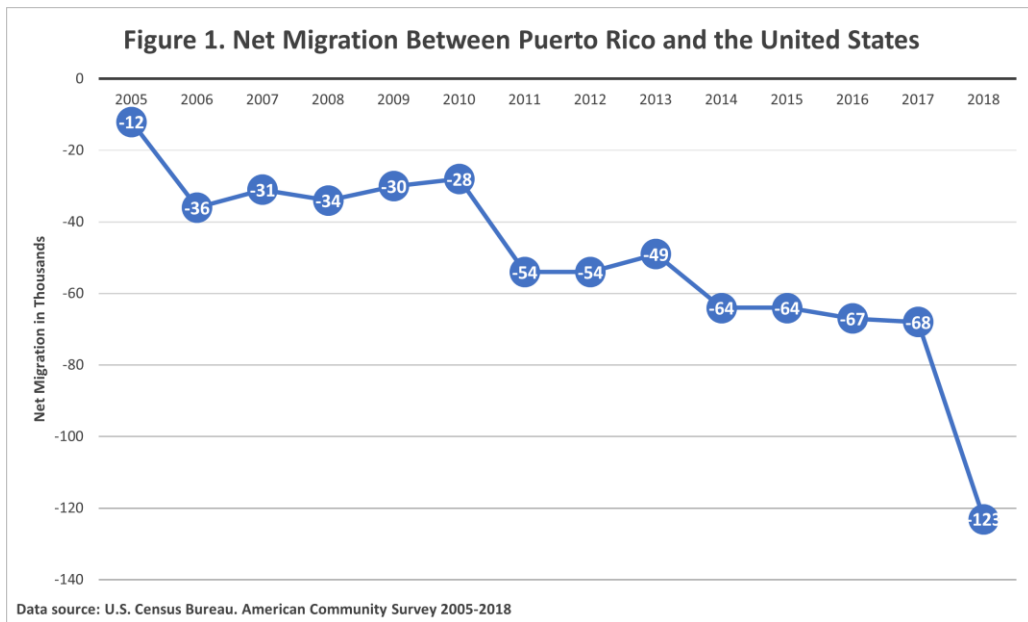
In the last 14 years, Puerto Rico has been experiencing rapid aging of the population. This demographic change coupled with an increased migration rate has demographically changed the population's composition and the burden of specific age-associated health outcomes. Although demographers agree on the impact migration is having on population composition, no studies have examined the broader impact of population migration on older adults' health and well-being in Puerto Rico.

Puerto Rico's Societal Context

Puerto Rico is an archipelago in the Caribbean, located to the east of the Dominican Republic. It has approximately 3.2 million inhabitants and 78 municipalities. Given the nature of an island, migration has always been a topic of interest, primarily due to the political relationship with the United States. Puerto Rico is a territory of the United States. It was taken from the Spaniards by force in 1898 during the Spanish-American War and has since been governed by the United States (Scarrano, 2015). In 1917, the Jones Act was instituted in Puerto Rico, a law that grants U.S citizenship to any person born in Puerto Rico. Puerto Ricans are born U.S citizens, can apply for a U.S Passport, travel to the United States without a passport or a VISA, which facilitates migration from Puerto Rico to the U.S. During the decade of the 1950s, Puerto Rico was granted a political status called a commonwealth. This commonwealth grants the island authority over its decisions within the island; however, these decisions are not above US congressional laws.

In 2001, Puerto Rico experienced a decrease in total population for the first time in its modern history. Demographers attribute this population loss to the decrease in birth rate, increase in mortality, and the increased emigration to the U.S. The first Puerto Rican exodus to the United States took place after 1945 due to economic changes having to do with the transformation of the island's economy from a plantation-based economy into a platform for export production in factories (Mora et al., 2017). Many of today's older adults in Puerto Rico migrated to the United States to work in factories in various states. Therefore, increased out-migration to the United States is not a new phenomenon. However, the recent increase in out-migration is unprecedented.

Migration in Puerto Rico has been increasing since 2006, contemporaneously to the American financial crisis of 2007-2008. More than half a million Puerto Ricans have left the island between 2006 and 2017 (Mora et al., 2017). Figure 1 highlights the total net migration between Puerto Rico and the United States from 2005 to 2018. About 714,000 Puerto Ricans have migrated out of Puerto Rico in this period. Since 2010, there has been a constant increase in net migration. Recent estimates for 2018 almost doubled the total net migration in 2017 (-123,000 vs -68,000). However, a portion of this increased migration is attributed to Hurricane María that affected Puerto Rico in September 2017. At the time, there are no estimates on the number of people who migrated back to the island after its recovery.



Most out-migrants in Puerto Rico relocate to the United States (79%) compared to 21% that relocates to other countries (Velazquez Estrada, 2018). Florida, New York, Pennsylvania, and Texas are the preferred locations for Puerto Ricans, given the numerous Puerto Rican communities established in these places (Velazquez Estrada,

2018). The migrant profile report, published every year by the Puerto Rico Statistical Institute (Velazquez Estrada, 2018), estimates that the median age for out-migrants is 30 years old and has remained constant for the last 11 years. Most of the out-migrants are between the ages of 15 to 44 years old. About 18% are children, and only 7% are over 65 years old. This age difference in out-migration selection is sustained at every socioeconomic level. The disproportion in age-specific out-migration has caused an increase in the percent of the total population that older adults represent. In 2000, about 11.2% of the population was over 65 years old, after the increased out-migration rate, in 2020, about 21% of the population is considered an older adult (United Nations, 2019). Although out-migration has been encouraged by many sectors of the population, the combined effects of decreased birth rate, high mortality, and negative net migration have reduced the natural rate of population growth and increased the financial burden of supporting an older, retired population.

The rapid aging of the Puerto Rican population poses an enormous burden on the social, education, and healthcare sectors of an already economically exhausted island. The average income for older adults in Puerto Rico is \$14,077 compared to \$30,270 for the general population (Vera Rodríguez, 2014). Almost half (40%) of older adults in Puerto Rico are under the U.S federal poverty line, and their health is worse than older adults in the United States. In 2014, 32.1% of Puerto Rican adults reported a disability (cognitive, mobility, vision, self-care, or independent living disability) compared with 22.5% in the United States & Territories. Among older adults, 49.6% reported any disability (49.6%), making Puerto Rico the United States' geographical area with the highest prevalence of any disability (Erickson, Lee, & Von Schrader, 2017).

Furthermore, 58.3% of Puerto Rican older adults reported having fair or poor self-rated health (Vera Rodríguez, 2014). Puerto Rico has the highest prevalence of diabetes, hypertension, and poor or fair self-rated health status among adults in the United States (C. Perez & Ailshire, 2017; Vera Rodríguez, 2014). This vulnerable population is clearly in great need of a healthcare sector capable of providing preventive physical and mental health services. However, outmigration is also endangering the healthcare labor force.

The economy has suffered due to the decrease in the labor force, especially in the healthcare sector. Increased numbers of migrating physicians and inadequate health system financing have affected service provision on the island. The Puerto Rico Statistical Institute estimates a 36% reduction in the health professionals workforce between 2006 and 2016 (Velazquez Estrada, 2018). The average appointment waiting time in Puerto Rico is between 6 to 12 months for specific specialties among older adults. A recent study comparing Medicare Advantage enrollees in Puerto Rico with those in the United States has found significant gaps in health-care services provided for older adults in Puerto Rico (Rivera-Hernandez, Leyva, Keohane, & Trivedi, 2016). Enrollees in Puerto Rico reported worse care compared to Hispanics and Whites in the United States.

Furthermore, since 2001, the Education Department has reported a constant overall decrease in enrollment throughout the island. The average elementary school enrollment in Puerto Rico was 310,000 for the early 2000s. Recent estimates put enrollment in the high 100,000. Although this decrease is not entirely due to migration, the Puerto Rico Education Department has reported a loss of expected students between academic years. A study of post-hurricane Maria school enrollment in Florida reported that 10,324 new Puerto Rican children enrolled in Florida school districts three months

after Hurricane María (Melendez, Hinojosa, & Roman, 2017). Melendez estimated that between 40,998 and 82,707 Puerto Ricans have migrated to Florida in the year following the hurricane. Demographers agree that these numbers underestimate the actual loss of population in Puerto Rico after the natural disaster and exacerbates the numerous effects of out-migration on the island.

Migration also impacts social dynamics and family structures. Familial separation, reduction of social networks, and lack of social connectedness are determinants of health for the left behind family members (F. Antman, 2010; Arenas & Yahirun, 2010; Ghimire et al., 2018; Kanaiaupuni & Donato, 1999; Kuhn et al., 2011; Y. Lu et al., 2012; M. Antman, 2012). Recent meta-analytic reviews have demonstrated the unprecedented impact of psychosocial factors like social isolation, social cohesion, and social support on many health outcomes regardless of age. However, the impact is more substantial in vulnerable populations, including children, pregnant women, older adults, and ethnic minorities (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015; Holt-Lunstad, Smith, & Layton, 2010). Among Hispanics, the relationships between social support, social cohesion, and social isolation with well-being have been well established (Alegria, Sribney, & Mulvaney-Day, 2007; Blazer, 1982; Chang, Chen, & Alegria, 2014; Escobar-Bravo, Puga-González, & Martín-Baranera, 2012; Falcón, Todorova, & Tucker, 2009; Mulvaney-Day, Alegria, & Sribney, 2007; L. G. Perez et al., 2015). Studies suggest that the relationship is attributed to certain Hispanic cultural traits such as "familismo" (familism) and "simpatía" (sympathy), in which high social support is an expectation (Rivera, 2007). These cultural expectations encompass a collective view of the world in which the family's interest is of high importance and more important than individual

priorities. Researchers have found that Hispanics with high adherence to "familismo" are less likely to seek emotional help than those with low adherence (Ishikawa, Cardemil, & Falmagne, 2010).

Although social support is seldom studied in relation to health among Puerto Rican older adults in Puerto Rico, some studies have investigated the influence of natural support systems on health and are extremely helpful for Hispanics. Evidence in older adults suggests that natural support systems are more relevant for health among Puerto Ricans than White Americans. Puerto Ricans who receive strong support from their natural support systems can better cope with stressful events and less likely to be afflicted with emotional or physical problems than those who receive little or no support from their natural support systems (De La Rosa, 1988). Delgado argues that Puerto Ricans' strong dependence on natural support systems has been influenced by their strong familial bonds, religious ties, and mistrust towards formal systems of support (Delgado, 1997). Although the family is without question the essential natural support system for Puerto Rican older adults in the United States and Puerto Rico, faith is a critical element in their lives. Often, religious institutions are the source of instrumental and emotional support in older adults at risk of isolation and loneliness, known as risk factors for various health conditions. Even though social support has not been studied in this population, lack of social support has been linked to depressive symptoms and ADL among older adults in other countries, stressing the importance of studying its impact on the Puerto Rican population (Abas et al., 2009; Blazer, 1982; Choi, Kim, DiNitto, & Marti, 2015; Jensen et al., 2014; Yao Lu, 2012; L. G. Perez et al., 2015; Unsar, Dindar, & Kurt, 2015). A recent study found that depressive symptoms are associated with developing ADL disability and

mortality in Puerto Rican older adults in Puerto Rico (Downer, Crowe, & Markides, 2017). Older adults with comorbid diabetes and high depressive symptoms experienced the highest odds of developing ADL disability and mortality.

No studies have examined the dimensions of social support and how they impact the health of the Puerto Rican older adult population in Puerto Rico. However, several studies of Puerto Ricans living in the United States have demonstrated the impact of psychosocial determinants on functional decline, self-rated health, mortality, activities of daily living, and depressive symptoms (Arevalo et al., 2014; Arévalo et al., 2015; Castaneda-Sceppa et al., 2010; Falcón et al., 2009; Zayas, Wisniewski, & Kennedy, 2013). Falcon and colleagues examined the role of social network support in ameliorating the psychological impact of life stressors for the older Puerto Rican population in the Boston Area (Falcón et al., 2009). Results demonstrated that social support dimensions, particularly emotional support, are generally protective of suffering from depression and perceived stress. As is expected in other study populations, this association was moderated by gender. Social support was beneficial for men but manifestly less so for women.

Furthermore, in a qualitative study about social support and disability, Guzzardo and colleagues found that despite being isolated, Puerto Rican older adults with disabilities tend to find resolve and meaning, strengthening their psychological health (Mariana, Wallis, Irina, & Luis, 2017). They also found that many older adults do not ask for help even if they are in need. This behavior could intensify the impact of social isolation and lack of social support due to out-migration.

A recent cross-sectional study comparing island older Puerto Ricans with mainland U.S. older adults found that island Puerto Ricans were less likely to suffer from heart disease, stroke, lung disease, cancer, activities of daily living limitations, and poor self-rated health. However, they were more likely to have hypertension and diabetes (C. Perez & Ailshire, 2017). The authors attribute these differences to the collectivistic values embedded in the Puerto Rican culture. They argue that certain traits in the Puerto Rican culture promote communication and interaction styles that are beneficial for health. Individuals who have strong social and community ties have better health compared with those who lack such ties. This has been proven in different Hispanic populations. However, no representative study in older Puerto Ricans living in Puerto Rico has examined the relationship between social ties and health.

As mentioned earlier, migration could represent a potential risk factor for older adults' lives with migrating adult-children and relatives. Migration is a ubiquitous factor that influences social and political environments and affects family structures and family dynamics around the decision-making processes. Given the increase in out-migration, the rapid aging of the population, and the lack of studies on the impact of migration on health, public health professionals could be overlooking a fundamental cause of poor health in the Puerto Rican older adult population. Therefore, I propose to explore the impact of out-migration on the health and well-being of older adults left behind in Puerto Rico. I plan to estimate the effect of population migration and familial separation on older adults' health and well-being. Also, I plan to examine the psychosocial determinants of late-life disability among older adults in Puerto Rico.

Specific Aims and Hypothesis

1. Estimate the effect of population migration on the health and well-being of older adults residing in Puerto Rico.

a. Is the population net migration rate at the municipal level associated with older adults' mental health residing in Puerto Rico?

H₁: Older adults residing in municipalities with a negative net migration rate will experience higher levels of depressive symptoms compared to older adults living in municipalities with a positive or 0 net migration rate, after adjustment for age, gender, education level, household support, economic difficulties, migratory experience, urbanicity, and municipal poverty.

b. Is the population net migration rate at the municipal level associated with the incidence of all-cause mortality in older adults residing in Puerto Rico?

H₁: Older adults residing in municipalities with a negative net migration rate will experience a higher incidence of all-cause mortality compared to older adults living in municipalities with positive or 0 net migration rate, after adjustment for age, gender, education level, household support, depressive symptoms score, comorbidities, migratory experience, economic difficulties, municipal poverty, urbanicity, and municipal total population size.

2. Examine the effect of adult-child migration on parental health and well-being among older adults in Puerto Rico.

- a. Is having at least one adult-child residing outside of Puerto Rico associated with depressive symptoms and ADL disability among older adults in Puerto Rico?

H₁: Older adults with at least one adult-child residing outside of Puerto Rico will report higher levels of depressive symptoms and ADL disability compared to older adults with no adult-child outside of Puerto Rico, after adjustment by age, gender, education level, marital status, number of children, economic difficulties, comorbidities, and urbanicity.

H₂: After validation of an Instrumental Variable (IV) approach using the proportion of male children as the instrument, older adults with at least one adult-child outside of Puerto Rico will report higher levels of depressive symptoms and disability compared to those with no adult-child outside of Puerto Rico.

3. Examine the psychosocial determinants of ADL disability in older adults residing in Puerto Rico.
 - a. What are the psychosocial determinants of incident ADL disability among older adults in Puerto Rico?

H₁: Among older adults in Puerto Rico, the probability of developing ADL disability will be higher among those who report lower social support, and social isolation, after adjustment for age, gender, socioeconomic status, marital status, comorbidities, urbanicity, and number of children.

Chapter II: The Impact of Municipal Net Migration on the Health and Well-being of Puerto Rican Older Adults

Aim 1a: Depression

Introduction

Migration has caused the development of more diverse and unique societies in various regions of the world. Countries like China, United States, Mexico, and many others, experience internal migration (population movement within geopolitical boundaries) and external migration (population movement between geopolitical boundaries) by the millions (F. Thomas, 2016). Geographic locations are "updated" constantly with an influx of people and customs (IOM, 2018). However, countries like Nepal (Ghimire et al., 2018) and Puerto Rico (Mora et al., 2017) are experiencing negative net migration, which means that the number of emigrants is greater than those entering the country. These changes in the countries' political and social contexts could have positives and negatives effects on population health, particularly for vulnerable populations.

There is limited empirical research focusing on the older adult population left behind. To date, no studies have examined the impact population migration has on the health of older adults. The migration and the left behind literature focus on the health of children and spouses. Studies in this field have estimated the impact of population migration on birthweight prevalence (Frank & Hummer, 2002; Hamilton & Choi, 2015), infant survival (Kanaiaupuni & Donato, 1999), spouses' mental health (M. Antman, 2012), changes in familial power dynamics (Parreñas, 2005), and other similar outcomes. However, as a socio-environmental exposure, population migration could represent a potential risk factor for the lives of older adults in sending areas.

Migration is a ubiquitous factor that influences social and political environments. In Puerto Rico, out-migration affects public education, healthcare services, the labor force, and many others. For example, the number of physicians practicing in Puerto Rico has dropped by 36% in the last ten years, causing longer wait times for appointments (Velazquez Estrada, 2018). The average appointment waiting time in Puerto Rico is between 6 to 12 months for specific specialties among older adults. A recent systematic review study on wait times found that when wait times are too long, patients may experience worse mental and physical health outcomes (Ansell, Crispo, Simard, & Bjerre, 2017).

Furthermore, public transportation services have been reduced due to a lack of public funding. These services are non-existent for a population that relies on them to integrate themselves into the community. Many older adults are incapable of participating in social activities due to the lack of municipal transportation services and the built environment not designed for non-drivers. On the psychosocial factor's literature, it is well known that social isolation is detrimental for mental health, and the effect is even more substantial among older adults (Cacioppo & Hawkley, 2003; Holt-Lunstad et al., 2015; House, Landis, & Umberson, 1988; Mariana et al., 2017). All these factors and many others could indirectly affect the mental health of older adults in Puerto Rico.

Given the increase in out-migration, the rapid aging of the population, and the lack of studies on the impact of migration on health, public health professionals could be overlooking a fundamental cause of disease in the Puerto Rican older adult population. Therefore, this study aims to estimate the impact of population migration on older adults' mental health left behind in Puerto Rico.

Methodology

Data source

The data used comes from the Decennial Census of Population and Housing Estimates in Puerto Rico, the Puerto Rico Department of Health Vital Statistics Reports, and the Puerto Rico Elderly: Health Conditions study (PREHCO)(Palloni, Dávila, & Sanchez-Ayendez, 2013).

The Decennial Census of Population and Housing Estimates is the process through which the United States estimates the total count of residents in the country, including territories. Puerto Rico has had censuses dating back to the 18th century. However, the first U.S census was conducted in 1910 after the U.S invasion of Puerto Rico (Scarrano, 2015). Since then, every decade, the U.S Census of population and housing estimates are conducted in Puerto Rico. Questionnaires vary slightly by decade; however, data remains similar regarding sex, age, race, household relationship, household type, housing occupancy, and housing tenure. In 2000, by request from the Government of Puerto Rico, the Census Bureau started using the same questionnaire in Puerto Rico as in the United States. Total population estimates are also stratified by the 78 geographical locations within Puerto Rico, also known as municipalities. The 2000-2005 U.S Census total population estimates by municipalities in Puerto Rico, in conjunction with mortality and births data from the Puerto Rico Department of Health Vital Statistics Reports, are used to estimate the period's municipality net migration rate.

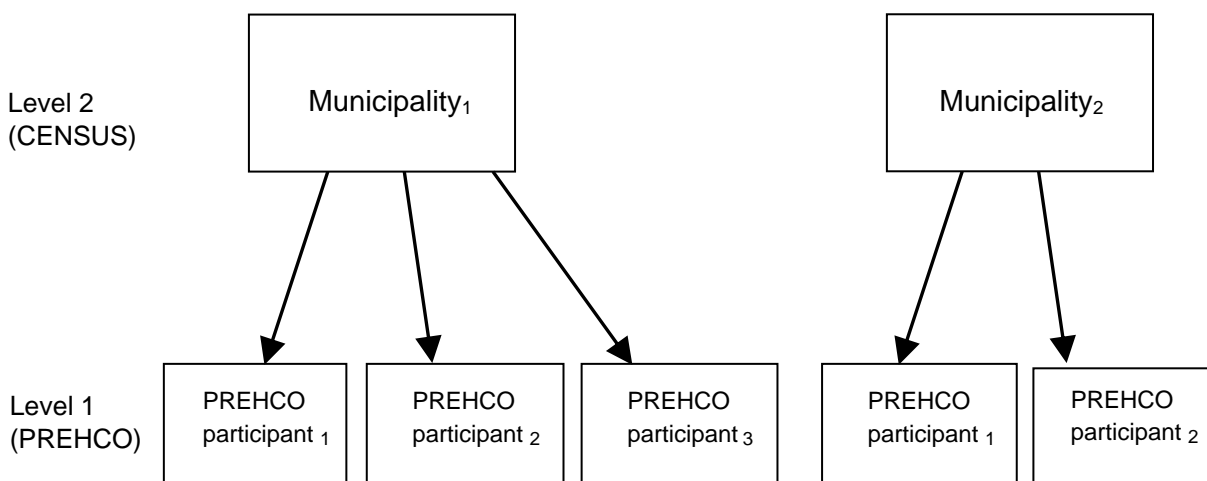
Individual-level data comes from the Puerto Rico Elderly: Health Conditions (Palloni et al., 2013) (PREHCO), a longitudinal survey of the noninstitutionalized population aged 60 and over and their surviving spouses. The sample is a multistage, stratified sample of the noninstitutionalized older adult population residing in Puerto Rico,

with oversamples of regions heavily populated by people of African descent and individuals over age 80 (McEnry & Palloni, 2010; Palloni et al., 2013). Data was collected through face-to-face interviews with older adults, including those with cognitive limitations who required the presence of a proxy, and their spouses, regardless of age. More than 20,600 households were visited in 233 sample sections. A total of 4,291 target interviews were conducted from May 2002 to May 2003. A second wave was conducted during 2006-2007. Only 4.7% of the overall sample refused to participate, and the survey response rate was 93.9%. The survey instrument includes modules on demographic characteristics, health status and conditions, family structure, migration status, economic status, cognitive and functional performance, income and assets, health insurance and use of health services, intergenerational transfers, housing, anthropometric measurements, and physical performance. A combination of the survey modules is used to obtain individual-level characteristics and health outcomes. PREHCO uses sampling weights to represent the total population over 60 years old in Puerto Rico at the time of the study. Sampling weights are incorporated in the analysis to ensure that results represent the older adult population in Puerto Rico. The study protocol and procedures were approved by the Institutional Review Boards (IRB) of the University of Wisconsin and the University of Puerto Rico.

PREHCO data is publicly available to any person for research purposes. Documentation on methodology, survey instruments, target sample, and previous publications can be access at the PREHCO website: www.prehco.rcm.upr.edu.

Statistical analysis and data management is conducted using SAS software version 9.4, Copyright © 2019 SAS Institute Inc.

Figure 2. Two-Level Clustered Data Structure Diagram



A cross-sectional design is employed using a two-level clustered data structure. Level 1 (individual-level) contains PREHCO participants' data from the second wave of PREHCO (2006-07). Level 2 (municipal-level) contains the municipality characteristics for the 2000-2005 period, including the exposure of interest, Municipal Net Migration Rate. The figure above shows the two-level clustered data structure. Every PREHCO participant is assigned the municipality of residence at the time of the interview. The municipality of residence and participants' ID is used as the merging criteria to create the master dataset.

Measures of Interest

Net Migration Rate

Migration is defined as a form of geographic or spatial mobility involving a change of usual residence between clearly defined geographic units (Shryock & Siegel, 2013). Given the lack of adequate statistics on migration for many countries and many periods,

it is often necessary to rely on retrospective approaches to approximate migration volume. Puerto Rico is not an exception. Migration flow estimates from Puerto Rico to other countries are based on net migration. Demographers observe the change in population estimates during a period and account for deaths and births to estimate population change due to migration. These estimates are achieved through the balancing equation of population change (Shryock & Siegel, 2013). This equation is used to estimate the difference between emigration and immigration for each municipality in Puerto Rico.

First, we estimate the net migration for each municipality using the population balancing equation (PBE) and solving for the term (Immigration - Emigration) (Shryock & Siegel, 2013):

$$(I - E) = P_{2005} - (P_{2000} + B_{2005-2000} - D_{2005-2000})$$

Net migration is derived as a residual; it cannot be obtained separately (Shryock & Siegel, 2013). This method requires subtracting an estimate of natural increase ($B_{2000-2005} - D_{2000-2005}$) during the period from the net change in population during the same period ($P_{2005} - P_{2000}$). A positive net migration means that the population is gaining people through net migratory exchanges. A negative net migration implies the population is losing people (Trovato, 2012).

Second, we estimate the net migration rate for municipalities in Puerto Rico using the Census' intercensal population estimates for 2000-2005 and the estimated net migration. The net migration rate equation is as follows: (Shryock & Siegel, 2013)

$$\text{Crude Net migration rate} = NMR = \frac{(I - E)}{P_i} \times 1,000$$

(I - E) = Net migration for the specific period

P_i = Mid-period total population

The total population for the mid-period is calculated as the sum of the population size for the beginning of the period (2000) and the end of the period (2005) divided by two $P_i = (P_{2000} + P_{2005}) / 2$. Then, the net migration ($I - E$) is divided over the population size for the mid-period to get the crude net migration rate for each municipality in Puerto Rico. This is interpreted as the number of people a municipality gained or lost to migration per 1,000 inhabitants from 2000 to 2005. This study uses the net migration rate as a continuous exposure at the municipality level.

Depressive symptoms

Depressive symptoms are assessed using a short form of the Geriatric Depression Scale (GDS-SF)(Sheikh & Yesavage, 1986). The GDS-SF is a 15-item assessment that measures self-rated symptoms of depression. The GDS-SF has a maximum score of 15 points; higher scores indicate more severe depressive symptoms. Studies have indicated that the GDS is a promising screen for detecting depression in older adults (Dias et al., 2017; Marc, Raue, & Bruce, 2008; Pocklington, Gilbody, Manea, & McMillan, 2016; Sheikh & Yesavage, 1986). Given the unknown distribution of depressive symptoms at the municipal level in Puerto Rico, for this study we use depressive symptoms as a continuous measure.

Covariates

Given the lack of research on population migration and the health of Puerto Rican older adults, it is a challenge to identify confounding factors with certainty. Therefore, we focus on the well-established social determinants of health among Hispanic older adults: age, gender, educational level, marital status, household members, and economic difficulties. Covariates at the individual level are measured in PREHCO's wave 2.

Educational level is defined as years of education completed. Economic difficulties are defined as how often the participant has experience difficulties paying living expenses.

Marital status and Household members are two factors associated with received and provided social support. By having both factors in the same model, we could be running into a multicollinearity problem. Therefore, we use a variable that considers the combination of both. Household Support is a variable with five levels: "Living with someone/Married," "Living with someone/Widowed," "Living with someone/ Divorced or Separated," "Alone/Widowed," "Alone/Divorced or Separated. "

Participant's migratory experience is associated with their overall health and a positive or negative perspective on migration. It could influence their perception of offspring's migration. Therefore, we use the migratory experience as a covariate in the analysis. Migratory experience is defined as whether the older adult lived in another country for more than three consecutive months after turning 18 years old.

Furthermore, we include other confounding factors at the municipal level that are highly associated with population migration and health: municipal poverty and urbanicity (Arévalo et al., 2015; Castañeda et al., 2015; Gushulak et al., 2009; Landale, Gorman, & Oropesa, 2006; Felicity Thomas & Gideon, 2013). This data comes from the Decennial Census of Population and Housing Estimates. Municipal poverty is defined as the average of the proportion of the population under the U.S federal poverty line in each municipality between 2000-2005. For urbanicity, the Census Bureau's urban-rural classification of geographical areas is used.

Analytic Approach

First, we calculate the descriptive statistics for the number of depressive symptoms. Mean number of depressive symptoms are estimated and stratified by sociodemographic variables. A bivariate analysis is conducted to explore the unadjusted associations between covariates and mean number of depressive symptoms. ANOVA and T-test are used to test mean differences for categorical covariates. Pearson's correlation coefficient is used to test the linear association between mean number of depressive symptoms and all continuous variables. Given the non-parametric distribution of the number of depressive symptoms in the data, we consider a Poisson distribution to estimate the predicted number of depressive symptoms. Pearson's chi-square test for overdispersion demonstrates that overdispersion is present in the data (Payne, Gebregziabher, Hardin, Ramakrishnan, & Egede, 2018). Previous studies have shown that negative binomial models are superior for dealing with overdispersion compared to other models in various scenarios (Payne et al., 2018). Therefore, a negative binomial generalized linear mixed model (GLMM) is used to estimate the effect of population migration on mean number of depressive symptoms (Austin, 2017).

The model has the following structure:

Level 1:

$$\lambda_{ij} = \exp(\beta_{0j} + \beta_{1j}Age_{ij} + \beta_{2j}Gender_{ij} + \beta_{3j}Educ_{ij} + \beta_{4j}HouseholdSupport_{ij} + \beta_{5j}MigratoryExp_{ij} + \beta_{6j}EconomicDifficulties_{ij}) \exp(e_{ij})$$

Level 2:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}NMR_j + \gamma_{02}Urbanicity_j + \gamma_{03}MunicipalPoverty_j + \mu_{ij}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}NMR_j + \gamma_{12}Urbanicity_j + \gamma_{13}MunicipalPoverty_j + \mu_{ij}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}NMR_j + \gamma_{22}Urbanicity_j + \gamma_{23}MunicipalPoverty_j + \mu_{ij}$$

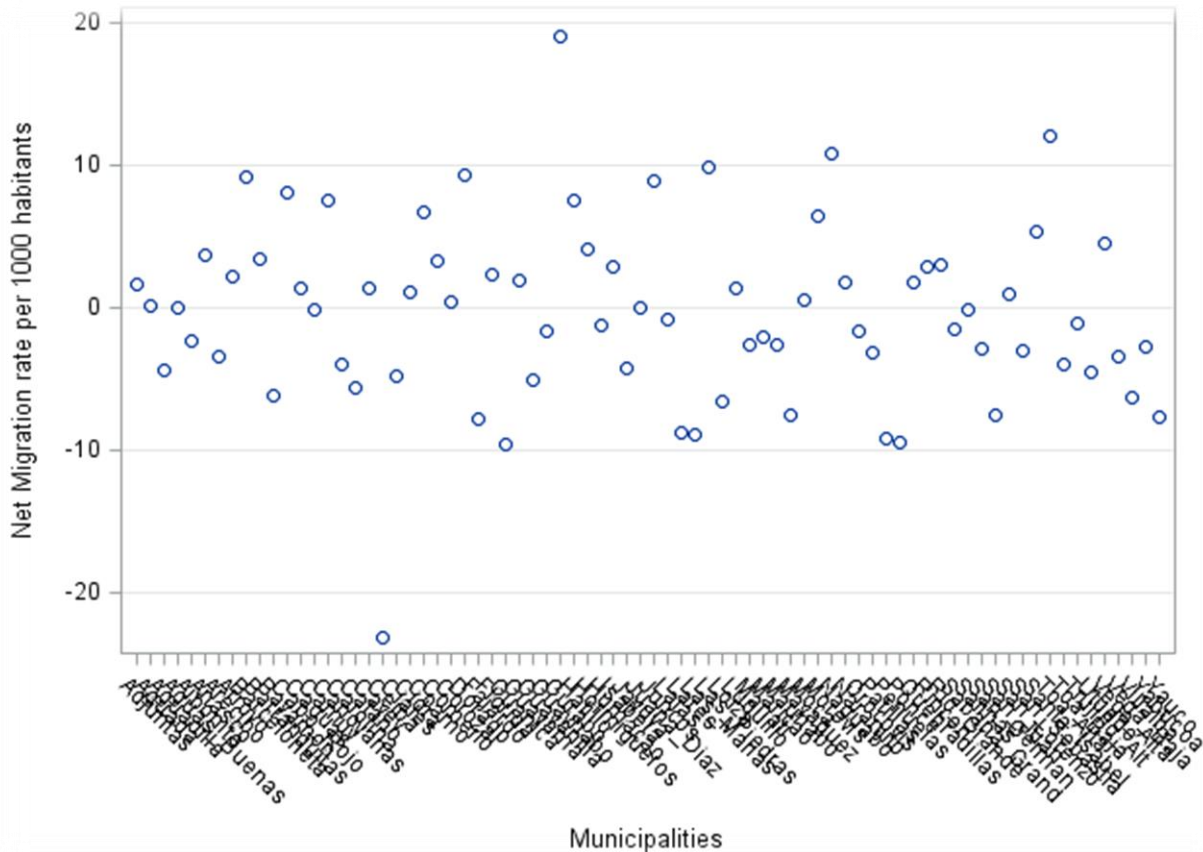
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β 's represents the fixed effects of the independent variables included in the model. The i 's indicate individuals and j 's indicate from which municipality. This model estimates the effect of the municipal net migration rate on the mean number of depressive symptoms holding all other covariates constant. Diagnostics are performed to assess the validity of the model. Survey sampling weights are included in the analysis to ensure the representativeness of the data.

Results

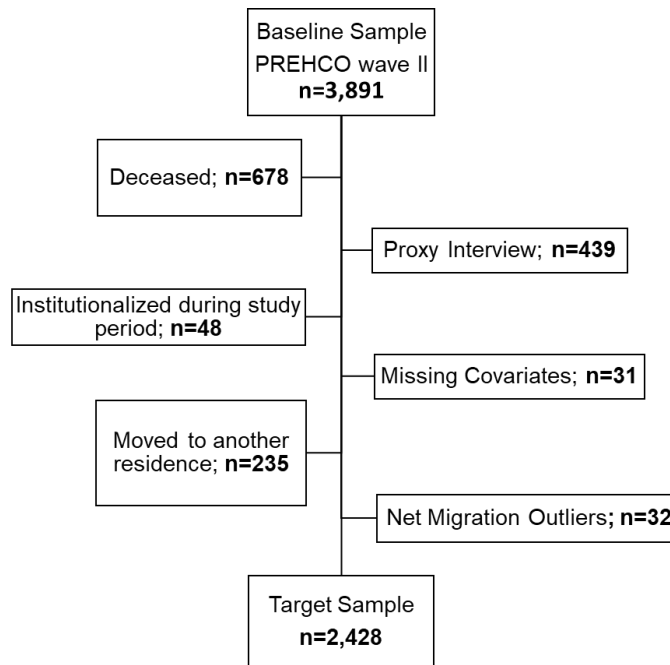
First, we estimate the net migration rate by municipalities. The following figure presents the net migration rate of the 76 municipalities available in the Census data. The mean net migration rate per 1,000 habitants is -0.34 with a standard deviation of 6.3. Most municipalities in Puerto Rico lost population in the period 2000-2005. About 41 municipalities experienced a negative net migration rate. Ceiba is the municipality with the biggest loss with an average of -23 inhabitants per 1,000. Gurabo was the municipality with the maximum gain of the population, with 19 inhabitants per 1,000.

Figure 3. Municipal Net Migration Rate for 2000-2005 in Puerto Rico.



After estimating the net migration rate, we merge the resulting dataset with data from PREHCO wave II. Municipality of residence at the time of the interview and Participants' ID are used as the merging criteria. The final sample excludes participants that used a proxy to respond to the interview, were deceased or institutionalized before the second wave of PREHCO, were lost to follow-up, were missing covariates, and changed residence from 2002-2006. 1,463 participants met the exclusion criteria. The final target sample is n=2,428. The following figure illustrates a summary of the selection into the analytic sample.

Figure 4. Selection into Analytic Sample



Of the 78 existing municipalities in Puerto Rico, PREHCO includes participants from 67 municipalities. After determining the analytic sample, there is a reduction in the total number of municipalities. Eight municipalities are not represented in the data and are excluded from the analysis. Toa Alta and Gurabo are outliers in the net migration rate distribution. Therefore, they must be excluded and the 32 participants within these municipalities. The two-level structure dataset created includes 57 municipalities.

Table 1 details the number of participants in each municipality in ascending order. The analytic sample has an average of 43 participants per municipality with a minimum of 2 and a maximum of 356.

Table 1. Total number of PREHCO's participants by municipalities in the analytic sample.

Municipality	PREHCO Participants	Municipality	PREHCO Participants
Peñuelas	2	Moca	19
Canóvanas	3	Cataño	20
Aguadilla	4	Rincón	21
Fajardo	5	Morovis	22
Aguas Buenas	6	Yauco	23
Yabucoa	7	San Germán	26
Adjuntas	7	Guánica	27
Vega Alta	7	Camuy	28
Lares	8	Caguas	32
San Sebastián	8	Trujillo Alto	35
Humacao	9	Aibonito	35
Cidra	9	Villalba	36
Cabo Rojo	10	Guayama	37
Comerío	10	Hatillo	38
Orocovis	10	Juana Díaz	41
Florida	10	Vega Baja	48
Hormigueros	10	Coamo	49
Corozal	11	Añasco	50
Utua	11	Toa Baja	55
Santa Isabel	11	Guaynabo	56
Lajas	12	Carolina	75
Rio Grande	12	Salinas	79
Juncos	13	Loíza	127
Guayanilla	14	Bayamón	144
Manatí	15	Ponce	194
Quebradillas	16	Mayagüez	228
Isabela	16	Arecibo	235
Cayey	17	San Juan	356
Barceloneta	19		

A descriptive analysis is conducted to examine the analytic sample characteristics. Most participants are on average 72.6 years old, female (57%), completed an average of 8 years of education, and are married and live with someone in the household (52%). There is a similar distribution in the migratory experience for participants (52.7% vs. 47.3%). Most older adults report never experiencing economic difficulties (55.2%) and the

mean number of depressive symptoms is 3.22 with a standard deviation of 0.11. In terms of municipalities within the analytic sample, the average net migration rate for all municipalities is -0.80, with a standard deviation of 5.4. The average population under the poverty line is 52.6% and most municipalities are classified as rural (80.7%).

Table 2. Analytic Sample Characteristics n=2,428; n=57

Variables	N	Weighted Mean (std) or Proportion (%)
Level 1		
Depressive Symptoms Score	2428	3.22 (0.11)
Age	2428	72.7 (0.20)
Gender		
Male	911	43.0%
Female	1517	57.0%
Educational level	2428	8.4 (0.12)
Household Support		
Living with Someone/Married	1006	52%
Living with Someone/Widowed	373	11.0%
Living with Someone/Divorced Separated	227	8.7%
Alone/Widowed	483	14.8%
Alone/Divorced Separated	339	13.5%
Migratory Experience		
Migrant	1058	52.7%
Non-Migrant	1370	47.3%
Economic Difficulties		
Frequently	250	10.8%
Sometimes	815	34.0%
Never	1363	55.2%
Level 2		
Net Migration Rate	57	- 0.80 (5.5)
Population Under the Poverty line	57	52.6 (8.3)
Urbanicity		
Rural	46	81.7%
Urban	11	19.3%

A bivariate analysis is conducted to assess the association between depressive symptoms and all covariates (See table 3). There is a statistically significant association between municipal net migration rate and depressive symptoms ($p < .0001$). As the net migration rate moves to less negative or positive categories, depressive symptoms tend to increase. Municipal poverty is positively associated with mean number of depressive symptoms. Also, rural municipalities have a higher mean number of depressive symptoms compare to urban municipalities (3.49 vs. 2.79; $p < .001$).

There are gender differences among participants. Females tend to have a higher mean number of depressive symptoms compared to males (3.64 vs. 2.67; $p < .0001$). Educational level is also associated with mean number of depressive symptoms ($r = -0.16$; $p < .0001$). As the educational level increases, the mean number of depressive symptoms decreases.

The variable household support, which is a combination of marital status and household members, present interesting results. Married older adults have the lowest mean number of depressive symptoms compared to other categories. Older adults widowed and living alone have the highest mean number of depressive symptoms (3.68).

Economic difficulties also present a gradient association with mean number of depressive symptoms. Older adults reporting having frequent difficulties with paying living expenses have an average of 5.27 depressive symptoms; the largest difference among covariates' levels when compared to those reporting difficulties sometimes (3.50) or never (2.64).

Table 3. Bivariate Analysis for the association between Depressive Symptoms Score and all covariates.

Variables	Pearson's correlation or Mean Number of Depressive Symptoms (95%CI)	Pvalue
Net Migration Rate***	0.09	<.0001
Municipal Poverty**	0.07	< 0.01
Age*	0.05	< 0.05
Educational level***	-0.16	<.0001
Gender***		<.0001
Male	2.67 (2.36-2.98)	
Female	3.64 (3.36-3.92)	
Household Support**		<.01
Living with Someone/Married	2.98 (2.65-3.30)	
Living with Someone/Widowed	3.37 (2.95-3.79)	
Living with Someone/Divorced Separated	3.43 (2.89-3.97)	
Alone/Widowed	3.68 (3.07-4.29)	
Alone/Divorced Separated	3.41 (2.98-3.84)	
Migratory Experience		0.9868
Migrant	3.22 (2.86-3.58)	
Non-Migrant	3.22 (2.99-3.45)	
Economic Difficulties***		<.0001
Frequently	5.27 (4.45-6.08)	
Sometimes	3.50 (3.18-3.83)	
Never	2.64 (2.38-2.91)	
Urbanicity***		<.0001
Urban	2.79 (2.55-3.03)	
Rural	3.49 (3.19-3.79)	

pvalue = * <.05; **<.01; ***<.001

Older adults' migratory experience is not associated with mean number of depressive symptoms (3.22 vs. 3.22; pvalue=0.99).

After completing the bivariate analysis, we proceed to build the multi-level models. Table 4 presents the parameter estimates for the three models. Model 1 estimates the unadjusted association between mean number of depressive symptoms and net migration rate. There is no statistically significant association between net

migration rate and depressive symptoms.

Table 4. Negative Binomial Generalized Linear Mixed Model Parameters to Predict the Mean Number of Depressive Symptoms.

Predictor Variables	Model 1		Model 2		Model 3	
	β	SE β	β	SE β	β	SE β
Intercept	1.06***	0.1	0.88***	0.12	0.96	0.98
Net Migration Rate	0.04	0.04	0.03	0.05	0.07	0.07
Age			0.005	0.003	0.005	0.003
Gender						
Female			0.28***	0.06	0.28***	0.06
Male (ref)	-	-	-	-	-	-
Educational level			-0.03***	0.007	-0.03***	0.007
Household Support						
Living with Someone /Widowed			-0.03	0.07	-0.03	0.08
Living with Someone /Divorced Separated			0.09	0.09	0.09	0.09
Alone /Widowed			0.04	0.07	0.04	0.07
Alone /Divorced Separated			0.14*	0.07	0.14	0.07
Living with Someone /Married	-	-	-	-	-	-
Migratory Experience						
Migrant			0.07	0.07	0.07	0.07
Non-Migrant (ref)	-	-	-	-	-	-
Economic Difficulties						
Frequently			0.69***	0.1	0.69***	0.1
Sometimes			0.24***	0.06	0.24***	0.06
Never (ref)	-	-	-	-	-	-
Urbanicity						
Urban					-0.06	0.48
Rural (ref)	-	-	-	-	-	-
Municipal Poverty					-0.001	0.02
Intraclass Correlation Coefficient (ICC)		46%		49%		45%

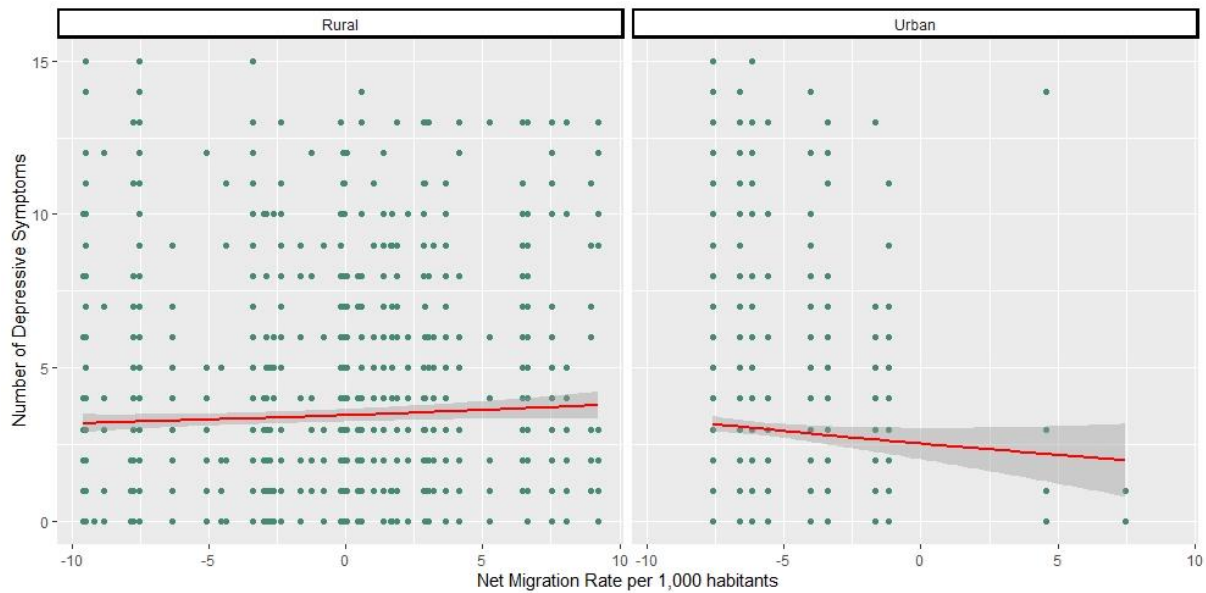
pvalue = * <.05; **<.01; ***<.001. Reference categories identified with (ref).

Model 2 incorporates level 1 variables. We can observe that gender, educational level, and economic difficulties are statistically significant predictors of depressive symptoms. In model 3, after including level 2 variables, the parameters remained

unchanged. Net migration rate is not significantly associated with depressive symptoms. For a one-unit increase in the educational level of an older adult, we can predict that their mean number of depressive symptoms will decrease by 3% ($p < .001$). Older adults reporting having frequent economic difficulties have a mean number of depressive symptoms of 99% ($\exp(0.69) = 1.99$; $p < .001$) higher when compared to older adults never experiencing economic difficulties. A similar pattern is observed for older adults reporting sometimes having economic difficulties ($\exp(.24) = 1.27$; $p < 0.001$). Females have a mean number of depressive symptoms 32% higher compared to males ($\exp(0.28) = 1.32$; $p < 0.001$).

The demography and epidemiology literature has identified urbanicity status as an important factor for health disparities (Abas et al., 2009). In the bivariate analysis, we estimated a higher mean number of depressive symptoms in older adults residing in rural municipalities compared to urban (3.49 vs. 2.79; $p < .001$). These findings are concordant with the urban vs rural literature in the world. However, in most countries is expected that older adults living in urban environments present higher levels of depression, this is not the case for Puerto Rico. Older adults in rural municipalities present higher levels of depressive symptoms. Urban and rural communities have discrepancies in healthcare access, social services available, culture, and social behaviors. These social determinants of health and social behaviors could potentially modify the effect of migration on health.

Figure 5. Scatter plot of Net Migration Rate and Depressive Symptoms by Urbanicity Status



These challenges prompt further analysis into the need for stratification by urbanicity status. Figure 5 illustrates the unadjusted association between net migration rate and depressive symptoms stratified by urbanicity status. Both scatter plots illustrate a modification of the effect dependent on urbanicity status. There is a negative association within urban municipalities and, inversely, a positive association within rural municipalities. Therefore, it is imperative to stratify our regression models by urbanicity status to increase the precision of effect estimation.

We decided to create two additional models stratified by urbanicity. Table 5 details the parameters for both models. The model for urban municipalities includes 11 municipalities and $n=926$ PREHCO participants. The model for rural municipalities includes 46 municipalities and $n=1,502$ PREHCO participants. In contrast to other models, the net migration rate is significantly associated with the mean number of depressive symptoms within urban municipalities. For older adults residing in urban

municipalities, each unit increase in the net migration rate is associated with 8% ($\exp(-0.08) = .92$; $pvalue < 0.05$) decrease in the mean number of depressive symptoms. As the net migration rate moves from losing inhabitants to gaining inhabitants, the mean number of depressive symptoms decreases. Also, gender, educational level, and economic difficulties remained significant within the urban municipalities.

On the other hand, the effect of the net migration rate on depressive symptoms among rural municipalities is not statistically significant ($\beta = .05$; $pvalue = 0.2413$). Estimates for gender, educational level, and economic difficulties are statistically significant. Economic difficulty is the strongest predictor in both stratified models.

Table 5. Urbanicity Stratified Models for Depressive Symptoms.

Predictor Variables	Model for Urban Municipalities (n=926)		Model for Rural Municipalities (n=1,502)	
	β	SE β	β	SE β
Intercept	0.63	0.30	1.52*	0.68
Net Migration Rate	-0.08*	0.03	0.05	0.05
Age	0.00	0.005	0.01	0.04
Gender				
Female	0.47***	0.10	0.18*	0.08
Male (ref)	-	-	-	-
Educational level	-0.04***	0.01	-0.02*	0.01
Household Support				
Living with Someone/Widowed	0.05	0.13	-0.08	0.09
Living with Someone/Divorced Separated	0.2	0.12	-0.02	0.10
Alone/Widowed	0.05	0.07	0.02	0.10
Alone/Divorced Separated	0.10	0.10	0.15	0.10
Living with Someone/Married(ref)	-	-	-	-
Migratory Experience				
Migrant	0.001	0.11	0.11	0.09
Non-Migrant (ref)	-	-	-	-
Economic Difficulties				
Frequently	0.61***	0.08	0.71***	0.12
Sometimes	0.22**	0.08	0.24**	0.09
Never (ref)	-	-	-	-
Municipal Poverty	-0.002	0.01	-0.002	0.01
Intraclass Correlation Coefficient (ICC)		5%		53%

pvalue = * <.05; **<.01; ***<.001. Reference categories identified with (ref).

Model for Urban municipalities includes 926 PREHCO participants and 11 municipalities.

Model for Rural municipalities includes 1,502 PREHCO participants and 46 municipalities.

Discussion

This study aims to estimate the effect of population migration on the depressive symptoms of older adults in Puerto Rico. Results suggest no significant association between net migration rate and depressive symptoms. However, stratified multilevel regression models identify the net migration rate as a risk factor for depressive symptoms within the urban region but not in the rural region. Economic difficulties, gender, and educational level are strong predictors of depression in late life in Puerto Rico. Currently, our findings concur with scientific literature in other countries. Although there is no consensus on the direction of the migration effect on health, several studies have found adverse effects on mental health. Our findings suggest that the loss of population due to migration is associated with more depressive symptoms among older adults living in the urban region of Puerto Rico.

The underlying causes of migration between internal and international migration are possibly driving rural and urban disparities. Demographers agree that internal migration flow mostly happens from rural municipalities to urban areas (Jorge Duany, 2011; Singer, 1972). An econometric study in Puerto Rico identified rural area push factors as the primary cause of out-migration flow (José Duany, 2003) rather than urban area pull factors. Young adults tend to move to the urban area looking for opportunities the rural areas lack, leaving their parents behind. Although there is a change in geographical location and some degree of familial separation, rural municipalities could vary in terms of distance from the urban area. There are municipalities as close as 15 minutes away and as far as three hours.

In contrast, the urban area migration experience is primarily international. Young adults with similar reasons for migration decide to move to other countries. This international migration has a more substantial impact on the social connectedness of older adults left behind. It creates barriers to the emotional and instrumental support provided by young adults. Furthermore, previous studies have identified greater social cohesion and support within rural areas compared to urban areas (Alegria et al., 2007; Choi et al., 2015; Cramm & Nieboer, 2013; Erdem, Van Lenthe, Prins, Voorham, & Burdorf, 2016). These social resources could be acting as buffers for the impact of population migration on depression among rural municipalities.

Out-migration has a broader impact on society. The unbalanced migration in Puerto Rico has affected social areas like employment, housing, healthcare services, and many other areas that indirectly affect the health of the population. Given that migration is predominantly among the working-age population, an age group that has been declining in size, the economy undergoes a direct loss because physical capital can only be partially substituted for the loss of human capital in the production process (Chen, Kuhn, Prettnner, & Bloom, 2018). For example, the working-age population pays municipal taxes destined to fund public transportation services, health services in the communities, social services, and older adults' finances such as pensions. The reduction of this group is causing an augmented economic burden per capita and a decrease in funds that provide basic needs and quality of life services for older adults. Studies have proven the association between the deterioration of health and social services and the wellbeing of older adults (Benmarhnia, Zunzunegui, Llácer, & Béland, 2014). Moreover, the impact is even more significant among older adults with a disability, a population representing half

of the older adults in Puerto Rico (Matos-Moreno & Mendes de Leon, 2018). Even though this study is not designed to observe economic difficulties as one of the pathways through which population migration impacts depressive symptoms, results confirm that is the strongest predictor for depression.

Population loss due to outmigration also impacts the funds destined for Public transportation services, a service predominantly available in the urban region of Puerto Rico. Ethnographic studies in Puerto Rico have described the austerity measures implemented in the public transportation services that have worsen the quality and quantity of the provided services (Fernandez, 1999). Public transportation is non-existent for a population that relies on them to socially integrate themselves into the community. Many older adults are incapable of participating in social activities and getting to medical appointments due to the lack of municipal transportation services and the built environment not designed for non-drivers. A third of the older adult population in Puerto Rico experiences social isolation, a psychosocial factor that negatively impacts mental and physical health (Cacioppo & Hawkley, 2003; Holt-Lunstad et al., 2015; House et al., 1988; Mariana et al., 2017). Moreover, ethnographers describe public transportation as places for social exchange and interaction (Fernandez, 1999). For a population that is limited on social participation, these moments of social interaction are essential for their mental and physical well-being.

The literature on migration and older adults' mental health identifies familial separation as the primary mechanism through which migration impacts depression. Our study focuses on the impact of population migration from a community perspective, which does not necessarily consider the more immediate effect of migration on household

disintegration. This study understands that older adults' support networks extend beyond their children and immediate family members. The migration of unrelated community members and the deterioration of the socio-economic context affect the social environments tied to older adults in sending areas (Singer, 1972). Furthermore, it is unclear which exposure level (municipal or household) is of more relevance for the well-being of older adults. In the next chapter, we examined the association between migration and older adult's mental health at the household level.

This study uses data from the only representative sample of older adults in Puerto Rico. PREHCO incorporates an island-wide sampling to represent the older adult population of every region in Puerto Rico. More than 75% of all municipalities in Puerto Rico are incorporated in this study, increasing confidence in the generalizability of the results. Also, we introduce an objective measure of migration in the studied municipalities by incorporating Census data. This is the first study in Puerto Rico that utilizes Census and individual-level data to estimate the migration impact on health. However, certain limitations prevent this study from identifying all the pathways through which population migration affects Puerto Rican older adults' mental health.

A limitation of this study is the difficulty of ascertaining the order of temporality given the data available. How long does it take for migration to affect the wellbeing of people in sending areas? At this time, no study has identified a cut point or threshold effect for the time or size it takes migration to affect health. Our study incorporates migration measures that precede the assessment of depression; however, it is unclear how and when migration begins to affect the mental health of those staying in sending

communities. Further research is needed to address these gaps in the migration and health literature.

A second limitation of this study is the inability to differentiate between internal and external migration on the estimated net migration rate. The United States Census in Puerto Rico began to collect data on migrant destinations through the Puerto Rico Community Survey in 2005. Therefore, this data is not available for the entire study period. Potentially, this limitation is introducing bias in our estimate of the impact of population migration on depression. Understanding the importance of different effects based on the type of migration will improve the methodology in future research. Although it is not possible to separately measure internal and external migration, by stratifying the regression models between urban and rural areas, our study reduced measurement error bias.

Another limitation is the lack of previous research studies on population migration and health in Puerto Rico and other countries. Studies on migration and health focus on the migrant's health rather than the population left behind. Within studies about the left-behind seldom focus on the older adult population. In Puerto Rico, no studies examine the relationship between migration and health, influencing the reliability of the included control variables in the regression models. Nevertheless, this study includes well-known social determinants of depression in late life studied in the Hispanic and Puerto Rican populations within the United States.

This study highlights the uncertainty of the impact of migration on mental health in Puerto Rico and the negative consequences on older adults living in urban municipalities. With the constant spiked of out-migration in the last 13 years, it is imperative to estimate

the prospective effect migration could have on older adults' health. This study represents the first attempt to understand migration as a social determinant of health for older adults left behind. Identifying critical factors at the municipal level should instruct the development of new policies to reduce the impact migration has on mental health. Our findings emphasize the need for comparative research on population migration and older adult's mental health in Puerto Rico and other Latin American countries.

Aim 1b: All-cause mortality

Introduction

Migratory patterns affect the health and well-being of older generations around the world (Angel, Angel, Díaz Venegas, & Bonazzo, 2010; Arévalo et al., 2015; Christensen, Doblhammer, Rau, & Vaupel, 2009). In recent times, population movement has become more common and accessible for younger generations. As the number of migrants has increased globally, the number of older adults left behind has also increased. Little attention has been paid to the consequences of population migration on the mortality of older adults left behind. Moreover, few studies have examined the consequences of population migration on the health and well-being of older adults that are left behind. Recent studies have identified some of the pathways through which population migration impacts the physical and mental health of family members left behind. However, no study has examined the effect of population migration on the mortality of older adults in sending areas. This chapter aims to estimate the association between municipal net migration rate and the mortality of older adults in Puerto Rico.

There is limited empirical research focusing on the older adult population left behind. The migration and the left behind literature have focused on the health of children and spouses. Studies in this field have estimated the impact of population migration on birthweight prevalence (Frank & Hummer, 2002; Hamilton & Choi, 2015), infant survival (Kanaiaupuni & Donato, 1999), spouses' mental health (M. Antman, 2012), changes in familial power dynamics (Parreñas, 2005), and other similar outcomes. However, as a

socio-environmental exposure, population migration could represent a potential risk factor for the mortality of older adults in sending areas.

All-cause mortality is one of the most important measurements of overall health in public health research (Blazer, 1982; H. Dong & Lee, 2014; Holt-Lunstad et al., 2015; Idler, Russell, & Davis, 2000; Jylhä, 2009). Rather than only measuring one aspect of well-being, mortality is directly and indirectly affected by biology, social behaviors, socio-environmental exposures, psychosocial factors, and others. The cumulative effect of all these factors is captured in the assessment of all-cause mortality. Recent literature on migration and mortality has found that migrants benefit from a lower risk of mortality than locals and non-migrants in receiving countries (H. Dong & Lee, 2014; Rasulo, Spadea, Onorati, & Costa, 2012). Theories like the Hispanic paradox and the Salmon bias explain the health disparities in mortality among migrants and racial groups highly associated with migration. However, these studies examine the relationship between migration and mortality at the individual level. Few studies have considered a population-level approach to migration and mortality. Eva et al. assessed the distortion of old-age mortality due to late-life migration in the Netherlands (Eva & Fanny, 2013). This study found that late-life migration can significantly distort regional old-age mortality. Like most population migration and mortality studies, the authors employed an ecological approach in their study design. No study at this time has incorporated a multi-level approach to examine the impact population migration has on the risk of mortality for older adults in sending countries, considering individual and community characteristics.

In Puerto Rico, the unbalanced out-migration affects social elements such as public education, healthcare services, the labor force, among others (Christensen et al.,

2009; IOM, 2018; Myers & Morris, 1966; Santos-Lozada, Kaneshiro, McCarter, & Marazzi-Santiago, 2020; F. Thomas, 2016). For example, the number of physicians practicing in Puerto Rico has dropped by 36% in the last ten years, leading to longer wait times for appointments (Velazquez Estrada, 2018). The average time to make the first appointment with specific subspecialties in Puerto Rico is between 6 to 12 months. A recent systematic review on first appointment delays and wait times found that patients may experience worse health outcomes when wait times are too long (Ansell et al., 2017). Furthermore, public transportation services have been reduced due to lack of public funding. These services are non-existent for a population that relies on them to integrate themselves into the community. Many older adults are incapable of participating in social activities due to the lack of municipal transportation services and the infrastructure that does not support pedestrian mobilization. In the psychosocial literature, it is well established that social isolation increases mortality risk, and the effect is even more substantial among older adults (Cacioppo & Hawkley, 2003; Holt-Lunstad et al., 2015; House et al., 1988; Mariana et al., 2017). These factors and many others could indirectly affect the mortality risk of older adults in Puerto Rico.

This study aims to estimate population migration's impact on the risk of all-cause mortality of older adults left behind in Puerto Rico. First, we estimate the net migration rate for each municipality in Puerto Rico. Second, we calculate the incidence of all-cause mortality for older adults. Finally, we estimate the association between the municipal net migration rate and the risk of all-cause mortality among Puerto Rican older adults considering individual and municipal level characteristics.

Methodology

Data Sources

The data used comes from the Decennial Census of Population and Housing Estimates in Puerto Rico, the Puerto Rico Department of Health Vital Statistics Reports, and the Puerto Rico Elderly: Health Conditions study (PREHCO)(Palloni et al., 2013).

The Decennial Census of Population and Housing Estimates is the process through which the United States estimates the total count of residents in the country, including territories. Puerto Rico has had censuses dating back to the 18th century. However, the first U.S census was conducted in 1910 after the U.S invasion of Puerto Rico (Scarrano, 2015). Since then, every decade, the U.S Census of population and housing estimates are conducted in Puerto Rico. Questionnaires vary slightly by decade; however, data remains similar regarding sex, age, race, household relationship, household type, housing occupancy, and housing tenure. In 2000, by request from the Government of Puerto Rico, the Census Bureau started using the same questionnaire in Puerto Rico as in the United States. Total population estimates are also stratified by the 78 geographical locations within Puerto Rico, also known as municipalities. The 1996-2002 U.S Census total population estimates by municipalities in Puerto Rico, in conjunction with mortality and births data from the Puerto Rico Department of Health Vital Statistics Reports, are used to estimate the period's municipality net migration rate.

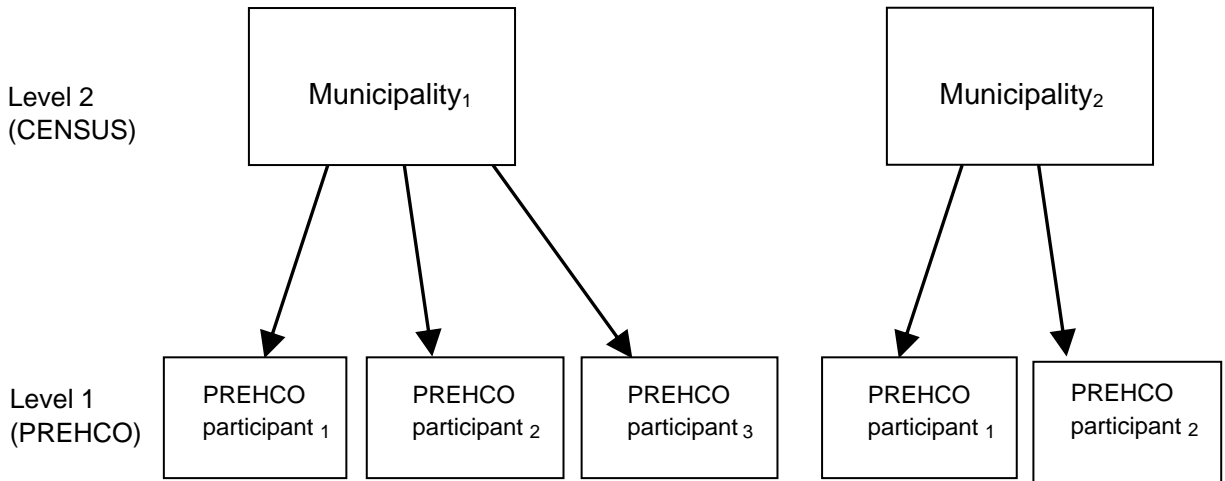
Individual-level data comes from the Puerto Rico Elderly: Health Conditions (Palloni et al., 2013) (PREHCO), a longitudinal survey of the noninstitutionalized population aged 60 and over and their surviving spouses. The sample is a multistage, stratified sample of the noninstitutionalized older adult population residing in Puerto Rico,

with oversamples of regions heavily populated by people of African descent and individuals over age 80 (McEnry & Palloni, 2010; Palloni et al., 2013). Data was collected through face-to-face interviews with older adults, including those with cognitive limitations who required the presence of a proxy, and their spouses, regardless of age. More than 20,600 households were visited in 233 sample sections. A total of 4,291 target interviews were conducted from May 2002 to May 2003. A second wave was conducted during 2006-2007. Only 4.7% of the overall sample refused to participate, and the survey response rate was 93.9%. The survey instrument includes modules on demographic characteristics, health status and conditions, family structure, migration status, economic status, cognitive and functional performance, income and assets, health insurance and use of health services, intergenerational transfers, housing, anthropometric measurements, and physical performance. A combination of the survey modules is used to obtain individual-level characteristics and health outcomes. PREHCO uses sampling weights to represent the total population over 60 years old in Puerto Rico at the time of the study. Sampling weights are incorporated in the analysis to ensure that results represent the older adult population in Puerto Rico. The study protocol and procedures were approved by the Institutional Review Boards (IRB) of the University of Wisconsin and the University of Puerto Rico.

PREHCO data is publicly available to any person for research purposes. Documentation on methodology, survey instruments, target sample, and previous publications can be access at the PREHCO website: www.prehco.rcm.upr.edu.

Statistical analysis and data management is conducted using SAS software version 9.4, Copyright © 2019 SAS Institute Inc.

Figure 6. Two-Level Clustered Data Structure Diagram



A longitudinal design is employed using a two-level clustered data structure. Level 1 (individual-level) contains PREHCO participants' data from the first wave of PREHCO (2002-03). Level 2 (municipal-level) contains the municipality characteristics for the 1996-2002 period, including the exposure of interest, Municipal Net Migration Rate. The figure above shows the two-level clustered data structure. We identified the municipality of residence for each PREHCO participant and merged them into these groups. Every PREHCO participant is assigned the municipality of residence at the time of the interview.

Measures of Interest

Net Migration Rate

Migration is defined as a form of geographic or spatial mobility involving a change of usual residence between clearly defined geographic units (Shryock & Siegel, 2013). Given the lack of adequate statistics on migration for many countries and many periods,

it is often necessary to rely on retrospective approaches to approximate migration volume. Puerto Rico is not an exception. Migration flow estimates from Puerto Rico to other countries are based on net migration. Demographers observe the change in population estimates during a period and account for deaths and births to estimate population change due to migration. These estimates are achieved through the balancing equation of population change (Shryock & Siegel, 2013). This equation is used to estimate the difference between emigration and immigration for each municipality in Puerto Rico.

First, we estimate the net migration for each municipality using the population balancing equation (PBE) and solving for the term (Immigration - Emigration) (Shryock & Siegel, 2013):

$$(I - E) = P_{2002} - (P_{1996} + B_{2002-1996} - D_{2002-1996})$$

Net migration is derived as a residual; it cannot be obtained separately (Shryock & Siegel, 2013). This method requires subtracting an estimate of natural increase ($B_{1996-2002} - D_{1996-2002}$) during the period from the net change in population during the same period ($P_{2002} - P_{1996}$). A positive net migration means that the population is gaining people through net migratory exchanges. A negative net migration implies the population is losing people (Trovato, 2012).

Second, we estimate the net migration rate for municipalities in Puerto Rico using the Census' intercensal population estimates for 1996-2002 and the estimated net migration. The net migration rate equation is as follows: (Shryock & Siegel, 2013)

$$\text{Crude Net migration rate} = NMR = \frac{(I - E)}{P_i} \times 1,000$$

(I - E) = Net migration for the specific period

P_i = Mid-period total population

The total population for the mid-period is calculated as the sum of the population size for the beginning of the period (1996) and the end of the period (2002) divided by two $P_i = (P_{1996} + P_{2002}) / 2$. Then, the net migration ($I - E$) is divided over the mid-period population to get the crude net migration rate for each municipality in Puerto Rico. This is interpreted as the number of people a municipality gained or lost to migration per 1,000 inhabitants from 1996 to 2002. This study uses the net migration rate as a continuous exposure at the municipality level.

All-cause Mortality

Mortality status at the second wave is determined by reports from a family member and confirmed with the National Death Index data files from 2002-2007. PREHCO includes the cause of death using the International Classification of Diseases Ninth edition and date of death. Time to an event is defined as the number of days between the first interview and the date of death. Day of interview and month of interview for participants missing values are imputed to 15 days and six months, respectively. The duration of follow-up among institutionalized participants is calculated using the date of interview in wave I and the specific date of institutionalization the proxies provided in the follow-up interview.

Covariates

Given the lack of research on population migration and Puerto Rican older adults' health, it is challenging to identify confounding factors with certainty. Therefore, we focus on the well-established social determinants of mortality among Hispanic older adults: age, gender, educational level, depressive symptoms, number of chronic conditions, and economic difficulties. Covariates at the individual level are measured in PREHCO's wave 1. Educational level is defined as years of education completed. The number of chronic

conditions is defined as a count measure of the following conditions: hypertension, diabetes, cancer, heart disease, stroke, and arthritis. Economic difficulties are defined as how often the participant has experience difficulties paying living expenses.

Participant's migratory experience is associated with their overall health and a positive or negative perspective on migration. It could influence their perception of population migration. Therefore, we use the migratory experience as a covariate in the analysis. Migratory experience is defined as whether the older adult lived in another country for more than three consecutive months after turning 18 years old.

Marital status and Household members are two factors associated with received and provided social support. By having both factors in the same model, we could be running into a multicollinearity problem. Therefore, we used a variable that considers the combination of both variables. We call this variable "Household Support." Household Support is a variable with five levels: "Living with someone/Married," "Living with someone/Widowed," "Living with someone/ Divorced or Separated," "Alone/Widowed," "Alone/Divorced or Separated."

Furthermore, we include other confounding factors at the municipal level that are highly associated with population migration and health: municipal poverty, urbanicity status, and average total population (Arévalo et al., 2015; Castañeda et al., 2015; Gushulak et al., 2009; Landale et al., 2006; Felicity Thomas & Gideon, 2013). This data comes from the Decennial Census of Population and Housing Estimates. Municipal poverty is defined as the average proportion of the population under the U.S federal poverty line in each municipality between 1996-2002. For urbanicity status, we used the

Census Bureau’s urban-rural classification of geographical areas. The average total population is defined as the average population in each municipality for the study period.

Analytic Approach

We begin the analytic approach with a descriptive analysis of mortality among the target sample. The average time to event is estimated and stratified by sociodemographic variables. A Cox regression model with mixed effects is used (Frailty Model) to estimate the association between all-cause mortality and population migration (Austin, 2017). We right-censored participants that did not have an event during the study period and were institutionalized. We perform a series of sensitivity analyses to determine the impact of other confounding variables in our model estimates. We built different models stratifying by urbanicity status and including proxies; however, our parameter estimates remained the same.

The primary model has the following structure:

Level 1:

$$\begin{aligned}
 h_{ij} = h_0(t) \exp & (b_j + \beta_{1j}Age_{ij} + \beta_{2j}Gender_{ij} + \beta_{3j}Educ_{ij} + \beta_{4j}HouseholdSupport_{ij} \\
 & + \beta_{5j}MigratoryExp_{ij} + \beta_{6j}EconomicDifficulties_{ij} \\
 & + \beta_{7j}\#ChronicConditions_{ij} + \beta_{8j}DepressivesSymptoms_{ij}) \exp (\alpha_{ij})
 \end{aligned}$$

Level 2:

$$\begin{aligned}
 \beta_{0j} &= \gamma_{00} + \gamma_{01}NMR_j + \gamma_{02}Urbanicity_j + \gamma_{03}MunicipalPoverty_j + \gamma_{04}TotalPop_j + \gamma_{05} + \mu_{ij} \\
 \beta_{1j} &= \gamma_{10} + \gamma_{11}NMR_j + \gamma_{12}Urbanicity_j + \gamma_{13}MunicipalPoverty_j + \gamma_{14}TotalPop_j + \gamma_{15} + \mu_{ij}
 \end{aligned}$$

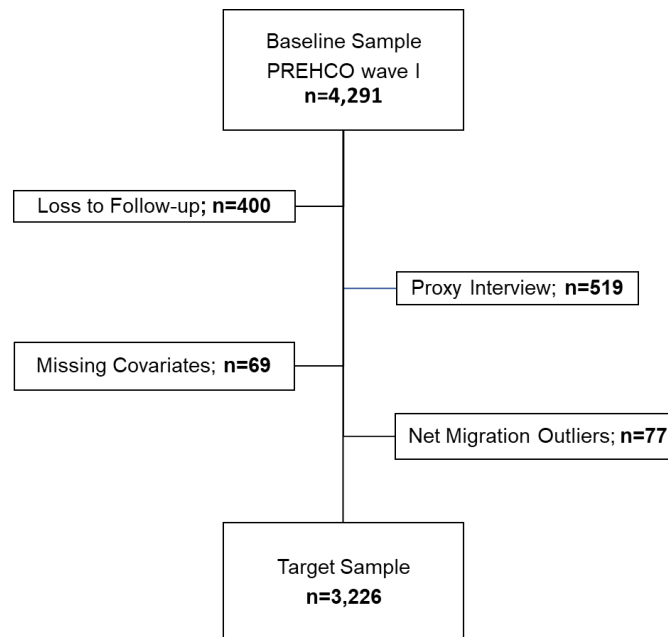
...

β 's represents the fixed effects of the independent variables included in the model. The i 's indicate individuals, and j 's indicate from which municipality. This model estimates the effect of the municipal net migration rate on all-cause mortality holding all other covariates constant. Diagnostics are performed to assess the validity of the model. Survey sampling weights are included in the analysis to ensure the representativeness of the results.

Results

First, we merge Census data with the PREHCO dataset. The municipality of residence and participants' ID is used as the merging criteria for both datasets. We begin our analysis by estimating the net migration rate for all municipalities. Out of the 78 municipalities in Puerto Rico, 55 municipalities are matched to PREHCO participants in the target sample. The following figure presents the net migration rate of the 55 municipalities available in the data. The mean net migration rate per 1,000 persons is 4.5, with a standard deviation of 4.1. Most municipalities in Puerto Rico experienced a positive net migration rate during the period 1996-2002.

Figure 8. Selection into Target Sample



After merging both datasets and excluding participants who do not meet the inclusion criteria, we conduct a descriptive analysis to observe the analytic sample characteristics. Most participants are on average 70 years old, female (56%), completed eight years of education on average, are married and lived with someone in the household (52.9%), reported on average three depressive symptoms, and have two chronic conditions. About 25% (n=398) of the participants died of any cause during the study period. The average follow-up time for deceased participants is 831 days and 1,450 days for censored participants.

Table 6. Target Sample Characteristics for n=3,226 participants and n=55 municipalities

Variables	N	Weighted Mean (std) or Proportion
Level 1		
Follow-up time (in days)		
Event	398	831 (24.90)
Censored	2828	1450 (3.90)
Age	3226	70.1 (0.20)
Gender		
Male	1273	44.2%
Female	1953	55.8%
Educational level	3226	8.25 (0.10)
Household Support		
Living with Someone/Married	1305	52.9%
Living with Someone/Widowed	535	11.9%
Living with Someone/Divorced Separated	350	9.9%
Alone/Divorced Separated	422	12.2%
Alone/Widowed	614	13.1%
Depressive Symptoms Score	3226	3.08 (0.10)
Number of Chronic Conditions	3226	1.64 (0.02)
Migratory Experience		
Migrant	599	19.7%
Non-Migrant	2627	80.3%
Economic Difficulties		
Frequently	472	13.0%
Sometimes	1142	35.0%
Never	1612	52.0%
Level 2		
Net Migration rate	55	4.5 (4.10)
Municipal Poverty	55	52.6 (8.40)
Urbanicity		
Rural	45	72.7%
Urban	10	27.3%
Average total population (x 1000)	55	58.52 (67)

In terms of municipalities within the analytic sample, the average net migration rate is 4.5, with a standard deviation of 4.1. The average population under the poverty line is 53%, most municipalities are rural (73%), and the average total population is 58,520 residents.

After completing the descriptive analysis, we proceed to build the multi-level models (see Table 7). Model 1 estimates the unadjusted association between all-cause mortality and net migration rate. The municipal net migration rate is not associated with all-cause mortality. The hazard ratio of mortality increases by 8% for one unit increase in the net migration rate (HR= 1.08; CI=0.92 – 1. p<0.3515). Model 2 presents the adjusted association between all-cause mortality and net migration rate controlling by level 1 covariates. The estimate of the association between the risk of mortality and net migration rate remained the same.

Furthermore, age, gender, educational level, household support, depressive symptoms, number of chronic conditions, migratory experience, and economic difficulties are significantly associated with all-cause mortality. When comparing the risk of mortality between migrants and non-migrants, we estimate a significant association. Non-migrants have a risk of mortality 18% higher than older adults that have migrated to the United States at some point in their lives (HR=1.18; CI=1.15 – 1.21; p<.0001).

Model 3 shows the adjusted association between all-cause mortality and net migration rate adjusting for level 1 and level 2 covariates. When adjusting for level 2 covariates, the hazard ratio for net migration rate increases to 1.17; however, it is marginally significant with a p= 0.1079. The risk of mortality increases by 17% for each

unit increase in the net migration rate. Older adults residing in municipalities with higher net migration rates seem to have an elevated risk of mortality.

On the other hand, no level 2 characteristics are significant even though they seem to affect the association between net migration rate and all-cause mortality. Level 1 covariates remain the same after adjusting for level 2 covariates. As expected, the risk of mortality increases with age (HR=1.07; CI=1.06 – 1.07 $p<0.0001$), with the number of depressive symptoms (HR=1.05; CI=1.04 – 1.05; $p<0.0001$), and with the number of chronic conditions (HR=1.16; CI=1.15 – 1.17; $p<0.0001$). Migratory experience is also significantly associated with mortality. Non-migrants have an 18% higher risk of mortality than older adults who have migrated to the United States at some point in their lives. Household support categories also present significant results. Those living with someone and divorced or separated have a 30% higher risk of mortality compared to those married or living with someone (HR=1.30; CI=1.25 -1.34; $p<0.0001$). Furthermore, those alone and divorced or separated also experience a 28% higher risk of mortality compared to those married or living with someone (HR=1.28; CI=1.24 -1.32; $p<0.0001$).

In contrast, those alone and widowed have a 16% lower risk of mortality than older adults living with someone or married (HR=0.84; CI=0.81 -0.86; $p<0.0001$). Educational level is also a protective factor. The risk of mortality decreases by 2% for each educational level the older adult has achieved (HR=0.98; CI=0.97 – 0.98; $p<0.0001$).

Based on previous findings on how the net migration rate affects older adults' well-being in Puerto Rico, it is imperative to conduct sensitivity analyses to ensure the validity of the results. To increase the sample size and the representativeness of the results, we also include participants that used proxies to complete the interview in PREHCO's wave

I. Results remain the same; however, proxies in the PREHCO study merit further study given the particularities of this subpopulation. Furthermore, we exclude older adults who changed residence between waves to minimize measurement error bias in the exposure of interest, however, results remain the same.

Finally, we stratify the models by urbanicity status, given that previous findings suggest urban-rural health disparities among older adults in Puerto Rico. The association between net migration rate and all-cause mortality remains not significant for urban municipalities (HR=1.02; CI= 0.98–1.05; p=0.39). All covariates are significant or marginally significant. However, for older adults residing in rural municipalities, the association between net migration rate and all-cause mortality is marginally significant. Among older adults residing in rural municipalities, for a unit increase in the net migration rate the risk of all-cause mortality increases by 25% (HR=1.25; CI= 0.99–1.59; p=.06). All covariates at level 1 are significant but not at level 2 among rural municipalities.

Table 7. Cox Regression model with mixed effects for All-cause Mortality

Predictor Variables	Model 1			Model 2			Model 3		
	HR	CI	P-value	HR	CI	P-value	HR	CI	P-value
Net Migration Rate	1.08	0.92 - 1.27	0.35	1.08	0.92 - 1.27	0.32	1.17	0.97 - 1.4	0.10
Age				1.07	1.06 - 1.07	<.0001	1.07	1.06 - 1.07	<.0001
Gender									
Male				1.51	1.48 - 1.55	<.0001	1.51	1.48 - 1.55	<.0001
Female (ref)	-	-	-	-	-	-	-	-	-
Educational level				0.98	0.97 - 0.98	<.0001	0.98	0.97 - 0.98	<.0001
Household Support									
Living with Someone/Widowed				1.00	0.97 - 1.03	0.99	1.00	0.97 - 1.03	0.99
Living with Someone/Divorced Separated				1.30	1.25 - 1.34	<.0001	1.30	1.25 - 1.34	<.0001
Alone/Divorced Separated				1.28	1.24 - 1.32	<.0001	1.28	1.24 - 1.32	<.0001
Alone/Widowed				0.84	0.81 - 0.86	<.0001	0.84	0.81 - 0.86	<.0001
Living with Someone/Married (ref)	-	-	-	-	-	-	-	-	-
Depressive Symptoms Score				1.05	1.04 - 1.05	<.0001	1.05	1.04 - 1.05	<.0001
Number of chronic conditions				1.16	1.15 - 1.17	<.0001	1.16	1.15 - 1.17	<.0001
Migratory Experience									
Non-Migrant				1.18	1.15 - 1.21	<.0001	1.18	1.15 - 1.21	<.0001
Migrant (ref)	-	-	-	-	-	-	-	-	-
Economic Difficulties									
Frequently				0.99	0.96 - 1.02	0.38	0.99	0.96 - 1.02	0.38
Sometimes				0.79	0.77 - 0.81	<.0001	0.79	0.77 - 0.81	<.0001
Never (ref)	-	-	-	-	-	-	-	-	-
Level 2									
Municipal Poverty Urbanicity							1.03	0.93 - 1.14	0.61
Rural							0.39	0.04 - 3.18	0.38
Urban (ref)	-	-	-	-	-	-	-	-	-
Average Total Population Size							1.01	0.99 - 1.02	0.26

Reference categories identified with (ref).

Table 8. Cox Regression model with mixed effects for All-cause Mortality by Urbanicity Status

Predictor Variables	Urban (n=1,205)			Rural (n=2,021)		
	HR	CI	P-value	HR	CI	P-value
Net Migration Rate	1.02	0.98-1.05	0.39	1.25	0.99-1.59	0.06
Age	1.07	1.06-1.07	<.0001	1.07	1.07-1.07	<.0001
Gender						
Male	1.98	1.91-2.05	<.0001	1.30	1.26-1.33	<.0001
Female (ref)	-	-	-	-	-	-
Educational level	0.92	0.91-0.92	<.0001	1.01	1.01-1.01	<.0001
Household Support						
Living with Someone/Widowed	0.95	0.90-1.01	0.09	0.97	0.94-1.01	0.15
Living with Someone/Divorced Separated	0.80	0.75-0.86	<.0001	1.56	1.50-1.62	<.0001
Alone/Divorced Separated	1.47	1.40-1.56	<.0001	1.22	1.17-1.26	<.0001
Alone/Widowed	1.44	1.37-1.51	<.0001	0.59	0.57-0.61	<.0001
Living with Someone/Married (ref)	-	-	-	-	-	-
Depressive Symptoms Score	1.05	1.04-1.06	<.0001	1.04	1.04-1.05	<.0001
Number of chronic conditions	1.20	1.19-1.22	<.0001	1.13	1.12-1.14	<.0001
Migratory Experience						
Non-Migrant	0.63	0.61-0.66	<.0001	1.55	1.50-1.60	<.0001
Migrant (ref)	-	-	-	-	-	-
Economic Difficulties						
Frequently	0.95	0.91-1.01	0.08	1.01	0.98-1.04	0.52
Sometimes	0.88	0.85-0.91	<.0001	0.75	0.73-0.77	<.0001
Never (ref)	-	-	-	-	-	-
Level 2						
Population Under the Poverty line	1.03	1.02-1.04	<.0001	1.06	0.92-1.22	0.45
Average Total Population Size	1.01	1.0-1.02	0.11	1.03	0.99-1.06	0.12

pvalue = * <.05; **<.01; ***<.001. Reference categories identified with (ref).

Model for Urban municipalities includes 1,205 PREHCO participants and 10 municipalities.

Model for Rural municipalities includes 2,021 PREHCO participants and 45 municipalities.

Discussion

This study aims to estimate the effect of population migration on the mortality of older adults in Puerto Rico. Results suggest no significant association between net migration rate and all-cause mortality. However, urbanicity status stratified multilevel regression models identify the net migration rate as a risk factor for all-cause mortality within the rural region but not in the urban region. Net migration rate, gender, household support, and migratory experience are strong predictors of all-cause mortality in late life in rural Puerto Rico. Currently, our findings concur with scientific literature in other countries. Although there is no consensus on the direction of the migration effect on health, studies have found adverse effects on overall health. Our findings suggest that the municipal net migration rate is associated with mortality among older adults living in the rural region of Puerto Rico.

In this study, we find that population migration does not affect the risk of mortality among older adults in Puerto Rico, adjusting for individual and municipal characteristics. At the same time, we find an effect of population migration only in the rural region of Puerto Rico. Out-migration in Puerto Rico began increasing in the mid-2000s. It is not until 2003-2004 that most municipalities started to show negative net migration rates in Puerto Rico. We use migration data that precedes the first wave of PREHCO (1996-2002) to minimize temporality bias; however, most municipalities in this period still experienced positive net migration rates. Some municipalities still show population growth during the study period. The demographic changes in the population caused by the increase in out-migration could not have taken place yet. After this period, the migration patterns changed drastically in the following years, resulting in a different social reality that we cannot

capture due to the restriction of the data or because the required unknown threshold effect of population migration has not taken place.

On the other hand, we find a marginal effect of population migration on mortality among older adults residing in rural municipalities. Previous studies on mortality disparities in other countries have found similar results regarding the changes in mortality risk, the importance of aging in place, and the rural and urban effects on the health of older adults (Abas et al., 2009; Knodel & Saengtienchai, 2007; Verheij, van de Mheen, de Bakker, Groenewegen, & Mackenbach, 1998). These findings are contradictory to our hypothesis regarding the direction of the effect. Results suggest that mortality risk increases as the net migration rate increases, which means higher population exchange is associated with higher mortality. As the net migration rate moves to the positive spectrum of its range, the mortality risk increases. These findings are not concordant with the literature. However, it is essential to consider that most municipalities have a positive net migration rate, and some still experience population growth. These results capture the effect of population exchange on the mortality of older adults and how municipalities, among those in the rural region, are affected by the exchanging of residents. Moreover, this population exchange does not eliminate the reduction of social ties and social network members among older adults which have been identified as one of the pathways through which population migration impacts health. The effect of population exchange on the mortality risk of older adults requires further study.

Furthermore, we find that migration at the individual level is associated with the risk of mortality among older adults in Puerto Rico. Currently, our findings concur with the healthy migrant theory, where migrants are expected to be a healthier subpopulation

(Razum, 2008). However, there seems to be a reverse salmon bias effect given the health status of returned migrants in Puerto Rico. The healthy migrant effect describes an empirically observed mortality advantage of migrants relative to individuals in the sending country. Studies have shown advantages in migrants' health compared to natives in the receiving country, especially mortality advantages even though this population is socially disadvantaged (Y. Lu & Qin, 2014; Puschmann, Donrovich, & Matthijs, 2017; Verheij et al., 1998). It is thought that migrants are among the healthiest individuals in the countries of origin; therefore, a selection bias affects mortality estimates in receiving countries. This study found that older adults who migrated at some point in their lives have a lower risk of mortality than those who have stayed in Puerto Rico. These results concur with the healthy migrant theory; however, following the salmon bias effect, these return migrants should have worse health outcomes, which is not the case.

The literature on migration and the mortality of older adults identifies familial separation and lack of support as the primary mechanism through which migration impacts health. Our study focuses on the impact of population migration from a community perspective, which does not necessarily consider the more immediate effect of migration on household disintegration. This study understands that older adults' support networks extend beyond their children and immediate family members. The migration of unrelated community members and the deterioration of the socio-economic context affect older adults' social environments in sending areas (Singer, 1972). Furthermore, at this time, it is unclear which exposure level (municipal or household) is of more relevance for older adult's well-being. In the next chapter, we examined the association between migration and older adults' overall health at the household level.

This study uses data from the only representative sample of older adults in Puerto Rico. PREHCO incorporates an island-wide sampling to represent the older adult population of every region in Puerto Rico. More than 75% of all municipalities in Puerto Rico are incorporated in this study, increasing confidence in the results' generalizability. Also, we introduce an objective measure of migration in the studied municipalities by incorporating Census data. This is the first study in Puerto Rico that utilizes Census and individual-level data to estimate the population migration impact on health. However, certain limitations prevent this study from identifying the pathways through which population migration affects the health and well-being of Puerto Rican older adults.

A limitation of this study is the difficulty of ascertaining the order of temporality given the data available. How long does it take for migration to affect the wellbeing of people in sending areas? At this time, no study has identified a cut point or threshold effect for the time or size it takes migration to affect health. Our study incorporates migration measures that precede the assessment of all-cause mortality; however, it is unclear how and when migration begins to affect the health of those staying in sending communities. Further research is needed to address these gaps in the migration and health literature.

A second limitation of this study is the inability to differentiate between internal and international migration on the net migration rate. The United States Census in Puerto Rico began to collect data on migrant destinations through the Puerto Rico Community Survey in 2005. Therefore, this data is not available for the entire study period. This limitation potentially introduces a bias in our estimates of the impact of population migration on all-cause mortality. Understanding the importance of different effects based on migration will

improve the methodology in future research. Although it is impossible to measure internal and international migration separately, by stratifying the regression models in the sensitivity analysis by urbanicity status, our study reduced measurement error bias.

Another limitation resides in the measurement of net migration rate and the inability of the measurement to distinguish between immigration and emigration. Given the net migration rate calculation, it is impossible to estimate the number of Puerto Ricans that have emigrated during a period. Currently, it is not possible to estimate the number of residents a municipality has lost. This population loss could be driving the social changes in the municipalities that have a detrimental effect on health for older adults. Our study captures a portion of the social change in the municipalities by incorporating the net migration rate. Further study is needed to identify the social changes associated with migration in Puerto Rico.

This study highlights the uncertainty of the impact of migration on health in Puerto Rico and the negative consequences on older adults' well-being. With the constant spiked of out-migration in the last 13 years, it is imperative to estimate the prospective effect migration could have on older adults' health. This study represents the first attempt to understand migration as a social determinant of health for older adults left behind. Identifying critical factors at the municipal level should instruct the development of new policies to reduce the impact migration has on health. Our findings emphasize the need for comparative research on population migration and older adults' well-being in Puerto Rico and other Latin American countries.

Chapter III: The Effect of Adult-child Migration on Parental Health and Well-being Among Older Adults in Puerto Rico

Introduction

Adult-children's migratory patterns are affecting the health and well-being of older generations around the world. In recent times, population movement has become more common and accessible for younger generations. As the number of adult-children migrants increases globally, the number of older parents left behind also increases. Even though this is not a new phenomenon, little attention has been paid to the consequences of adult-children migration on the health of older parents left behind. Furthermore, experts disagree on the pathways through which adult-children migration impact parental health. Recent studies have identified multiple disadvantages and benefits from adult-children migration on parental well-being. This disagreement highlights the need and importance for further research on identifying the pathways through which adult-children migration affects parental health and well-being. This chapter aims to estimate the association between adult-children migration and parental mental and physical health.

The older generations left behind may experience positive effects from the migration of their adult-children. As the young population moves away and adult-children migrate, elderly parents who are left behind may enjoy socio-economic and psychological benefits. Remittances are one of the economic benefits more studied in the literature (Davis & Lopez-Carr, 2010; Hamilton & Choi, 2015; Kanaiaupuni & Donato, 1999). Increments in household income influenced by monetary transfers from adult-children migrants are linked to better parental health and well-being. Kuhn's study in Bangladesh showed a strong positive effect of adult-children's migration on their parents' health and well-being (Kuhn et al., 2011).

Moreover, migrant children may provide significantly larger financial transfers during a health crisis, acting as a basic health insurance policy. Remittances and improvements on technology can facilitate communication concerning health-related information via phone calls or the internet (Frank & Hummer, 2002). Improved communication may also mitigate the social penalties associated with having a migrant child (Guo, Chi, & Silverstein, 2009; Knodel & Saengtienchai, 2007).

On the other hand, evidence shows that older adults also experience adverse effects from having migrant adult-children. Familial separation, reduction of social networks, and lack of social connectedness are known determinants of health for the left behind family members (F. Antman, 2010; Arenas & Yahirun, 2010; Ghimire et al., 2018; He et al., 2016; Kanaiaupuni & Donato, 1999; Kuhn et al., 2011; Y. Lu et al., 2012; M. Antman, 2012; Jacqueline M. Torres, Rudolph, Sofrygin, Glymour, & Wong, 2018). The absence of their children as caregivers and providers of instrumental support affects their overall health (F. Thomas, 2016; J. M. Torres et al., 2019; J. M. Torres et al., 2020). Antman's study in Mexico used a counterfactual approach to prove that older adults with at least one child outside of Mexico had poorer self-reported physical and mental health (F. Antman, 2010). Antman argues that depression is the pathway through which the physical health of older adults in Mexico deteriorates, accentuating the importance of studying the effect of migration on depressive symptoms.

These effects are of relevance for Puerto Rico. Given the unprecedented levels of outmigration in recent years, the number of older adults left behind is increasing. More than 700,000 Puerto Ricans have migrated to the United States and other countries in the last 13 years (Velazquez Estrada, 2018). Evidence suggests that most Puerto Rican

migrants are between 28 and 35 years, a particular age-group representing young professionals, adult-children, and the labor force (Velazquez Estrada, 2018). Social Scientists and Demographers argue that these migratory patterns are responsible for increasing the percent of older adults within the Puerto Rican population in the last ten years. In 2010, older adults in Puerto Rico represented 11% of the total population. In 2020, this population increased to 21%. The accelerated rapid aging due to outmigration is increasing the number of older adults facing psychosocial isolation and reduced functional support.

With the increase in the prevalence of older adults facing psychosocial isolation and reduced functional support, the Puerto Rican older generation could face detrimental health outcomes. Several studies of Puerto Ricans living in the United States have demonstrated the impact of psychosocial determinants on mortality, activities of daily living, and depressive symptoms (Arevalo et al., 2014; Arévalo et al., 2015; Castaneda-Sceppa et al., 2010; Falcón et al., 2009; Zayas et al., 2013). Falcon and colleagues examined the role of social network support in ameliorating the psychological impact of life stressors for the older Puerto Rican population in the Boston Area (Falcón et al., 2009). Results demonstrate that social support dimensions, particularly emotional support, are generally protective of suffering from depression and perceived stress. Social support was beneficial for men but manifestly less so for women. The research on psychosocial factors and health in Puerto Rican older adults primarily focuses on Puerto Ricans in the United States. There are no studies on psychosocial factors and health in Puerto Rico's older adult population. However, given the cultural and social similarities of

Puerto Ricans living in the United States, we can argue that the impact of psychosocial factors on older adults' health in Puerto Rico could be similar.

In contrast, the accelerated aging levels due to outmigration in Puerto Rico also increase the prevalence of having migrant adult-children and the benefits that arise from it. A study on the psychological wellbeing of left behind Puerto Rican older adults found that being optimistic, grateful, and keeping the thought that their adult-children have a better quality of life in the United States buffers the sadness and adverse effects that arise from familial separation, decreasing the risk of suffering from depression and disability (Toro Adorno, Rodríguez Gómez, & López Córdova, 2021). Most participants were optimistic, happy, and proud to have migrant adult-children. Furthermore, the increase in remittances by migrant adult-children could improve older adults' socioeconomic status and quality of life in Puerto Rico. However, no study has examined the association between the positive benefits of migration and the health of left-behind older adults in Puerto Rico.

The literature on adult-children migration and parental health is currently mixed, and experts have been unable to agree on how migration affects parental well-being. Some experts argue that unmeasured confounding in observational studies is the cause for these contradictory findings, specifically factors associated with selection into migration. However, Kuhn and Antman both conducted counterfactual approaches to reduce the bias introduced by unmeasured confounders and found contrasting results (F. Antman, 2010; Kuhn et al., 2011). Both studies examined the causal relationship between adult-children migration and self-reported physical and mental health but found positive and negative significant effects. These studies were conducted in different countries;

therefore, the authors argue that the migration and health relationship could depend on the country's cultural and social norms. Whether these findings generalize to Puerto Rican older adults remains an open question.

In conclusion, the unprecedented levels of outmigration and the rapid aging of the Puerto Rican population is increasing the prevalence of having migrant adult-children among older adults. Therefore, it is imperative to study how having migrant adult-children impacts the well-being of older parents. In this chapter, we examine the prevalence of having migrant adult-children. We also estimate the association between adult-children migration, depressive symptoms, and disability of older adults left behind in Puerto Rico. Finally, we employ an Instrumental Variable (IV) approach to estimate the causal relationship between adult-children migration and parental mental and physical health.

Methodology

Data source

This study's data comes from the Puerto Rico Elderly: Health Conditions study (PREHCO) (Palloni et al., 2013). PREHCO is a longitudinal survey of the noninstitutionalized population aged 60 and over and their surviving spouses. The sample is a multistage, stratified sample of the noninstitutionalized older adult population residing in Puerto Rico, with oversamples of regions heavily populated by people of African descent and individuals over age 80 (McEnry & Palloni, 2010; Palloni et al., 2013). Data was collected through face-to-face interviews with older adults, including those with cognitive limitations who required the presence of a proxy, and their spouses, regardless of age. More than 20,600 households were visited in 233 sample sections. A total of 4,291 target interviews were conducted from May 2002 to May 2003. A second wave was

conducted during 2006-2007. Only 4.7% of the overall sample refused to participate, and the survey response rate was 93.9%. The survey instrument includes modules on demographic characteristics, health status and conditions, family structure, migration status, economic status, cognitive and functional performance, income and assets, health insurance and use of health services, intergenerational transfers, housing, anthropometric measurements, and physical performance. A combination of the survey modules is used to obtain individual-level characteristics and health outcomes. PREHCO uses sampling weights to represent the total population over 60 years old in Puerto Rico at the time of the study. Sampling weights are incorporated in the analysis to ensure that results represent the older adult population in Puerto Rico. The study protocol and procedures were approved by the Institutional Review Boards (IRB) of the University of Wisconsin and the University of Puerto Rico.

PREHCO data is publicly available to any person for research purposes. Documentation on methodology, survey instruments, target sample, and previous publications can be access at the PREHCO website: www.prehco.rcm.upr.edu.

Statistical analysis and data management are conducted using SAS software version 9.4, Copyright © 2019 SAS Institute Inc. and R Core Team (2020).

Measures of Interest

Adult-Child Migration

PREHCO contains demographic data on participants' offspring. It also includes data on the current residence of every child. Specifically, it asked participants if the adult-child lives in the same municipality, a different municipality, in the United States, or a different country. We define adult-child migration as children living in the United States or

other countries at the time of interview. The variable is defined as having at least one adult-child living outside of Puerto Rico. Therefore, the variable of interest has a dichotomous structure.

Depressive symptoms

Depressive symptoms are assessed using a short form of the Geriatric Depression Scale (GDS-SF)(Sheikh & Yesavage, 1986). The GDS-SF is a 15-item assessment that measures self-rated symptoms of depression. The GDS-SF has a maximum score of 15 points; higher scores indicate more severe depressive symptoms. Studies have indicated that the GDS is a promising screen for detecting depression in older adults (Dias et al., 2017; Marc et al., 2008; Pocklington et al., 2016; Sheikh & Yesavage, 1986). For the current study, a cut-off of five is used to determine substantial depressive symptoms. A recent meta-analysis showed the cut-off of five to have the best sensitivity and specificity to predict clinically diagnosed depression across different languages, including Spanish (Pocklington et al., 2016). There was good sensitivity (80.7%) and acceptable specificity for this cut-off among Hispanic older adults (Aguilar-Navarro, Fuentes-Cantu, Avila-Funes, & Garcia-Mayo, 2007).

PREHCO also contains a module on health conditions and well-being. Within the items included in the survey instrument, participants were asked if a physician has ever told them that they have depression. We use this dichotomous variable to assess the lifetime history of depression and its association with adult-children migration.

Activities of Daily Living (ADL)

When compensatory mechanisms are unavailable or no longer sufficient to complete tasks that have become difficult, older adults may need the assistance of other people to manage their daily lives (Albert, 2010). Previous research suggests that those

who cannot adapt to such changes are at greater risk of health deterioration (Freedman, Grafova, Schoeni, & Rogowski, 2008; Freedman & Spillman, 2016; Garcia, Downer, Crowe, & Markides, 2017; Nagi, 1976). ADLs are considered the fundamental and universal competencies of adulthood. The loss of essential ADL competencies, the ability to toilet or bathe oneself, is a severe threat, not just to social participation and safety, but also to adulthood and self-worth (Albert, 2010). PREHCO included the Katz (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963) difficulties with activities of daily living. During the first wave, participants were asked whether they have difficulty eating, dressing, toileting, walking, getting up or laying down in bed, or bathing due to a health problem. Participants were asked not to consider difficulties or limitations that they expected to last fewer than three months. Participants who reported having difficulties in at least one ADL are considered as having ADL disability.

Covariates

Given the lack of research on familial separation and health of Puerto Rican older adults, it is challenging to identify confounding factors with certainty. Therefore, we focus on the well-established social determinants of health among Hispanic older adults: age, gender, educational level, marital status, number of children, economic difficulties, number of chronic conditions, and urbanicity. Covariates are measured in PREHCO's wave 1. Educational level is defined as years of education completed. Number of children is defined as the total number of children alive at the time of the interview. Economic difficulties are defined as how often the participant has experience difficulties paying living expenses. Chronic conditions are defined as a count measure of the following chronic conditions: hypertension, diabetes, cancer, heart disease, stroke, and arthritis.

Instrument for IV Analysis

Previous studies have identified endogeneity in the association between adult-children migration and parental mental and physical health (F. M. Antman, 2010; Kuhn et al., 2011; Li, Wu, Yi, Wang, & Baležentis, 2020). To conduct an instrumental variable analysis, it is imperative to identify a vital instrument that complies with the IV assumptions. These same studies have identified the proportion of male children as a valid instrument to estimate the causal relationship between adult-children migration and parental health (M. Antman, 2012). For our analysis, the instrument is defined as the proportion of male children among all alive children within the family of the interviewed older adult.

Analytic Approach

We begin our analysis by examining the target sample characteristics using a descriptive approach. Weighted means and standard deviation are used to observe the distribution of continuous variables. Weighted frequencies and percentages are used for categorical variables. Percentages and means are calculated for depression, disability, and covariates. Further, we estimate the bivariate association between adult-children migration, depression, disability, and all covariates. Given the dichotomous structure of both health outcomes and the prevalence of common diseases in this study population (Prevalence >10%), we create log-binomial regression models to estimate the adjusted association between adult-child migration and both health outcomes separately. The models have the following structure:

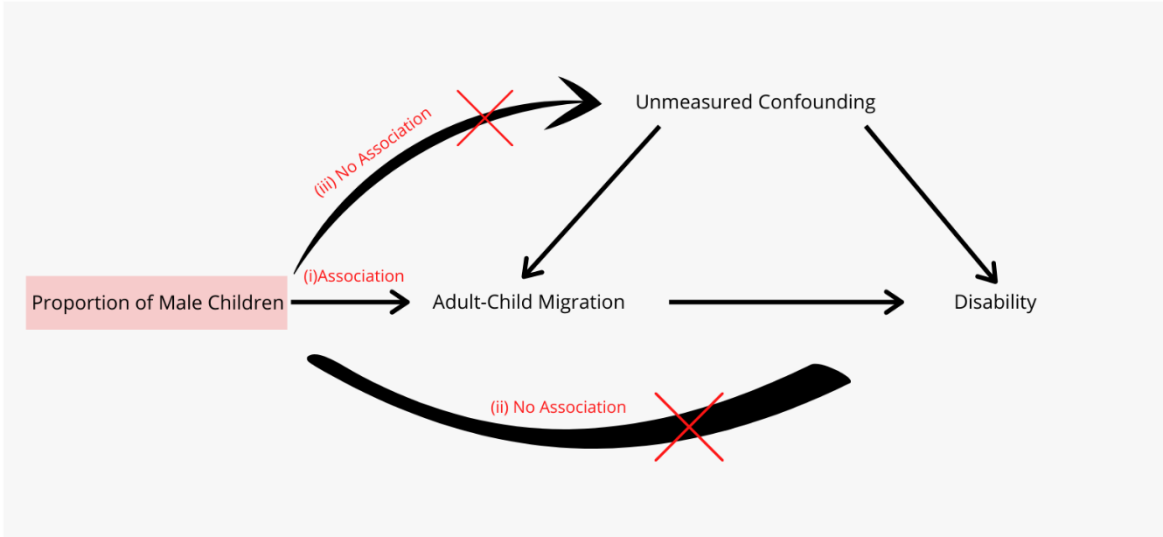
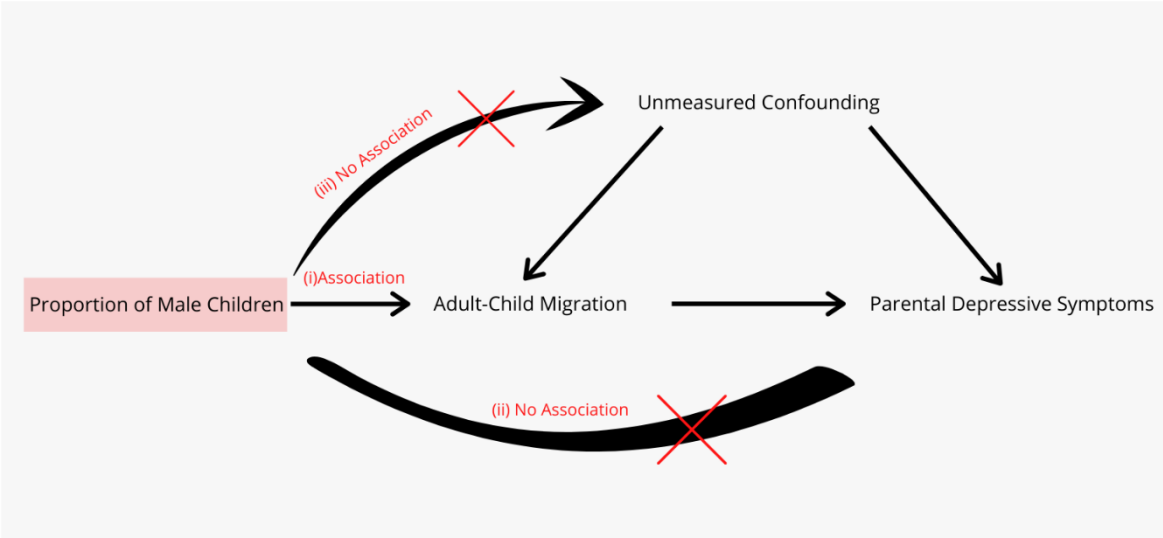
$$\begin{aligned}
& \text{Log} (\text{Pr}(\text{HealthOutcome} = 1)) \\
& = \beta_0 + \beta_1 \text{AdultChildMig} + \beta_2 \text{Age}_i + \beta_3 \text{Gender}_i + \beta_4 \text{Educ}_i + \beta_5 \text{Marital}_i \\
& + \beta_6 \text{\#ofChildren}_i + \beta_7 \text{EconomicDiff}_i + \beta_8 \text{\#ChronicConditions}_i \\
& + \beta_9 \text{Urbanicity}_i
\end{aligned}$$

β 's represents the effects of the independent variables included in the model. The i 's indicate individuals. This model estimates the effect of adult-children migration on parental mental and physical health, holding all other covariates constant. Diagnostics are performed to assess the validity of the model. Survey sampling weights are included in the analysis to ensure the representativeness of the data.

Researchers have established an association between adult-child migration and parental health confounded by many risk factors. However, unmeasured factors potentially affect the relationship between adult-child migration and parental health in these observational studies (F. Antman, 2010; Ghimire et al., 2018; Knodel & Saengtienchai, 2007; Kuhn et al., 2011). Therefore, we have to estimate the causal association between adult-child migration, depressive symptoms, and disability using an Instrumental Variable Analysis (IV). Previous research has demonstrated the use of the proportion of male children as a valid instrument in IV analysis for adult-child migration and parental health (F. Antman, 2010). However, these studies were conducted on Mexican older adults residing in Mexico. Although migration and migration journeys are different between Mexicans and Puerto Ricans, we assume the impact on parental health could be similar for those left behind. Therefore, our first step is to test the instrument against the three main causal assumptions of the IV analysis.

- I. *The Proportion of male children is associated with adult-child migration.*
- II. *The Proportion of male children is associated with parental depressive symptoms and disability only through adult-child migration.*
- III. *The Proportion of male children shares no common causes with parental depressive symptoms and disability.*

Figure 9. Instrumental Variable Assumptions



The figure above illustrates the association of the instrument with the exposure and outcomes of interest. The proportion of male children is associated with adult-child migration and only associated with parental health through adult-child migration. Therefore, the first two assumptions must be validated using statistical methods. (I) We create a log-binomial regression model with adult-children migration as the dependent variable and the proportion of male children as the independent variable. For the second assumption (II), we test the association between the proportion of male children and each parental health outcome (Depressive symptoms and Disability) using a log-binomial regression model with the health outcome as the independent variable. The third (III) assumption needs to be validated conceptually. We provide evidence in the results section.

After the instrument's validation, we use the two-stage residual inclusion method (2SRI) to estimate the causal relationship (Koladjo, Escolano, & Tubert-Bitter, 2018). The first stage of the 2SRI predicts adult-child migration using the proportion of male children. The model will have the following structure:

$$\begin{aligned} \text{Log}(\text{Pr}(\text{AdultChildMig} = 1)) = & \beta_0 + \beta_1 \text{MaleChildProp} + \beta_2 \text{Age}_i + \beta_3 \text{Gender}_i + \\ & \beta_4 \text{Educ}_i + \beta_5 \text{Marital}_i + \beta_6 \text{\#ofChildren}_i + \beta_7 \text{EconomicDiff}_i + \\ & \beta_8 \text{\#ChronicConditions}_i + \beta_9 \text{Urbanicity}_i \end{aligned}$$

In the second stage, the adult-children migration parameter will be replaced by the predicted parameter of the proportion of male children in the first stage. This parameter is denoted by β_z .

$\text{Log}(\text{Pr}(\text{HealthOutcome} = 1))$

$$\begin{aligned} &= \beta_0 + \beta_1 \text{AdultChildMig}_i + \beta_2 \text{Age}_i + \beta_3 \text{Gender}_i + \beta_4 \text{Educ}_i + \beta_5 \text{Marital}_i \\ &+ \beta_6 \text{\#ofChildren}_i + \beta_7 \text{EconomicDiff}_i + \beta_8 \text{\#ChronicConditions}_i \\ &+ \beta_9 \text{Urbanicity}_i \end{aligned}$$

Results

First, we implement the exclusion criteria to the complete sample in PREHCO's wave I. We exclude participants that used a Proxy to complete the interview, participants without living children, and participants missing covariates. There are 906 participants who meet the exclusion criteria. Therefore, after excluding participants the analytic sample resulted in 3,385 PREHCO participants. The following figure illustrate the analytic sample selection.

Figure 10. Selection into Analytic Sample

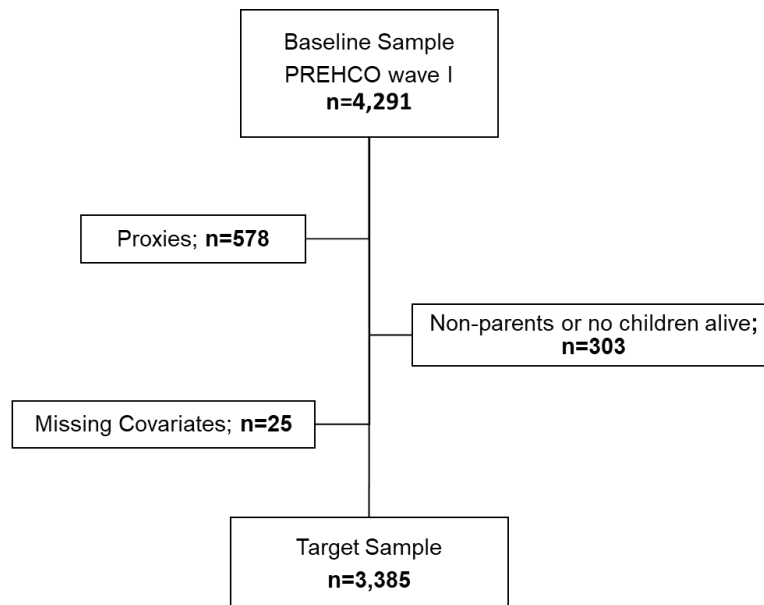


Table 9. Target Sample Characteristics

Variables	N	Weighted Mean (std) or Proportion	Elevated GDS Depression Score (n=931)	Not Elevated GDS Depression Score (n=2,454)
Adult-children Migration				
At least one adult-children outside of PR	1768	52.0%	53.5%	51.5%
No adult-children living outside of PR	1617	48.0%	46.5%	48.5%
Depressive Symptoms				
Elevated Depression Score	931	25.9%	-	-
Not Elevated Depression Score	2454	74.1%	-	-
Age	3385	69.9 (0.2)	70.2 (0.3)	69.8 (0.2)
Gender				
Male	1345	44.7%	33.9%	47.1%
Female	1768	56.3%	66.1%	52.9%
Educational level	3385	8.3 (0.1)	7.5 (0.2)	8.5 (0.1)
Marital Status				
Married or Living Together	1451	55.3%	46.7%	58.4%
Widowed	1233	25.5%	32.5%	23.0%
Divorced/Separated/Never Married	701	19.2%	20.8%	18.6%
Number of Children Alive	3385	4.2 (0.06)	4.3 (0.1)	4.1 (0.1)
Economic Difficulties				
Frequently	492	12.4%	19.6%	9.9%
Sometimes	1228	36.2%	40.8%	34.6%
Never	1665	51.4%	39.6%	55.5%
Number of chronic conditions	3385	1.67 (0.03)	1.98 (0.1)	1.56 (0.1)
Urbanicity				
Urban	1325	39.30%	31.9%	41.9%
Rural	2060	60.70%	68.1%	58.1%

The analytic sample is on average 70 years old, female (56.3%), have completed eight years of education, are married or living together (55.3%), and have four children. Most older adults have never experienced economic difficulties (51.4%), report having

two chronic conditions, and reside in rural municipalities (60.7%). About 52% of the sample have at least one adult-children residing outside of Puerto Rico and 25.9% had elevated levels of depressive symptoms at the time of interview.

After examining the sample characteristics, we want to stratify the sample by elevated depression symptoms status (See table 9). We see a slight increase in having an adult-migrant child among participants with elevated depressive symptoms (53.5% vs. 51.5%). Older adults with elevated levels of depressive symptoms are more likely to be female (66.1%), have 7.5 years of education, are married (46.7%), have on average four children, most have experienced “sometimes” economic difficulties (40.8%), have two chronic conditions on average, and reside in rural municipalities.

On the other hand, older adults with low levels of depressive symptoms have similar characteristics, although gender disparities are stagnant (47.1% vs. 52.9%). Most are female, the vast majority are married (58.4%), have on average four children, have 69.8 years of age, and reside in rural municipalities. One of the strongest differences between older adults with elevated levels and low levels of depressive symptoms in this sample is how they experienced economic difficulties. Most older adults with low levels of depressive symptoms have never experienced economic difficulties (55.5%). Moreover, older adults with low levels of depressive symptoms present higher levels of education.

Once we have explored the covariates stratified by elevated depression symptoms status, we move to create the log-binomial regression model for depressive symptoms using adult-child migration as the independent variable of interest. Table 10 shows the parameters for the log-binomial regression models. Model 1 contains the unadjusted

association between adult-children migration and depressive symptoms. Model 2 contains the association between adult-children migration and depressive symptoms adjusted by all covariates. In model 1 we see that adult-children migration is not associated with elevated levels of depressive symptoms (PR= 1.06; CI: 0.90 – 1.25; p=0.48). The parameter tends to indicate more of a negative effect of migration on parental depression, however, there is no significance. Furthermore, model 2 presents the adjusted parameter which remain not significant after adjusting for the covariates (PR= 0.99; CI: 0.85 – 1.16; p=0.91).

Table 10. Log-Binomial Regression Model Parameters to Predict Depressive Symptoms

Predictor Variables	Model 1		Model 2	
	PR	CI	PR	CI
Adult-children Migration				
At least one migrant adult-child	1.06	0.90 - 1.25	0.99	0.85- 1.16
No migrant adult-child (ref)	-	-	-	-
Age				
			0.99	0.98 - 1.01
Gender				
Female			1.26*	1.03 - 1.54
Male (ref)	-	-	-	-
Educational level				
			0.98	0.96 - 1.01
Marital Status				
Divorced/Separated/Never Married			1.16	0.94 - 1.44
Widowed			1.25*	1.01 - 1.54
Married or Living Together (ref)	-	-	-	-
Number of Children Alive				
			0.99	0.97 - 1.02
Economic Difficulties				
Frequently			1.77***	1.46 - 2.14
Sometimes			1.23*	1.01 - 1.49
Never (ref)	-	-	-	-
Number of chronic conditions				
			1.17***	1.10 - 1.25
Urbanicity				
Urban			0.76***	0.65 - 0.89
Rural (ref)	-	-	-	-

pvalue = † <0.1, * <.05; ** <.01; *** <.001. Reference categories identified with (ref).

By examining the parameters in table 10, we see differences in gender, marital status, economic difficulties, and urbanicity status. Females have 26% (PR= 1.26; CI: 1.03 – 1.54) higher prevalence of suffering from elevated levels of depressive symptoms compared to males. Widowed older adults have 25% (PR= 1.25; CI: 1.01 – 1.54) higher prevalence of elevated levels of depressive symptoms compared to married older adults. Moreover, economic difficulties have a robust association with elevated levels of depressive symptoms. Older adults that experience frequent economic difficulties have 1.77 times the prevalence of elevated levels of depressive symptoms compared to older adults that have never experienced economic difficulties (PR= 1.77; CI: 1.46 – 2.14).

Lastly, number of chronic conditions and urbanicity status also demonstrate significant differences. For one unit increase in chronic conditions, the prevalence of elevated levels of depressive symptoms increases by 17% (PR= 1.17; CI: 1.10 – 1.25). Participants residing in urban municipalities have 76% (PR= 0.76; CI: 0.65 – 0.89) lower prevalence of elevated levels of depressive symptoms compared to those residing in rural municipalities. Not all covariates resulted in a significant association. Age, educational level, and number of children alive are not significantly associated with depressive symptoms.

Concerned by the threshold effect of adult-children migration on depression, and the limitations that a cut-off point in the GDS scale presents, we need to explore another measure of depression. We use the self-reported depression question in PREHCO to obtain a lifetime history of depression (called depression from now on).

Table 11 shows the sample characteristics stratified by lifetime history of depression. About 19.3% of older adults report been told by a physician that they at some point in their life suffered from depression. Among those who suffered depression, 55.8% report having at least one child living outside of Puerto Rico. Most are on average 67.7 years of age, female, married, have four children, have sometimes experienced economic difficulties, have two chronic conditions, and reside in rural municipalities. Among those who have never had depression, 51.1% report having at least one child outside of Puerto

Table 11. Target Sample Characteristics with Lifetime History of Depression

Variables	N	Weighted Mean (std) or Proportion	Depression (n=643)	No Depression (n=2,742)
Adult-children Migration				
At least one adult-children outside of PR	1768	52.0%	55.8%	51.1%
No adult-children living outside of PR	1617	48.0%	44.2%	48.9%
Lifetime History of Depression				
Depression	643	19.3%	-	-
No Depression	2742	80.7%	-	-
Age	3385	69.9 (0.2)	67.7 (0.4)	70.4 (0.2)
Gender				
Male	1345	44.7%	33.6%	46.0%
Female	1768	56.3%	66.4%	54.0%
Educational level	3385	8.3 (0.1)	8.2 (0.2)	8.3 (0.1)
Marital Status				
Married or Living Together	1451	55.3%	52.4%	56.1%
Widowed	1233	25.5%	25.5%	25.4%
Divorced/Separated/Never Married	701	19.2%	22.1%	18.5%
Number of Children Alive	3385	4.2 (0.06)	4.1 (0.2)	4.2 (0.1)
Economic Difficulties				
Frequently	492	12.4%	17.3%	11.2%
Sometimes	1228	36.2%	44.3%	34.3%
Never	1665	51.4%	38.4%	54.5%
Number of chronic conditions	3385	1.67 (0.03)	2.0 (0.1)	1.59 (0.1)
Urbanicity				
Urban	1325	39.30%	37.7%	39.7%
Rural	2060	60.70%	62.3%	60.3%

Rico. Most are on average 70.4 years of age, are female, married, have never experienced economic difficulties, have 1.59 chronic conditions on average, and reside in rural municipalities.

We now create the log-binomial regression model like the previous one with the lifetime history of depression measure. We follow the same method while creating the model. Model 1 is the unadjusted log-binomial regression model and model 2 contains the adjusted parameters.

Table 12. Log-Binomial Regression Model Parameters to Predict Life-Time History of Depression

Predictor Variables	Model 1		Model 2	
	PR	CI	PR	CI
Adult-children Migration				
At least one migrant adult-child	1.17	0.96 - 1.41	1.20†	0.99 - 1.46
No migrant adult-child (ref)	-	-	-	-
Age			0.95***	0.94 - 0.97
Gender				
Female			1.32*	1.06 - 1.65
Male (ref)	-	-	-	-
Educational level			0.99	0.98 - 1.02
Marital Status				
Divorced/Separated/Never Married			1.14	0.91 - 1.43
Widowed			1.09	0.86 - 1.39
Married or Living Together (ref)	-	-	-	-
Number of Children Alive			0.98	0.95 - 1.03
Economic Difficulties				
Frequently			1.46**	1.13 - 1.90
Sometimes			1.41***	1.14 - 1.74
Never (ref)	-	-	-	-
Number of chronic conditions			1.24***	1.15 - 1.34
Urbanicity				
Urban			0.95	0.79 - 1.15
Rural (ref)	-	-	-	-

pvalue = † <0.1, * <.05; ** <.01; *** <.001. Reference categories identified with (ref).

Table 12 presents the estimated parameters for the log-binomial regression models. The unadjusted association between adult-children migration and depression is not significant ($p=0.11$). However, when adjusting for the covariates the association between adult-children migration and depression is marginally significant ($p=0.06$). Older adults with at least one adult-child outside of Puerto Rico have 20% (PR=1.20; CI: 0.99 – 1.46) higher prevalence of having suffer depression at some point compared to older adults with no children outside of Puerto Rico.

There are other covariates that are also significant in this model. Age is associated with depression. It seems to be protective for this sample. A unit increase in age is associated with 5% lower prevalence of depression (PR= .95; CI: 0.94 – 0.97). Females have 32% higher prevalence of depression compared to males (PR=1.32; CI: 1.06 – 1.65). Furthermore, older adults who report having frequently experienced economic difficulties have 46% (PR=1.46; CI: 1.13 – 1.90) higher prevalence of depression compared to those who have never experienced economic difficulties. Older adults sometimes experiencing economic difficulties have 41% (PR=1.41; CI: 1.14 – 1.74) higher prevalence of depression. Moreover, a unit increase in chronic conditions is associated with an increase of 24% in the prevalence of having suffer from depression (PR= 1.24; CI: 1.15 - 1.34).

Table 13. Target Sample Characteristics with Disability

Variables	N	Weighted Mean (std) or Proportion	Disability (n=510)	No Disability (n=2,875)
Adult-children Migration				
At least one adult-children outside of PR	1768	52.0%	56.2%	51.4%
No adult-children living outside of PR	1617	48.0%	43.8%	48.6%
ADL Disability				
Disability	510	13.0%	-	-
No Disability	2875	87.0%	-	-
Age	3385	69.9 (0.2)	70.8 (0.4)	69.8 (0.2)
Gender				
Male	1345	44.7%	32.7%	45.3%
Female	1768	56.3%	67.3%	54.7%
Educational level	3385	8.3 (0.1)	7.1 (0.3)	8.5 (0.1)
Marital Status				
Married or Living Together	1451	55.3%	50.8%	56.0%
Widowed	1233	25.5%	32.7%	24.4%
Divorced/Separated/Never Married	701	19.2%	16.5%	19.6%
Number of Children Alive	3385	4.2 (0.06)	4.5 (0.2)	4.1 (0.1)
Economic Difficulties				
Frequently	492	12.4%	18.5%	11.5%
Sometimes	1228	36.2%	49.0%	34.3%
Never	1665	51.4%	32.5%	54.2%
Number of chronic conditions	3385	1.67 (0.03)	2.3 (0.1)	1.6 (0.1)
Urbanicity				
Urban	1325	39.30%	65.3%	60.0%
Rural	2060	60.70%	34.7%	40.0%

In terms of parental physical health, we use disability as our outcome of interest. First, we estimate the sample characteristics stratified by parental disability status (see table 13). About 13% of older adults in this sample have at least one disability. Most older adults with at least one disability have migrant adult-children (56.2%). On average are 70.8 years old, female, married, have sometimes experienced economic difficulties, have 2.3 chronic conditions, and live-in rural municipalities.

There is no association between having and migrant adult-children and parental disability in both regression models (see table 14). In model 1, the unadjusted association between migrant adult-children and disability is not significant with a $p=0.13$ (PR=1.18; CI: 0.95 – 1.48). Once we adjust for covariates, the association becomes weaker (PR=1.14; CI: 0.91 – 1.43; $p=0.26$). However, other covariates are good predictors of disability.

Table 14. Log-Binomial Regression Model Parameters to Predict Disability

Predictor Variables	Model 1		Model 2	
	PR	CI	PR	CI
Adult-children Migration				
At least one migrant adult-child	1.18	0.95 - 1.48	1.14	0.91 - 1.43
No migrant adult-child (ref)	-	-	-	-
Age			1.01	0.99 - 1.02
Gender				
Female			1.34*	1.01 - 1.76
Male (ref)	-	-	-	-
Educational level			0.97†	0.94 - 1.00
Marital Status				
Divorced/Separated/Never Married			0.83	0.62 - 1.12
Widowed			0.96	0.69 - 1.32
Married or Living Together (ref)	-	-	-	-
Number of Children Alive			0.98	0.94 - 1.02
Economic Difficulties				
Frequently			1.86***	1.37 - 2.54
Sometimes			1.73***	1.33 - 2.24
Never (ref)	-	-	-	-
Number of chronic conditions			1.47***	1.34 - 1.61
Urbanicity				
Urban			0.91	0.73 - 1.14
Rural (ref)	-	-	-	-

pvalue = † <0.1, * <.05; ** <.01; *** <.001. Reference categories identified with (ref).

Females have 34% higher prevalence of disability compared to males (PR=1.34; CI: 1.01 – 1.76). Older adults who experience frequent economic difficulties have 1.86 times the prevalence of disability compared to older adults who never experience

economic difficulties (PR=1.86; CI: 1.37 – 2.54). Those who sometimes experience economic difficulties have 73% higher prevalence of disability (PR=1.73; CI: 1.33 – 2.24). Moreover, chronic conditions are strong predictors of disability. For one unit increase in chronic conditions, the prevalence of disability increase by 47% (PR=1.47; CI: 1.34 – 1.61).

Instrumental Variable Analysis

The IV approach relies critically on the validity of the instruments. Table 15 shows the IV assumptions and their respective tests. We start by testing the first assumption that stipulates an association between the proportion of male children (instrument) and adult-children migration, we use a log-binomial regression model. The parameter is statistically significant (PR =1.28; CI: 1.09 – 1.49; $p < 0.001$). It seems that as the proportion of male children increases the prevalence of having a migrant adult-children increases by 28%.

The second assumption stipulates that the proportion of male children is not associated with parental depressive symptoms and/or disability; and the association between these two variables is only through the adult-children migration. To test this assumption, we create a log-binomial regression model for depressive symptoms and another for disability. The proportion of male children is the independent variable, and these models are adjusted by having a migrant adult-child to test the only pathway through which the instrument is associated with the health outcomes. The models result not significant with a $p=0.59$ for depressive symptoms and $p=0.96$ for disability. The proportion of male children is not associated with parental depressive symptoms nor parental disability.

Table 15. Validation of Instrumental Variable for IV Analysis

Instrumental Variable Assumptions	Depression	Disability	Instrument Validation
(I) Proportion of male children is associated with having a migrant adult-child.	PR=1.28; [CI= 1.09 - 1.49]	PR=1.28; [CI= 1.09 - 1.49]	TRUE
(II) Proportion of male children is NOT associated with parental depressive symptoms and disability; only through having a migrant adult-child.	PR=0.93; [CI= 0.70 - 1.22]	PR=1.01; [CI= 0.70 - 1.46]	TRUE
(III) Proportion of male children shares no common causes with parental depressive symptoms and disability	N/A	N/A	TRUE

(I) Assumption tested with a log-binomial regression to predict prevalence of having a migrant adult-child.

(II) Assumption tested with a log-binomial regression to predict prevalence of elevated depressive symptoms or disability adjusting by covariates.

(III) Assumption tested conceptually.

These results show that the first and second assumptions are true for both health outcomes. The proportion of male children is associated with adult-children migration and is not associated with parental depressive symptoms nor disability. The only assumption left must be tested conceptually.

The third assumption stipulates that the proportion of male children shares no common causes with parental depressive symptoms and/or disability. Depression is a multifaceted component affected by exogenous risk factors like stress life events, period of illnesses, chronic conditions, and exposure to other social and financial disadvantages (Abas et al., 2009; Chowdhury, Balluz, Zhao, & Town, 2014; Jensen et al., 2014; L. G. Perez et al., 2015; Song, 2017). There is no evidence that the same set of factors would affect the proportion of male children in the offspring of adults with or without depression. The same reasoning can be applied to the relationship between the proportion of male children and disability. Therefore, nor the instrument, depression, or disability shares common causes confirming the third assumption to be true.

Table 16. Determinants of having a migrant adult-child. First stage IV regression.

Variables	PR	CI
Intercept	0.22	0.14 - 0.34
Proportion of Male Children	1.32	1.12 - 1.55
Age	1.01	0.99 - 1.01
Gender		
Female	0.90	0.81 - 0.99
Male (ref)	-	-
Educational level	1.01	0.99 - 1.01
Marital Status		
Widowed	1.16	1.04 - 1.29
Divorced/Separated/Never Married	1.00	0.89 - 1.13
Married or Living Together (ref)	-	-
Number of Children Alive	1.10	1.08-1.12
Economic Difficulties		
Frequently	0.98	0.86 - 1.11
Sometimes	1.01	0.92 - 1.11
Never (ref)	-	-
Number of chronic conditions	1.02	0.98 - 1.12
Urbanicity		
Urban	0.96	0.88 - 1.06
Rural (ref)	-	-

Reference categories identified with (ref).

Now that all assumptions are true, we can build the IV analysis and estimate the causal relationship between adult-children migration and parental depressive symptoms and parental disability. In the first step of the IV analysis, we estimate the association between adult-children migration and male children proportion adjusting for the confounders listed previously. Table 16 shows the first stage of the IV analysis. We can observe that the proportion of male children is associated with having at least one adult-child outside of Puerto Rico. For a unit increase in the proportion of male children, the prevalence of having a migrant adult-child increases by 32% (PR=1.32; CI: 1.12 – 1.55).

Furthermore, other covariates are also significant on predicting the prevalence of having a migrant adult-child like gender, marital status, and number of children alive.

For the second stage of the IV analysis, we use the predicted values of the first stage and incorporate it in the log-binomial regression model for elevated levels of depressive symptoms. In this stage we want to estimate the association between adult-children migration and elevated levels of depressive symptoms using the instrument. To obtain the causal relationship we substitute the adult-children migration parameter by the predicted values in the previous stage. Table 17 shows the second stage results of the IV analysis.

The estimate for the casual relationship between adult-child migration and parental elevated levels of depressive symptoms remains not significant (PR= 0.87; CI: 0.26 – 2.92; $p=0.83$). There seems to be no association within this sample. However, other covariates yield significant results. Economic difficulties is the strongest predictor of depression. Older adults experiencing frequent economic difficulties have 1.74 times the prevalence of suffering from elevated levels of depressive symptoms compared to older adults who never experience economic difficulties. Similar pattern happens with older adults who sometimes experience economic difficulties (PR= 1.26; CI: 1.04 – 1.53). In addition, females have 27% (PR= 1.27; CI: 1.02 – 1.57) higher prevalence of elevated levels of depressive symptoms compared to males. Divorced, separated, or never married older adults have 27% (PR= 1.27; CI: 1.01 – 1.58) higher prevalence of elevated levels of depressive symptoms compared to married older adults. Number of chronic conditions is still significant and urbanicity status resulted in significant parameters. Older adults residing in urban municipalities have a 25% (PR=0.75; CI:0.63 – 0.89) lower

prevalence of suffering from elevated levels of depressive symptoms compared to older adults residing in rural municipalities. Furthermore, the instrumental variable analysis yielded similar non-significant results for the causal association between adult-child migration and depression when using lifetime history of depression ($p=0.54$).

Table 17. Causal relationship between Adult-Child Migration and Health Outcomes. Second stage IV regression.

Variables	Depression		Disability	
	PR	CI	PR	CI
Intercept	0.20***	0.08-0.44	0.03***	0.01-0.09
Adult-children Migration	0.87	0.26-2.92	0.78	0.14-4.46
Age	0.99	0.98-1.01	1.01	0.99-1.02
Gender				
Female	1.27*	1.02-1.57	1.31†	0.99-1.74
Male (ref)	-	-	-	-
Educational level	0.98	0.97-1.01	0.98	0.95-1.01
Marital Status				
Widowed	1.19	0.94-1.50	0.86	0.61-1.19
Divorced/Separated/Never Married	1.27*	1.01-1.58	0.96	0.70-1.32
Married or Living Together (ref)	-	-	-	-
Number of Children Alive	1.00	0.93-1.09	1.01	0.89-1.14
Economic Difficulties				
Frequently	1.74***	1.43-2.13	1.85***	1.35-2.53
Sometimes	1.26***	1.04-1.53	1.73***	1.33-2.26
Never (ref)	-	-	-	-
Number of chronic conditions	1.19***	1.11-1.28	1.47***	1.34-1.62
Urbanicity				
Urban	0.75***	0.63-0.89	0.91	0.73-1.13
Rural (ref)	-	-	-	-

pvalue = † <0.1, * <.05; ** <.01; *** <.001. Reference categories identified with (ref).

Adult-children migration is replaced by the predicted values of the first stage in the IV analysis.

There is no causal relationship between adult-child migration and parental disability (PR=0.78; CI: 0.14 – 4.46). Gender, economic difficulties, and number of chronic conditions are all significant predictors of disability in late life. In contrast with the IV model for depression, urbanicity is not a significant predictor of disability.

Discussion

This study examines the association between adult-children migration and the health of older adults left behind in Puerto Rico. Results indicate no association between elevated levels of depressive symptoms and adult-children migration. However, when considering a lifetime history of depression, older adults with a migrant adult-child are more likely to report a history of depression than older adults with no children residing outside of Puerto Rico. Consistent results are found in the counterfactual approach for both measurements. We found no causal relationship between adult-children migration and depression. Furthermore, adult-children migration is not associated with parental disability. The counterfactual approach for parental depression and disability confirms the strong effect of economic difficulties on the well-being of older adults in Puerto Rico. Also, gender and chronic conditions are consistent risk factors for the health and wellbeing of older adults left behind.

The literature on migration and health for the left behind parents is mixed with effects moving in both directions. When using life-course depression as the health outcome of interest, our results compared to studies in China and Mexico (Y. Lu et al., 2012; M. Antman, 2012). Older adults facing the migration of adult children are prone to suffer from depression at some point in their lives. The literature suggests that the loss of an adult-child to migration limits the desired contact of the older parent with the migrant child. This increases the perception of loneliness and social isolation, two psychosocial factors linked to depressive symptoms and physical health in older adults (Holt-Lunstad et al., 2015). When the expected levels of emotional and instrumental support from adult children cannot be met, older parents could find themselves stressed and lonely. Also,

the longing that comes from missing a son/daughter could increase the feelings of sadness and agony, leading to stress and depression. Furthermore, Antman (F. Antman, 2010) found that older adults with migrant adult children also face physical health deterioration due to the toll depression takes on the body. Our results did not identify this proposed pathway between adult-children migration and physical health in Puerto Rican older adults. It is possible that the nuance of the increase in outmigration has not affected the physical health of older adults in Puerto Rico yet.

On the other hand, our results of no association between adult-children migration and parental elevated levels of depressive symptoms and disability are supported by previous studies (Abas et al., 2009; Ghimire et al., 2018; John, David, & Steven, 2011; Jacqueline M. Torres et al., 2018). Ghimire found that depressive symptoms and self-reported physical health are not associated with adult-children migration among left-behind older adults in Nepal. Studies in Tonga, Thailand, and other countries have found similar results (Abas et al., 2009; John et al., 2011). The discrepant findings in the literature suggest that in understanding migration and health, context is critical. A few factors may explain our null findings. The literature suggests that the migration of adult-children disrupts the family structure of the older adult left behind. Familial separation and increased social isolation are caused by the migration of adult-children in many countries. However, this study sample has, on average, four children, and half of the older adults are married. The psychological and instrumental loss of having a migrant adult-child could be replaced and provided by other adult-children or family members after an adult-child has migrated. These older adults may enjoy several advantages such as emotional support from other family members, increased efficiency due to pooled household labor,

immediate help and care during illness and adversity, among others (Ghimire et al., 2018). Moreover, a recent study on the psychological wellbeing of left behind Puerto Rican older adults found that being optimistic, grateful, and holding on to the thought that their adult-children have a better quality of life in the United States buffers the sadness and adverse effects that arise from familial separation, decreasing the risk of suffering from depression and disability (Toro Adorno et al., 2021). Most participants were optimistic, happy, and proud to have migrant adult-children. Most older adults still identified missing their migrant sons/daughters as the most challenging thought to overcome after the migration event. However, having other family members taking care of them could explain this study's results. Further study is needed to identify how the family structure impacts the relationship between adult-children migration and the health and wellbeing of older adults left behind.

This study uses data from the only representative sample of older adults in Puerto Rico. PREHCO incorporates an island-wide sampling to represent the older adult population of every region in Puerto Rico. More than 75% of all municipalities in Puerto Rico are incorporated in this study, increasing confidence in the results' generalizability. Also, we introduce an objective measure of adult-children migration by incorporating the residence of every adult-children through the family roster provided in PREHCO. However, certain limitations prevent this study from identifying the pathways through which adult-children migration affects the health and well-being of Puerto Rican older adults.

A limitation of this study is the difficulty of ascertaining the order of temporality given the data available. How long does it take for adult-children migration to affect the

wellbeing of people in sending areas? At this time, no study has identified a cut point or threshold effect for the time it takes adult-children migration to affect health. Our study incorporates an adult-children migration measure; however, it is unclear how and when this adult-children migration happened. This study reduced the effect of unmeasured confounding by employing a counterfactual approach; nevertheless, further research is needed to address these gaps in the migration and health literature.

The second limitation is the time of the study. PREHCO was conducted during 2002 - 2007, a time where outmigration was beginning to increase. It is not until 2007-2009 when Puerto Rico starts documenting the increase in outmigration due to the financial crisis that began in 2007 (Rodríguez, Figueroa, & Negrón, 2012; Velazquez Estrada, 2018). This study design captures the effect of adult-child migration at the beginnings of a migratory wave that would last at least for the next 14 years. It is highly probable that most adult-children migrants in the data are not taking part in these recent migratory patterns. However, PREHCO is currently the only representative sample of older adults in Puerto Rico. Moreover, we found a significant effect of adult-children migration on parental depression, which supports the need for more recent data collection projects to estimate the impact of outmigration on the health of older adults in Puerto Rico.

Another limitation is the subjective measure of depression. The depression measures are self-reported and may not reflect the genuine estimates of mental health status. However, self-reported information on mental health has been the widely accepted approach, especially when available resources are limited.

This study shows that the relationship between adult-children migration and the health of left behind older adults in Puerto Rico is not as straightforward as in other

countries. Having migrant adult-children does not affect older adults' health by itself. The many factors around the migration process are responsible for the impact adult-children migration has on parental health. This study highlights the uncertainty of the impact of adult-children migration on parental health. With the accelerating pace of out-migration in the last 14 years, it is imperative to estimate the prospective effect migration could have on older adults' health. This is the first attempt to understand migration as a social determinant of health for older adults left behind. Identifying critical factors should inform the development of new policies to reduce the impact migration has on health. Our findings emphasize the need for comparative research on adult-children migration and older adults' well-being in Puerto Rico.

Chapter IV: Psychosocial Determinants of Activities of Daily Living Disability among Older Adults in Puerto Rico.

Introduction

The disruption of the social environment in late life increases the burden of detrimental health outcomes (Aida et al., 2013; Alegria et al., 2007; Bozo & Guarnaccia, 2010). As family size continues to dwindle globally, given the decrease in fertility and the changes in other demographic forces, more and more older adults have fewer family members to rely on (IOM, 2018; Sudharsanan & Bloom, 2018). This demographic transition has increased the number of older adults with reduced social networks, isolated and feeling alone (Gerst-Emerson & Jayawardhana, 2015; Holt-Lunstad et al., 2015; Lauren Newmyer, Ashton M. Verdery, Rachel Margolis, & Léa Pessin, 2020b). The recent changes in psychosocial determinants associated with healthy aging have increased academic attention. However, no study in Puerto Rico has examined the consequences of social support and loneliness on the health of older adults. This study examines the association between social support and loneliness with the incidence of disability in Puerto Rican older adults.

Disability is defined as the difficulty to perform social and self-care tasks across any domain of life due to physical, sensory, emotional, or cognitive limitations (L. Dong, Freedman, & Mendes de Leon, 2020; Garcia et al., 2017). Disability is a well-known measure of population health. The prevalence of disability provides a useful population measure to assess current and future health patterns for older populations. Even though there are many scales and instruments to measure functional disability, the Activities of Daily Living (ADL) are widely used in the literature given its efficiency (Katz et al., 1963). Disability in late life is linked to many mental and physical health outcomes; depression, dementia, self-rated health, chronic conditions, among others (Bozo & Guarnaccia, 2010; Castaneda-Sceppa et al., 2010; Jensen et al., 2014; Mendes de Leon, Eschbach, &

Markides, 2011; Monteverde, Noronha, & Palloni, 2009; Stuck et al., 1999). It has also been used as a proxy for overall health among older adults.

Moreover, disability is associated with psychosocial determinants of health like social support, social network, loneliness, and social capital (Aida et al., 2013; Escobar-Bravo et al., 2012; Jensen et al., 2014; McLaughlin et al., 2012). Many studies have examined the protective effects and the risks the changes in the psychosocial determinants of health have on disability in late life. Experts agree that findings are mixed and dependent on context. Several studies have found that social support is beneficial for the health and well-being of older adults (Bozo & Guarnaccia, 2010; Jensen et al., 2014; Liao & Scholes, 2017; McLaughlin et al., 2012), and loneliness has detrimental consequences for their health (Cacioppo & Hawkley, 2003; Coyle & Dugan, 2012; Holt-Lunstad et al., 2015; House et al., 1988). Satisfaction with the social support received from informal sources of support (family and friends) is associated with improvements in depression, self-rated health, chronic conditions, and ADLs. However, studies have also found that the effect of social support on older adults' health depends on the quality and source of the support, which can negatively affect the older adults. Increased stress due to familial responsibilities, discrepancies in the expected vs. received social support, and feelings of perceived abandonment are negative qualities within social support networks that affect mental and physical health. Understanding the positive and negative pathways between social support, loneliness, and health is critical to assess the impact psychosocial determinants have on functional disability.

Social support is defined as those social interactions that provide individuals with actual assistance or embedded them into a web of social relationships perceived to be

loving, caring, and readily available in times of need. Social support has been shown to have both buffering effects and direct beneficial effects on various health-related outcomes. Conventionally there are two known approaches to explain the association between social support and health. On the one hand, the direct effect approach postulates social support as a benefit for health status, independently of the individual's stress levels. This approach stipulates that social support positively impacts emotional and physical well-being and decreases the probability of adverse effects within these domains (Castro, Campero, & Hernández, 1997).

On the other hand, is the buffer effect. This model postulates that social support protects individuals from the pathogenic effects of stressful events. It acts as a mediator between stress and disease. Either social support inhibits the psychopathologic processes that could develop in its absence or allows people to redefine the stressful events, like feelings of loneliness, and confronts them with less stressful strategies

Older adult loneliness has gain attention in recent years. Experts acknowledge the increases in older adults' loneliness in the world and its effect on older adults' mental and physical health (Lauren Newmyer, Ashton M Verdery, Rachel Margolis, & Léa Pessin, 2020a). Loneliness is defined as “an individual's subjective perception of deficiencies in his or her network of social relationships (Berkman & Kawachi, 2000). The relevant aspects of loneliness are that older adults experience loneliness due to deficiencies in social relations, are subjective, and are unpleasant and distressing. Studies have linked loneliness with older adults' poor mental and physical health, depression, disability, and other detrimental health outcomes. A study conducted in Puerto Rico found that older adults living alone have a higher prevalence of feeling lonely than older adults living with

someone, a feeling associated with detrimental health outcomes like depression and disability (Gao et al., 2021). With the recent changes in family structures and the increases in older adults living alone in Puerto Rico, it is imperative to examine the effect of psychosocial determinants on the disability of older adults residing in Puerto Rico.

Given the unprecedented levels of outmigration in recent years, the number of older adults left behind is increasing. More than 700,000 Puerto Ricans have migrated to the United States and other countries in the last 14 years (Velazquez Estrada, 2018). Evidence suggests that most Puerto Rican migrants are between 28 and 35 years, a particular age-group representing young professionals, adult-children, and the labor force (Velazquez Estrada, 2018). Social Scientists and Demographers argue that these migratory patterns are responsible for increasing the percent of older adults within the Puerto Rican population in the last ten years. In 2010, older adults in Puerto Rico represented 11% of the total population. In 2020, this population increased to 21%. The accelerated rapid aging due to outmigration is increasing the number of older adults facing loneliness and reduced functional support.

With the increase in the prevalence of older adults facing loneliness and reduced functional support, the Puerto Rican older generation could face detrimental health outcomes. Several studies of Puerto Ricans living in the United States have demonstrated the impact of psychosocial determinants on mortality and disability (Arevalo et al., 2014; Arévalo et al., 2015; Castaneda-Sceppa et al., 2010; Falcón et al., 2009; Zayas et al., 2013). Falcon and colleagues examined the role of social network support in ameliorating the psychological impact of life stressors for the older Puerto Rican population in the Boston Area (Falcón et al., 2009). Results demonstrate that social support dimensions,

particularly emotional support, are generally protective of suffering from depression and perceived stress. Social support was beneficial for men but manifestly less so for women.

The research on psychosocial factors and disability in Puerto Rican older adults primarily focuses on Puerto Ricans in the United States (Castaneda-Sceppa et al., 2010; Delgado, 1997; Melvin, 1997; Monteverde et al., 2009; Zayas et al., 2013). However, some studies have examined late-life disability in Puerto Rico (Downer et al., 2017). Downer and colleagues found that suffering from high depressive symptoms and diabetes increases the odds of developing activities of daily living disability among older adults in Puerto Rico. Other studies have examined the association between loneliness and mortality in Puerto Rico. The authors did not find an association between perceived loneliness, social network size, and mortality among older adults. Even though disability and psychosocial factors have been studied in older Puerto Ricans residing in Puerto Rico, no studies examine the pathways between social support, loneliness, and disability.

In conclusion, the unprecedented levels of outmigration and the rapid aging of the Puerto Rican population increase the prevalence of loneliness and reduced social support. Family structures have changed drastically in recent years. These changes affect the social resources that older adults used to rely on. Therefore, it is imperative to study the pathways and effects of psychosocial determinants on late-life disability among older adults in Puerto Rico. In this chapter, we examine the prevalence of loneliness and social support. We also estimate the incidence of activities of daily living disability in Puerto Rico. Lastly, we examine the association between psychosocial determinants and the incidence of disability among older adults in Puerto Rico.

Methodology

Data source

This study's data comes from the Puerto Rico Elderly: Health Conditions study (PREHCO) (Palloni et al., 2013). PREHCO is a longitudinal survey of the noninstitutionalized population aged 60 and over and their surviving spouses. The sample is a multistage, stratified sample of the noninstitutionalized older adult population residing in Puerto Rico, with oversamples of regions heavily populated by people of African descent and individuals over age 80 (McEnry & Palloni, 2010; Palloni et al., 2013). Data was collected through face-to-face interviews with older adults, including those with cognitive limitations who required the presence of a proxy, and their spouses, regardless of age. More than 20,600 households were visited in 233 sample sections. A total of 4,291 target interviews were conducted from May 2002 to May 2003. A second wave was conducted during 2006-2007. Only 4.7% of the overall sample refused to participate, and the survey response rate was 93.9%. The survey instrument includes modules on demographic characteristics, health status and conditions, family structure, migration status, economic status, cognitive and functional performance, income and assets, health insurance and use of health services, intergenerational transfers, housing, anthropometric measurements, and physical performance. A combination of the survey modules is used to obtain individual-level characteristics and health outcomes. PREHCO uses sampling weights to represent the total population over 60 years old in Puerto Rico at the time of the study. Sampling weights are incorporated in the analysis to ensure that results represent the older adult population in Puerto Rico. The study protocol and procedures were approved by the Institutional Review Boards (IRB) of the University of Wisconsin and the University of Puerto Rico.

PREHCO data is publicly available to any person for research purposes. Documentation on methodology, survey instruments, target sample, and previous publications can be access at the PREHCO website: www.prehco.rcm.upr.edu.

Statistical analysis and data management is conducted using SAS software version 9.4, Copyright © 2019 SAS Institute Inc.

Measures of Interest

Social Support

PREHCO evaluated the participant's social support using five questions focused on received instrumental and emotional support. Following are the questions used:

- Do you receive help with transportation?
- Do you receive help with work tasks, household chores, or gardening?
- Do you receive help with errands?
- Does someone care for you when you are sick?
- Is there someone that helps you by visiting you, keeping you company, or listening to you?

Respondents could report if they received the mentioned support or not. For this analysis, I will calculate the count of affirmative responses to create a continuous measure of social support.

Living Alone

Previous studies have developed different methods to capture the perception of loneliness in older adults and estimated significant relationships between various

measures (Newmyer et al., 2020b). Studies using survey data have used one-item and three-item measures, items within depression scales, among others. PREHCO does not contain a validated scale of loneliness; however, it contains questions regarding the number of household members. For this study, we use living alone at the time of the interview to measure loneliness. Previous studies have found a positive association between living alone and feelings of loneliness in Puerto Rican older adults (Gao et al., 2021).

Activities of Daily Living (ADL)

When compensatory mechanisms are unavailable or no longer sufficient to complete tasks that have become difficult, older adults may need the assistance of other people to manage their daily lives (Albert, 2010). Previous research suggests that those who cannot adapt to such changes are at greater risk of health deterioration (Freedman et al., 2008; Freedman & Spillman, 2016; Garcia et al., 2017; Nagi, 1976). ADLs are considered the fundamental and universal competencies of adulthood. The loss of essential ADL competencies, the ability to toilet or bathe oneself, is a severe threat, not just to social participation and safety, but also to adulthood and self-worth (Albert, 2010). PREHCO included the Katz (Katz et al., 1963) difficulties with activities of daily living. During the first wave, participants were asked whether they have difficulty eating, dressing, toileting, walking, getting up or laying down in bed, or bathing due to a health problem. Participants were asked not to consider difficulties or limitations that he or she expected to last fewer than three months. Participants who reported having difficulties in at least one ADL are considered as having ADL disability.

Covariates

Given the lack of research on psychosocial determinants and disability of Puerto Rican older adults, it is challenging to identify confounding factors with certainty. Therefore, we focus on the well-established social determinants of health among Hispanic older adults: age, gender, educational level, marital status, number of children, economic difficulties, number of chronic conditions, and urbanicity. Covariates are measured in PREHCO's wave 1. Educational level is defined as years of education completed. Number of children is defined as the total number of children alive at the time of the interview. Economic difficulties are defined as how often the participant has experience difficulties paying living expenses. Chronic conditions are defined as a count measure of the following chronic conditions: hypertension, diabetes, cancer, heart disease, stroke, and arthritis.

Analytic Approach

We begin our analysis by examining the target sample characteristics using a descriptive approach. Weighted means and standard deviation are used to observe the distribution of continuous variables. Weighted frequencies and percentages are used for categorical variables. Percentages and means are calculated for disability, social support, loneliness, and covariates. Given the dichotomous structure of the incidence of disability, we create logistic regression models to estimate the adjusted association between social support, loneliness, and disability. The model for social support and loneliness has the following structure:

Logit (Pr(Disability = 1))

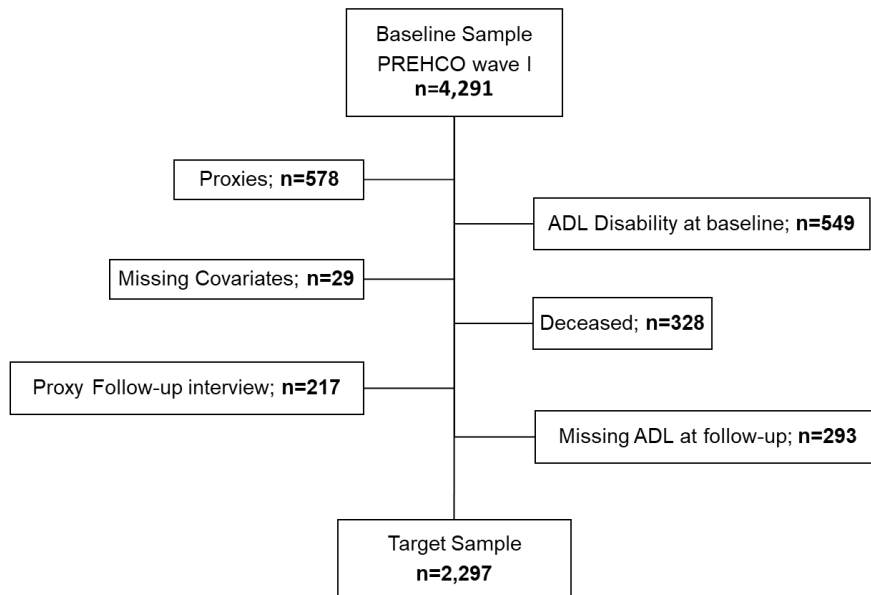
$$\begin{aligned} &= \beta_0 + \beta_1 \text{SocialSupport} + \beta_2 \text{Loneliness}_i + \beta_3 \text{Age}_i + \beta_4 \text{Gender}_i + \beta_5 \text{Educ}_i \\ &+ \beta_6 \text{Marital}_i + \beta_7 \text{\#ofChildren}_i + \beta_8 \text{EconomicDiff}_i \\ &+ \beta_9 \text{\#ChronicConditions}_i + \beta_{10} \text{Urbanicity}_i \end{aligned}$$

β 's represents the effects of the independent variables included in the model. The i 's indicate individuals. This model estimates the effect of social support and loneliness on the incidence of parental disability, holding all other covariates constant. Diagnostics are performed to assess the validity of the model. Survey sampling weights are included in the analysis to ensure the representativeness of the data.

Results

First, we implement the exclusion criteria to the complete sample in PREHCO's wave I. We exclude participants that used a Proxy to complete the interviews (from wave I and wave II), with ADL disability at baseline, missing covariates, deceased, and missing ADL disability data in follow-up wave. 1,994 participants meet the exclusion criteria. Therefore, after excluding participants, the analytic sample resulted in 2,297 PREHCO participants. The following figure illustrates the analytic sample selection.

Figure 11. Selection into Analytic Sample



The target sample for this study is on average 68.8 years old, Female (54.8%), have 8.7 years of education, are married (55.6%), and have on average 3.8 children (see table 18). Most older adults have not experienced economic difficulties (54.1%), have on average 1.52 chronic conditions, and live in rural municipalities (60.8%). The incidence of disability is 13.4% from 2002-2007 among older adults in Puerto Rico. Furthermore, older adults on average have a social support score of 1.69, and 23.9% live alone.

After examining the sample characteristics, we stratified the sample by incident disability (see table 18). We can see that 30.7% of participants who reported a disability in follow-up were living alone at baseline. Furthermore, the incidence of disability among older adults living alone is 17.2% compared to 12.2% among older adults living with someone (results not shown). Also, we see differences in the social support score. Older adults reporting a disability have on average a score of 2.04 compared to 1.64 among older adults with no disability at follow-up. Among other covariates, the stratified sample

has similar distributions. However, more females are among older adults with disabilities at follow-up than older adults not reporting a disability (66.1% vs. 53.1%). Moreover, older adults with a disability have lower educational levels, have more chronic conditions, and there are more widowed older adults compared to older adults not reporting a disability.

Table 18. Target Sample Characteristics

Variables	N	Weighted Mean (std) or Proportion	Disability (n=344)	No Disability (n=1,953)
Social Support	2297	1.69 (0.04)	2.04 (0.1)	1.64 (0.04)
Living Alone				
Yes	707	23.9%	30.7%	22.8%
No	1590	76.1%	69.3%	77.2%
ADL Disability				
Disability	344	13.4%	-	-
No Disability	1953	86.6%	-	-
Age	2297	68.8 (0.2)	70.2 (0.5)	68.5 (0.2)
Gender				
Male	913	45.2%	33.9%	46.9%
Female	1384	54.8%	66.1%	53.1%
Educational level	2297	8.7 (0.1)	7.7 (0.3)	8.9 (0.1)
Marital Status				
Married or Living Together	996	55.6%	48.1%	56.8%
Widowed	729	21.7%	27.4%	20.9%
Divorced/Separated/Never Married	572	22.6%	24.5%	22.3%
Number of Children Alive	2297	3.8 (0.1)	3.7 (0.2)	3.8 (0.1)
Economic Difficulties				
Yes	1083	45.9%	58.2%	44.0%
No	1214	54.1%	41.8%	56.0%
Number of chronic conditions	2297	1.52 (0.04)	2.04 (0.1)	1.44 (0.04)
Urbanicity				
Urban	907	39.2%	33.8%	40.0%
Rural	1390	60.8%	66.2%	60.0%

Table 19 contains the estimated parameters for the logistic regression models for incident disability. The model for social support is significant to predict incident disability. For a unit increase in the social support score, the odds of developing a disability is 15% (OR=1.15; CI: 1.01 – 1.32; p=0.04). In this model, the educational level is marginally significant. Economic difficulties, chronic conditions, and participant's age are significant predictors of incident disability. Older adults experiencing economic difficulties have 46% higher odds of developing a disability than older adults not experiencing difficulties (OR=1.46; CI: 1.01 – 2.10). Furthermore, for a unit increase in chronic conditions, the odds of developing a disability increase by 42% (OR=1.42; CI: 1.22 – 1.66). For a unit increase in age, the odds of developing a disability increase by 3% (OR= 1.03; CI: 1.01 – 1.06).

The model for loneliness is marginally significant. Older adults living alone have 47% higher odds of developing a disability than older adults who live with someone (OR=1.47; CI: 0.95 – 2.29; p=0.08). We estimate a similar association between covariates compared to the model of social support. However, for the model for loneliness, gender is statistically significant. Females have 51% higher odds of developing a disability than males when loneliness is taken into account. Age, education, economic difficulties, and chronic conditions are still significant.

After estimating the effect of social support and loneliness separately, we create a third logistic regression model with both measures. In this model, the association between social support and incident disability remained significant after controlling for loneliness. A unit increase in the social support score is associated with 17% higher odds of

Table 19. Logistic Regression models for Incident Disability

Variables	Social Support		Living Alone		Both Psychosocial Measures	
	OR	CI	OR	CI	OR	CI
Social Support	1.15*	1.01 - 1.32	-	-	1.17*	1.02 - 1.35
Living Alone						
Yes	-	-	1.47†	0.95 - 2.29	1.58*	1.01 - 2.46
No (ref)	-	-	-	-	-	-
Age	1.03*	1.01 - 1.06	1.03*	1.00 - 1.06	1.03*	1.01 - 1.06
Gender						
Female	1.39	0.94 - 2.05	1.51*	1.01 - 2.25	1.41†	0.96 - 2.01
Male (ref)	-	-	-	-	-	-
Educational level	0.97†	0.93 - 1.00	0.96*	0.93 - 0.99	0.97†	0.93 - 1.00
Marital Status						
Divorced/Separated/Never Married	1.17	0.76- 1.80	0.88	0.53 - 1.46	0.91	0.55 - 1.51
Widowed	0.91	0.55 - 1.50	0.73	0.41 - 1.30	0.71	0.40 - 1.26
Married or Living Together (ref)	-	-	-	-	-	-
Number of Children Alive	1.01	0.99 - 1.01	1.00	0.99 - 1.01	1.00	0.99 - 1.01
Economic Difficulties						
Yes	1.46*	1.01 - 2.10	1.49*	1.04 - 2.14	1.46*	1.01 - 2.10
No (ref)	-	-	-	-	-	-
Number of chronic conditions	1.42***	1.22 - 1.66	1.45***	1.25 - 1.69	1.43***	1.23 - 1.66
Urbanicity						
Urban	0.87	0.60 - 1.25	0.85	0.59 - 1.23	0.86	0.60 - 1.25
Rural (ref)	-	-	-	-	-	-

pvalue = † <0.1, * <.05; ** <.01; *** <.001. Reference categories identified with (ref).

developing a disability (OR=1.17; CI: 1.02 – 1.35; p=0.03). Moreover, the association between loneliness and incident disability is stronger when adjusting for received social support. Older adults who live alone have 58% higher odds of developing a disability when controlling for received social support (OR=1.58; CI:1.01 – 2.46; p=0.04). The covariates remained significant in all models. Age, gender, educational level, economic difficulties, and chronic conditions predict incident disability in this sample. Females have 41% higher odds of developing a disability than males when controlling for social support and loneliness. A one-unit increase in the educational level is associated with a decrease

of 3% in the odds of developing a disability. Moreover, Older adults experiencing economic difficulties have 46% higher odds of developing a disability than older adults who have never experienced economic difficulties. Finally, a unit increase in chronic conditions is associated with an increase of 43% in the odds of developing a disability.

Discussion

There is strong evidence of the relationship between psychosocial measures and disability in later life. Social support and loneliness have been associated with the development of disability in many countries; however, thus far there have no systematic data on these relationships for Puerto Rican older adults. The present study examines the association between social support, loneliness, and incident disability among older adults in Puerto Rico. Results indicate a strong association between both psychosocial measures and incident disability. Received social support is associated with higher odds of developing a disability. Even though social support is considered a psychosocial measure that benefits older adults, the use of support networks combined with the health-related need for support may account for the association found in this study. In terms of loneliness, our results are in line with what has been found in other cultural contexts. Living alone was used as a marker of loneliness and found to increase risk for ADL disability after adjustment for all control variables and social support. In addition, the results indicate that having economic difficulties and having chronic health conditions were associated with a significantly increased risk for incident disability among older adults in Puerto Rico.

The social support and health literature have found this psychosocial measure beneficial and detrimental for the health of older adults (Chang et al., 2014; Escobar-Bravo et al., 2012; Jensen et al., 2014; Liao & Scholes, 2017). Studies have found that older adults benefit from instrumental and emotional support, most commonly from adult children and close family members (Chang et al., 2014; Jensen et al., 2014; Liao & Scholes, 2017; Mariana et al., 2017; McLaughlin et al., 2012; Unsar et al., 2015). Help

with instrumental tasks like transportation, chores, grocery shopping, among others, alleviate the physical burdens these tasks may require of older adults. Furthermore, emotional support also works as a buffer from stressful life events and other challenges that would have a more powerful impact if the support was not present (Lakey & Orehek, 2011; White, Philogene, Fine, & Sinha, 2009). Falcon and colleagues examined the role of social network support in ameliorating the psychological impact of life stressors for the older Puerto Rican population in the Boston Area (Falcón et al., 2009). Results demonstrate that social support dimensions, particularly emotional support, are generally protective of suffering from depression, perceived stress, and functional decline. In a sensitivity analysis using only emotional support, results indicate that there is no association between emotional support and incident disability when adjusting for all covariates (OR=1.1; CI: 0.78-1.55). Even though our results are discrepant from Falcon's study, there is a need to include a validated scale for emotional support in PREHCO in order to confirm these results.

On the other hand, social support is identified to have detrimental effects on the health of older adults as well. In the early stages of functional decline, received social support could reflect signs of early disability. Spouse or family members taking care of the older adult could identify markers of early disability and, consequently, provide the support needed with daily tasks before any reported disability. Moreover, older adults could also identify these signs and seek help from their social support systems. The support received does not negatively affect the risk of disability; nevertheless, it is the accurate identification of early functional decline and the willingness of older adults to ask for help that yields the results from this study. Puerto Rican older adults who need support

would be driven to ask for help in daily tasks like transportation, chores, among others. Receiving instrumental support at the beginning of the study could mean that older adults activate their social support resources when in need and prone to accelerated functional decline. Studies in different populations have found similar associations between instrumental support and increased risk of developing disability (Litwin & Stoeckel, 2013; Mendes de Leon et al., 1999), in line with the general “use it or lose it” notion that continued engagement in instrumental daily tasks may slow down the overall disability process.

Furthermore, our results indicate that received social support does not vary by living situation. Older adults receive instrumental and emotional support independently of living alone or not. This concurs with evidence among Hispanics in the United States that have identified high social support as an expectation (Ishikawa et al., 2010; Rivera, 2007). These cultural expectations encompass a shared view of the world in which the family's interest is considered of higher importance than individual needs or priorities. Therefore, Puerto Rican older adults understand that they will receive the social support needed; it is just a matter of when to activate the social support system. Further study is needed to understand how the activation of the social support system and its social resources affect the development of disability among older adults in Puerto Rico.

Another explanation for the observed association between greater social support and disability in this study is the anticipation of providing instrumental support. Previous findings suggest that providing support before this support may be necessary for daily functioning may have an adverse effect on physical strength and capacities and reduce self-efficacy (Litwin & Stoeckel, 2013; Mendes de Leon, Seeman, Baker, Richardson, &

Tinetti, 1996). Although these tasks may tax the physical strength and energy older adults have, they also promote perceptions of efficacy that encourage the continued engagement in these instrumental activities of daily living and thereby slow down the progression of functional decline (Garcia et al., 2017; Landi et al., 2007). These results could mean that older adults in Puerto Rico use their social support resources before they are in need, consequently accelerating their functional decline in coming years.

The literature on loneliness has proven its detrimental effects on overall health. It is associated with increases in the risk of disability, mental health disorders, and mortality (Coyle & Dugan, 2012; Gao et al., 2021; Holt-Lunstad et al., 2015; Luo, Hawkey, Waite, & Cacioppo, 2012; Newmyer et al., 2020a; Nummela, Seppänen, & Uutela, 2010). Living alone is commonly used as a measure of loneliness. Even though living alone does not necessarily represent feelings of loneliness among Puerto Rican older adults, these two concepts have shown robust associations. Puerto Rican older adults who live alone are more likely to report feelings of loneliness than older adults who live with someone (Gao et al., 2021). Lonely older adults also commonly have more limited social relations, lack of social support, poor mental and physical health (Holt-Lunstad et al., 2015; Newmyer et al., 2020a). These characteristics, mainly poor mental health, may affect an individual's ability to take care of themselves (L. Dong et al., 2020; L. G. Perez et al., 2015). For example, depression is one of the risk factors consistently associated with functional decline (Castaneda-Sceppa et al., 2010; Chowdhury et al., 2014; Jensen et al., 2014; Unsar et al., 2015). Older adults who are depressed are more likely to incur behavioral changes that negatively affect their overall health status. Downer et al. found that Puerto Rican older adults who are highly depressed are at higher risk of developing a disability

compared to older adults not reporting depression (Downer et al., 2017). Results from this study are consistent with these findings in that older adults who live alone were more likely to develop a disability compared to those living with someone. However, depression is not the only mechanism through which loneliness might affect disability.

The literature suggests that the loss of a social support resource limits the desired contact of the older adult with that family member, leaving them with feelings of abandonment (F. M. Antman, 2010; Yao Lu, 2012; Song, 2017). The impact is dependent on the relationship with that social resource; missing a spouse or partner has a more significant impact on older adults. When the expected levels of emotional and instrumental support cannot be met, older adults could find themselves stressed and lonely due to abandonment or feelings of loneliness. Moreover, the longing that comes from missing a close family member such as a spouse, daughter or son could also increase sadness, and increase stress and functional decline. The results from this study are similar to those found in the literature in other countries. Independently on how loneliness is measured, studies find that loneliness is highly associated with an increased risk of developing a disability (Hajek & König, 2017; Mulasso, Roppolo, Giannotta, & Rabaglietti, 2016; Philip, Polkey, Hopkinson, Steptoe, & Fancourt, 2020). Furthermore, the change in how loneliness is perceived is also dictated by the social support available. Older adults who feel alone and with no social support system are at higher risk than older adults with an active social support system. Further study is needed to identify the pathways to loneliness and kinlessness among older adults in Puerto Rico and how these psychosocial measures impact overall mental and physical health.

The effect of loneliness and social support on health is poorly understood among older Puerto Ricans. Some studies have investigated the influence of informal support systems on health (De La Rosa, 1988; Delgado, 1995). Puerto Ricans who receive strong support from their informal support systems can better cope with stressful events and less likely to be afflicted with emotional or physical problems than those who receive little or no support from their informal support systems (De La Rosa, 1988). Delgado argues that Puerto Ricans' strong dependence on informal support systems has been influenced by their strong familial bonds, religious ties, and mistrust towards formal systems of support (Delgado, 1997). Although the family is without question the essential natural support system for Puerto Rican older adults in the United States and Puerto Rico, faith is a critical element in their lives. Often, religious institutions are the source of instrumental and emotional support in older adults at risk of isolation and loneliness. In this study, the number of children alive did not play an essential role in the relationship between social support, loneliness, and disability. Because our study was not designed to differentiate between social support sources and the received support, the informal support system could impact the relationship. Religious institutions could be providing much of the support for older adults when support from close family members is not available to older adults in Puerto Rico. This aspect of informal support systems is common in Puerto Rico; however, no recent study has examined the dimensions of social support that religious institutions provide in Puerto Rico or how these institutions are replacing the support that family members normally might provide.

This study uses data from the only representative sample of older adults in Puerto Rico. PREHCO incorporates an island-wide sampling to represent the older adult

population of every region in Puerto Rico. More than 75% of all municipalities in Puerto Rico are incorporated in this study, increasing confidence in the results' generalizability. Also, we employed a prospective design to eliminate temporality bias and estimate the prospective effect of psychosocial measures on incident disability in Puerto Rican older adults. However, certain limitations prevent this study from identifying the mechanisms through which social support and loneliness affect disability in Puerto Rican older adults.

The first limitation is the number of older adults that were excluded due to the study design and the potential selection bias. We excluded about 46% (1,994 participants) of the sample due to prevalent disability in the first wave, death, and missing disability data. Participants with ADL disability at baseline (N=549) were excluded due to the prospective approach of the study design. An additional 510 participants were excluded due to missing ADL disability data at follow-up. This exclusion could affect our study results by underestimating the incidence of disability given that most participants without ADL data at follow-up were the result of the need for a proxy to complete the survey. Proxy use could be due to a physical or cognitive impairment. We cannot differentiate between reason for proxy use; therefore, we had to exclude all participants that use a proxy at follow-up. We understand that this study could be underestimating the incidence of disability among older adults in Puerto Rico and its association with psychosocial measures.

The second limitation is related to the kind of psychosocial measures available in the PRECHO data. Social support is measured with many scales and questions. The questions and items included in PREHCO have been used in many other countries and studies (Alegria et al., 2007; Blazer, 1982; De La Rosa, 1988; Escobar-Bravo et al., 2012;

Falcón et al., 2009; Jensen et al., 2014; Mendes de Leon et al., 1999). However, the scale used in this study has a primary focus on instrumental support: four of the five questions included assessed receiving instrumental support, while only one assessed emotional support. The buffer effect of emotional support could not be well captured in our analysis. Evidence suggests that social support's effect depends on the type of support received. Therefore, the estimated effect of social support in our analysis is primarily instrumental rather than emotional support. Further study is needed to incorporate different types of social support and examine how it associates with changes in physical and mental health among Puerto Rican older adults.

Furthermore, loneliness is also a psychosocial measure that needs further study among Puerto Rican older adults. Previous studies have developed different methods to capture loneliness in older adults and its relationship with other measures (Newmyer et al., 2020b). There are one-item and three-item measures, items within depression scales, among others. PREHCO does not contain a validated scale of loneliness; therefore, we used the living alone variable as a proxy measure for loneliness. Not all older adults who live alone feel lonely or have a reduced social support system, which could have led to underestimating the true relationship between loneliness and ADL disability. However, previous evidence suggests a robust positive association between living alone and feelings of loneliness in Puerto Rican older adults (Gao et al., 2021).

The third limitation is the possible introduction of selection bias at baseline. PREHCO could have naturally excluded participants sensitive to the effects of psychosocial measures. For example, older adults battling depression and loneliness are less willing to participate in voluntary studies and more likely to die or have a shorter life

expectancy. Therefore, this study's participants could have been less sensitive to loneliness and social support, causing an underestimation of the effect.

Puerto Rico is experiencing drastic changes in its population composition and age structure. Increases in out-migration, rapid aging of the population, and weak social structures to support the growing older adult population increase the burden of age-associated diseases. Loneliness and social support are two important aspects of older adults' psychosocial environment. Social support which focused mostly on receiving instrumental types of support was found to increase risk of developing ADL disability. Loneliness, assessed through the marker of living alone, was also associated with increased risk for ADL disability, although this association failed to reach statistical significance. As out-migration progresses and older adults find themselves alone and consequently with reduced social support resources, public health organizations and healthcare systems must adapt to this new reality and develop new mechanisms to help older adults with ADL disability. The reduction of feelings of loneliness could help older adults have a longer disability-free life expectancy and a better quality of life.

Chapter V: Conclusion

Migration is a common phenomenon in Puerto Rico. Since the 1950s, Puerto Rico has experienced population migration mainly to the United States but not exclusively. While out-migration in prior decades kept increasing at a constant rate, the island's total population size continued to grow. It was not until 2001 when Puerto Rico experienced for the first time in its history a population decline. After 2001, most municipalities in Puerto Rico reported a population decline due primarily to the loss of young adults. It is important to understand that population decline is not only due to out-migration; other demographic processes, such as declines in fertility, also played an important role. However, the accelerated levels of population aging in Puerto Rico are due to the outmigration of young adults. More than 700,000 Puerto Ricans have migrated to the United States and other countries in the last 14 years (Velazquez Estrada, 2018). Evidence suggests that most Puerto Rican migrants are between 28 and 35 years, a particular age-group representing young professionals, adult-children, and the country's labor force (Velazquez Estrada, 2018). Social Scientists argue that these migratory patterns are responsible for increasing the percent of older adults within the Puerto Rican population in the last ten years. In 2010, older adults in Puerto Rico represented 11% of the total population. In 2020, this population increased to 21%. The accelerated rapid aging due to outmigration is increasing the number of older adults facing loneliness, reduced functional support, and structural changes to the place of residence.

When unbalanced migration, meaning when geographical locations experience more outmigrants compared to immigrants or vice-versa, the social fabric of those locations suffer positively and negatively (Abas et al., 2009; Acevedo-Garcia, Sanchez-Vaznaugh, Viruell-Fuentes, & Almeida, 2012; Alexander, Polimis, & Zagheni, 2019;

Caraballo-Cueto, 2015; Gushulak et al., 2009; Mora et al., 2017). Changes in public funds, available social resources, and social structures destined to provide public services affect the population's health and well-being; the effect is even more significant among older adults. Moreover, the broader impact of unbalanced migration on the health of older adults left behind in sending countries has been well studied in other countries; however, there is no evidence of this impact in Puerto Rico. In three separate aims, the present dissertation studies the overall impact of migration on the physical and mental health of non-migrant older adults. In the first aim, we estimate the initial consequences of population migration on the mental and overall health of older adults left behind. The second aim explores the impact of migration at the household level focused on familial separation. We examine the association between adult-children migration and the mental and physical health of older parents left behind in Puerto Rico. Finally, in the last aim, we examine the association between psychosocial determinants of health and incident disability among older adults in Puerto Rico, understanding that out-migration of family and friends impacts the social support resources and increases the risk of loneliness among older adults, and affects their overall health.

To estimate the effect of migration on the health of older adults in Puerto Rico, this study uses data from the United States Census Bureau, Puerto Rico's Department of Health, and the Puerto Rico Elderly: Health Conditions study (PREHCO). Data from the US Census and the Department of Health were used to estimate the net migration rate by municipalities in Puerto Rico. The first aim incorporated a multilevel approach. Municipality data came from the US Census and Puerto Rico's Department of Health. Individual data came from PREHCO. Subsequent aims used data from PREHCO.

PREHCO is a longitudinal survey of the noninstitutionalized population aged 60 and over and their surviving spouses. The sample is a multistage, stratified sample of the noninstitutionalized older adult population residing in Puerto Rico, with oversamples of regions heavily populated by people of African descent and individuals over age 80 (McEnry & Palloni, 2010; Palloni et al., 2013). Data was collected through face-to-face interviews in 2002-2003 and a follow-up wave in 2006-2007. Currently, PREHCO is the only study with a representative sample of the older adult population in Puerto Rico. It contains data on sociodemographics, health conditions, migratory experience, functional status, cognitive impairment, family roster, household members, among other topics.

In the first aim, this dissertation examines the association between net migration rate, depressive symptoms, and all-cause mortality, considering the variability within and between municipalities. Our results indicate that there are urban-rural disparities in the effect of out-migration on older adults' depressive symptoms. In the overall sample, we did not find an association between net migration rate and depressive symptoms. However, when stratifying the sample by urbanicity status, we find that the net migration rate among urban municipalities is associated with higher levels of depressive symptoms. The association concurs with what we hypothesized but only among urban municipalities. As the net migration rate moves from positive to negative, the number of depressive symptoms among older adults increases. This means that older adults in urban municipalities who experienced high negative net migration rates have a higher average of depressive symptoms. These findings could be a consequence of three possible explanations: (1) the underlying causes of internal and international migration, (2) the differences in the experience of migratory patterns between urban and rural

municipalities, (3) the differences in the available psychosocial factors among urban and rural communities.

The underlying causes of migration between internal and international migration are possibly driving rural and urban disparities. Demographers agree that internal migration flow mostly happens from rural municipalities to urban areas (Jorge Duany, 2011; Singer, 1972). An econometric study in Puerto Rico identified rural area push factors as the primary cause of out-migration flow (José Duany, 2003) rather than urban area pull factors. Young adults tend to move to the urban area looking for opportunities the rural areas lack, leaving their family members and community behind. Although there is a change in geographical location and some degree of separation, rural municipalities could vary in terms of distance from the urban area.

In contrast, the urban area migration experience is primarily international. Young adults with similar reasons for migration decide to move to other countries instead of rural municipalities. This international migration has a more substantial impact on the social connectedness of older adults left behind. It creates barriers to the emotional and instrumental support provided by young adults.

Furthermore, previous findings have identified greater social cohesion and support within rural areas compared to urban areas; social resources that could be acting as buffers for the impact of population migration on depression (Alegria et al., 2007; Choi et al., 2015; Cramm & Nieboer, 2013; Erdem et al., 2016). The differences in psychosocial characteristics between urban and rural municipalities could explain the findings of this study.

This study was also designed to measure the impact of population migration on all-cause mortality. In the overall sample, we find null results. However, when stratifying the sample by urbanicity status, we find that migration is marginally associated with the risk of all-cause mortality among rural municipalities. As the net migration rate becomes more positive (more residents added to the municipality), mortality risk among older adults also increased. While not significant, this finding appears to be in contradiction with our hypothesis, which predicted that positive net migration would be associated with decreased mortality rather than increased. Because the migration rate estimates were calculated for the period 1996-2002, most municipalities still experience a positive net migration rate. Only four municipalities experienced a negative net migration rate in the study sample. These results are possibly capturing the effect of population exchange on the overall health of older adults. This does not mean that a positive net migration rate increases the risk of mortality; on the contrary, the exchange of residents impacts the social context where older adults live. It is essential to understand that a place that experiences a positive net migration rate also loses residents. It does not mean that the place under study is not losing residents; it means that new residents overcome the loss. The social support systems and the risk of loneliness are still affected by a positive net migration rate.

Even though this study focuses on the effect of population migration on the left behind older adults, migratory experience yielded significant results. Older adults who migrated at some point in their lives have a lower risk of mortality than non-migrants. This finding is concordant with the healthy migrant theory that stipulates the health “superiority” of migrants compared to the population in the sending country or region. Furthermore,

economic difficulties is one of the strongest predictors of mortality among older adults in Puerto Rico. Experiencing recurrent economic difficulties increases the prevalence of chronic conditions and increases the risk of mortality. This economic aspect is commonly associated with population migration, where increased out-migration impacts the economy of the community of residence. Reducing the labor force and funds available for public services reduces the governmental services available for older adults at the municipal level. These services commonly include public transportation and healthcare, two services that are indispensable for older adult's well-being. Furthermore, this study incorporates econometric measures at the municipal level; however, we did not find any association between the measures and all-cause mortality. Further demographic and sociological studies are needed to examine how the increased out-migration has changed public funds and services at the municipal level and how this change affects the health of the residents left behind.

Our previous analysis focuses on the impact of population migration from a community perspective, which does not necessarily consider the more immediate effect of migration on household disintegration. Understanding the various dimensions of migration and its effect on sending communities and families left behind, we developed a study to measure the impact familial separation has on the health and well-being of older adults left behind. The second aim examines the association between adult-children migration, parental depression, and prevalent disability among older adults residing in Puerto Rico.

This aim did not find an association between parental depressive symptoms, prevalent disability, and adult-children migration. However, when using a lifetime history

of depression as the mental health indicator of interest, older adults with migrant adult-children are more likely to report a history of depression than older adults with no children residing outside of Puerto Rico. The literature concurs with our findings. The migration and health literature has mixed findings when estimating this association. Other studies have found positive, null, and even opposite findings. The association between adult-children migration and lifetime history of depression has been found in studies in China and Mexico (Y. Lu et al., 2012; M. Antman, 2012). Older adults facing the migration of adult-children are prone to suffer from depression at some point in their lives. The literature suggests that the loss of an adult-child to migration limits the desired contact of the older parent with the migrant child. This increases the perception of loneliness and social isolation, two psychosocial factors linked to depressive symptoms and physical health in older adults (Holt-Lunstad et al., 2015).

On the other hand, the results of no association between adult-children migration and parental elevated levels of depressive symptoms and prevalent disability are supported by previous studies as well (Abas et al., 2009; Ghimire et al., 2018; John et al., 2011; Jacqueline M. Torres et al., 2018). Ghimire found that depressive symptoms and self-reported physical health are not associated with adult-children migration among left-behind older adults in Nepal. Studies in Tonga, Thailand, and other countries have found similar results (Abas et al., 2009; John et al., 2011). The discrepant findings in the literature suggest that in understanding migration and health, context is critical.

A few factors may explain the null findings. The literature suggests that the migration of adult-children disrupts the family structure of the older adult left behind. Familial separation and increased loneliness are caused by the migration of adult-children

in many countries. However, this study sample has, on average, four children, and half of the older adults are married. The psychological and instrumental loss of having a migrant adult-child could be replaced and provided by other adult-children or family members staying behind after an adult-child has migrated. Moreover, a recent study on the psychological wellbeing of left behind Puerto Rican older adults found that being optimistic, grateful, and holding on to the thought that their adult-children have a better quality of life in the United States buffers the sadness and adverse effects that arise from familial separation, decreasing the risk of suffering from depression and disability (Toro Adorno et al., 2021). Most participants were optimistic, happy, and proud to have migrant adult-children. Most older adults still identified missing their migrant sons/daughters as the most challenging thought to overcome after the migration event. However, having other family members taking care of them could explain this study's results

To decompose the relationship between adult-children migration and the health and well-being of older adults in Puerto Rico, the analysis included a causal approach. We use an Instrumental Variable Analysis to estimate the causal association between parental depression, prevalent disability, and adult-children migration. By using the proportion of male children as the instrument in the analysis, we attempted to estimate the causal relationship. The results indicate no causal association between parental depressive symptoms, prevalent disability, and adult-children migration. In this analysis, the lifetime history of depression also yielded null findings. This study shows that the relationship between adult-children migration and the health of left behind older adults in Puerto Rico is not as straightforward as in other countries. Having migrant adult-children does not affect older adults' health by itself. The many factors around the migration

process are responsible for the impact adult-children migration has on parental health. Understanding that adult-children migration might not directly affect older parents' mental and physical health, we designed a third analysis to estimate the association between psychosocial measures and the incidence of disability.

The third and final aim examines the association between social support, living alone, and incident disability in Puerto Rican older adults. Results indicate a strong association between both psychosocial measures and incident disability. Received social support is associated with higher odds of developing a disability. In terms of loneliness, our results align with what has been found in other cultural contexts. Living alone was used as a marker of loneliness and increased risk for ADL disability after adjustment for all control variables and social support. Economic difficulties also demonstrated a substantial effect on incident disability among older adults.

Even though social support is considered a psychosocial measure that benefits older adults, the use of support systems combined with the health-related need for support may account for the association found in this study. In the early stages of functional decline, received social support could reflect signs of early disability. Spouse or family members taking care of the older adult could identify markers of early disability and, consequently, provide the support needed with daily tasks before any reported disability. Moreover, older adults could also identify these signs and seek help from their social support systems. The support received does not negatively affect the risk of disability; nevertheless, it is the accurate identification of early functional decline and the willingness of older adults to ask for help that yields the results from this study. Receiving

instrumental support at the beginning of the study could mean that older adults activate their social support resources when in need and prone to accelerated functional decline.

Another explanation for the observed association between greater social support and disability in this study is the anticipation of providing instrumental support. Providing support before this support may be necessary for daily functioning may harm physical strength and capacities and reduce self-efficacy (Litwin & Stoeckel, 2013; Mendes de Leon et al., 1996). Although these tasks may tax the physical strength and energy older adults have, they also promote perceptions of efficacy that encourage the continued engagement in these instrumental activities of daily living and thereby slow down the progression of functional decline (Garcia et al., 2017; Landi et al., 2007).

The results for loneliness and disability concur with our hypothesis. Puerto Rican older adults living alone have a higher risk of disability than older adults living with someone. Lonely older adults commonly have more limited social relations, lack of social support, poor mental and physical health (Holt-Lunstad et al., 2015; Newmyer et al., 2020a). These characteristics, mainly poor mental health, may affect an individual's ability to take care of themselves (L. Dong et al., 2020; L. G. Perez et al., 2015). For example, depression is one of the risk factors consistently associated with functional decline (Castaneda-Sceppa et al., 2010; Chowdhury et al., 2014; Jensen et al., 2014; Unsar et al., 2015). Older adults who are depressed are more likely to incur behavioral changes that negatively affect their overall health status. Downer et al. found that Puerto Rican older adults who are highly depressed are at higher risk of developing a disability than older adults not reporting depression (Downer et al., 2017). Results from this study are

consistent with these findings in that older adults who live alone are more likely to develop a disability than those living with someone.

In this dissertation, I considered an ecological approach to studying population and individual-level determinants of health among older adults in Puerto Rico and the role of migration. Every analysis has incorporated a different approach to examine the relationship of migration with the health and well-being of older adults in Puerto Rico. Even though every analysis was motivated by its own scientific questions and corresponding methodological approach, the findings suggest some general patterns worthy of discussing. For example, in the population-level analysis, we find that the net migration rate is associated with depressive symptoms. We also find similar results at the individual level. Adult-children migration also affects depression among older adults. Both analyses find that migration, at the population and household level, increases the prevalence of depression or depressive symptoms. Studies in Mexico and other countries have found similar results; however, this is the first study that proves the association at the population level.

Moreover, the results for both analyses are not mutually exclusive. There is a possibility that at the population level, we are capturing a portion of the effect at the household level. In this study, we did not control by household-level migration because we wanted to estimate the association, understanding that the net migration rate at the municipality also incorporates the household level effect and the impact migration has on the social context.

Furthermore, in the third analysis, we find that living alone impacts the incidence of disability among older adults in Puerto Rico. The literature on living alone and functional

decline stipulate depression as one mechanism through which living alone accelerates functional decline resulting in a disability. The increase in out-migration at the population and household level could be increasing the number of older adults living alone, therefore, increasing the prevalence of depression, resulting in a higher incidence of disability. These results are of high importance given the constant increase in out-migration in recent years in Puerto Rico and the inadequate services available for the mental health of older adults on the island. Further study is needed to examine how population migration impacts household level migration and the impact both factors have on the mental health and disability among older adults in Puerto Rico.

Another example is the consistent effect of economic difficulties within this dissertation. Economic difficulties is associated with every health outcome included in our analysis. It increases the number of depressive symptoms, it is associated with a higher risk of mortality, it is associated with increases in depression and prevalent disability, and it is associated with increases in the odds of incident disability. It looks like, among Puerto Rican older adults, the burden of economic difficulties takes a toll on the physical body and mental status. This is concordant with studies in other countries (Brinda et al., 2016; Massa & Chiavegatto Filho, 2021). Not complying with economic demands increases the prevalence of stress, which is associated with detrimental health outcomes. This dissertation is not designed to estimate the effect of economic difficulties on older adults' health and well-being; however, it is imperative to study this indicator given the results found. Economic difficulties is a strong determinant of health for Puerto Rican older adults. Further research is needed to establish the mechanisms and pathways through which migration might affect economic difficulties and the health of older adults.

On the other hand, there are also contrasting results in these studies. We found that the net migration rate at the municipal level is associated with depression among urban municipalities and with mortality among rural municipalities. The literature suggests that the impact of migration on physical health or overall health is through mental health (M. Antman, 2012). We were not able to disentangle these two findings due to data limitations. We expected similar effects among urban municipalities and rural municipalities. In the household-level analysis, we did not find an effect of adult-child migration on physical health. Therefore, the household migration effect is not causing the differences between these places. Other social, economic, or behavioral factors might be affecting overall health within rural municipalities. Urban municipalities seem to operate differently than rural municipalities, and migration plays a different role in each environment. There is a need to further study why migration affects older adults' health differently in both settings.

Our findings do not reinforce the effect of migration on the health of older adults; however, in the future, they could be affected by the increase in outmigration. This study estimates that 52% of older adults in Puerto Rico have at least one adult-child residing outside of the country, which is more than we hypothesized. This estimate is for 2002-2003, a moment in the history of Puerto Rico where out-migration was beginning to increase. We believed that in recent times, the prevalence of having an adult-child could be much higher. Furthermore, reports on migration from Puerto Rico's Statistical Institute confirm that out-migration is increasing and, consequently, the proportion of older adults in Puerto Rico (Velazquez Estrada, 2018). These increments in out-migration at the population level and household level will increase the burden of age-related diseases

among older adults and potentially could affect the psychosocial resources available for this population. It is imperative to begin to conduct data collection focused on studying social and environmental factors that affect older adults left behind in Puerto Rico.

Results from this dissertation prompted further research questions on how migration associates with older adults' health outcomes. First, in future studies, we plan to examine the changes in municipal services that affect older adults. Given that the tax base is affected by migration and the services for older adults are tied to municipal budget, there is a need to study the social services available for older adults within municipalities and how these changes affect the health and well-being of older adults in Puerto Rico. Second, there is a need for better and more detailed measures of social support that are not limited to family members. We plan to collect extensive data on social support measures from neighbors, friends, and children. We want to measure and study the social network dynamics and how outmigration in Puerto Rico is changing the networks available for older adults. Older Puerto Ricans will benefit from adequate data on social support (instrumental and emotional support) and loneliness. These data will permit social scientists to draw rigorous conclusions on how psychosocial measures affect older adults' mental and physical health in Puerto Rico. Third, since outmigration in Puerto Rico does not seem to stop in the near future, we need to gather more information on older adults' migration and their children to create a more complete picture of the migration in Puerto Rico. This includes the buffer effect of remittances in the migration and health relationship among Puerto Rican older adults. Currently, there is no individual data on remittances from family members to older adults in Puerto Rico. The literature suggests that remittances are one of the mechanisms that help improve health for the left behind

populations. They are also known to work as buffers for life stressors generated by limited economic resources. Since we find that economic difficulties is a consistent predictor of overall health among all these studies, it is imperative to study how remittances interplay in the relationship between migration and health among Puerto Rican older adults. Furthermore, there is also a need for better psychosocial measures.

This study highlights the uncertainty of the impact of migration on the health of non-migrant older adults. With the accelerating pace of out-migration in the last 14 years, it is imperative to estimate the prospective effect migration could have on older adults' physical and mental health. Therefore, it is essential to continue monitoring the health and well-being effects of this out-migration among Puerto Rican older adults. This dissertation represents the first attempt to understand migration as a social determinant of health for older adults left behind. Identifying critical factors should inform the development of new policies to reduce the impact migration has on health. Our findings emphasize the need for comparative research on migration and older adults' well-being in Puerto Rico.

References

- Abas, M. A., Punpuing, S., Jirapramukpitak, T., Guest, P., Tangchonlatip, K., Leese, M., & Prince, M. (2009). Rural–urban migration and depression in ageing family members left behind. *British Journal of Psychiatry*, *195*(1), 54-60. doi:10.1192/bjp.bp.108.056143
- Acevedo-Garcia, D., Sanchez-Vaznaugh, E. V., Viruell-Fuentes, E. A., & Almeida, J. (2012). Integrating social epidemiology into immigrant health research: a cross-national framework. *Social Science and Medicine*, *75*(12), 2060-2068. doi:10.1016/j.socscimed.2012.04.040
- Aggleton, P., Bell, S. A., & Kelly-Hanku, A. (2014). 'Mobile men with money': HIV prevention and the erasure of difference. *Glob Public Health*, *9*(3), 257-270. doi:10.1080/17441692.2014.889736
- Aguilar-Navarro, S. G., Fuentes-Cantu, A., Avila-Funes, J. A., & Garcia-Mayo, E. J. (2007). Validity and reliability of the screening questionnaire for geriatric depression used in the Mexican Health and Age Study. *Salud Publica de México*, *49*(4), 256-262. doi:10.1590/S0036-36342007000400005
- Aida, J., Kondo, K., Kawachi, I., Subramanian, S. V., Ichida, Y., Hirai, H., . . . Watt, R. G. (2013). Does social capital affect the incidence of functional disability in older Japanese? A prospective population-based cohort study. *Journal of Epidemiology and Community Health*, *67*(1), 42-47. doi:10.1136/jech-2011-200307
- Albert, S. M. F., Vicki A. (2010). *Public Health and Aging: Maximizing Function and Well-Being* (Second Edition ed.). New York, NY: Springer Publishing Company.
- Alegria, M., Sribney, W., & Mulvaney-Day, N. E. (2007). Social Cohesion, Social Support and Health Among Latinos in the United States. *Social science & medicine* (1982), *64*(2), 477-495. doi:10.1016/j.socscimed.2006.08.030
- Alexander, M., Polimis, K., & Zagheni, E. (2019). The Impact of Hurricane Maria on Out-migration from Puerto Rico: Evidence from Facebook Data. *Population and development review*, *45*(3), 617-630. doi:10.1111/padr.12289
- Angel, R. J., Angel, J. L., Díaz Venegas, C., & Bonazzo, C. (2010). Shorter Stay, Longer Life: Age at Migration and Mortality Among the Older Mexican-Origin Population. *Journal of Aging and Health*, *22*(7), 914-931. doi:10.1177/0898264310376540
- Ansell, D., Crispo, J. A. G., Simard, B., & Bjerre, L. M. (2017). Interventions to reduce wait times for primary care appointments: a systematic review. *BMC Health Services Research*, *17*(1), 295-295. doi:10.1186/s12913-017-2219-y
- Antman, F. (2010). *How Does Adult Child Migration Affect the Health of Elderly Parents Left Behind? Evidence from Mexico*.
- Antman, F. M. (2010). Adult Child Migration and the Health of Elderly Parents Left Behind in Mexico. *The American economic review*, *100*(2), 205-208. doi:10.1257/aer.100.2.205
- Arenas, E., & Yahirun, J. (2010). Left Behind: The Effects of Children's Migration on Parent's Mental Health in Mexico.
- Arevalo, S. P., Tucker, K. L., & Falcon, L. M. (2014). Life events trajectories, allostatic load, and the moderating role of age at arrival from Puerto Rico to the US mainland. *Social Science and Medicine*, *120*, 301-310. doi:10.1016/j.socscimed.2014.09.040
- Arévalo, S. P., Tucker, K. L., & Falcón, L. M. (2015). Beyond cultural factors to understand immigrant mental health: Neighborhood ethnic density and the moderating role of pre-migration and post-

- migration factors. *Social Science and Medicine*, 138(Supplement C), 91-100. doi:<https://doi.org/10.1016/j.socscimed.2015.05.040>
- Austin, P. C. (2017). A Tutorial on Multilevel Survival Analysis: Methods, Models and Applications. *International Statistical Review*, 85(2), 185-203. doi:doi:10.1111/insr.12214
- Benmarhnia, T., Zunzunegui, M.-V., Llácer, A., & Béland, F. (2014). Impact of the economic crisis on the health of older persons in Spain: research clues based on an analysis of mortality. SESPAS report 2014. *Gaceta Sanitaria*, 28, 137-141. doi:<https://doi.org/10.1016/j.gaceta.2014.02.016>
- Berkman, L. F., & Kawachi, I. (2000). *Social Epidemiology*: Oxford University Press.
- Blazer, D. G. (1982). SOCIAL SUPPORT AND MORTALITY IN AN ELDERLY COMMUNITY POPULATION1. *American Journal of Epidemiology*, 115(5), 684-694. doi:10.1093/oxfordjournals.aje.a113351
- Bozo, O., & Guarnaccia, C. A. (2010). Activities of daily living, social support, and future health of older Americans. *Journal of Psychology*, 144(1), 1-14.
- Brinda, E. M. M. B. B. S. P. D., Rajkumar, A. P. M. D. D. N. B. M. R. C. P. P. D., Attermann, J. P. D., Gerdtham, U. G. P. D., Enemark, U. P. D., & Jacob, K. S. M. D. M. R. C. P. P. D. (2016). Health, Social, and Economic Variables Associated with Depression Among Older People in Low and Middle Income Countries: World Health Organization Study on Global AGEing and Adult Health. *The American Journal of Geriatric Psychiatry*, 24(12), 1196-1208. doi:10.1016/j.jagp.2016.07.016
- Cacioppo, J. T., & Hawkley, L. C. (2003). Social Isolation and Health, with an Emphasis on Underlying Mechanisms. *Perspectives in Biology and Medicine*, 46(3), S39-S52. Retrieved from <https://muse.jhu.edu/article/44865>
- Caraballo-Cueto, J. (2015). Some Determinants of the Puerto Rican Migration to the US in 1950-2014.
- Castaneda-Sceppa, C., Price, L. L., Noel, S. E., Midle, J. B., Falcon, L. M., & Tucker, K. L. (2010). Physical Function and Health Status in Aging Puerto Rican Adults: The Boston Puerto Rican Health Study. *Journal of Aging and Health*, 22(5), 653-672. doi:10.1177/0898264310366738
- Castañeda, H., Holmes, S. M., Madrigal, D. S., Young, M.-E. D., Beyeler, N., & Quesada, J. (2015). Immigration as a Social Determinant of Health. *Annual Review of Public Health*, 36(1), 375-392. doi:10.1146/annurev-publhealth-032013-182419
- Castro, R., Campero, L., & Hernández, B. (1997). La investigación sobre apoyo social en salud: situación actual y nuevos desafíos. *Revista de Saúde Pública*, 31, 425-435. Retrieved from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0034-89101997000400012&nrm=iso
- Chang, J., Chen, C.-N., & Alegria, M. (2014). *Contextualizing Social Support: Pathways to Help Seeking in Latinos, Asian Americans, and Whites* (Vol. 33).
- Chen, S., Kuhn, M., Prettner, K., & Bloom, D. E. (2018). The macroeconomic burden of noncommunicable diseases in the United States: Estimates and projections. *PloS One*, 13(11), e0206702-e0206702. doi:10.1371/journal.pone.0206702
- Choi, N. G., Kim, J., DiNitto, D. M., & Marti, C. N. (2015). Perceived Social Cohesion, Frequency of Going Out, and Depressive Symptoms in Older Adults: Examination of Longitudinal Relationships. *Gerontol Geriatr Med*, 1, 2333721415615478. doi:10.1177/2333721415615478
- Chowdhury, P. P., Balluz, L. S., Zhao, G., & Town, M. (2014). Health behaviors and obesity among Hispanics with depression, United States 2006. *Ethnicity and Disease*, 24(1), 92-96. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/24620454>
- Christensen, K., Doblhammer, G., Rau, R., & Vaupel, J. W. (2009). Ageing populations: the challenges ahead. *Lancet*, 374(9696), 1196-1208. doi:10.1016/S0140-6736(09)61460-4
- Coyle, C. E., & Dugan, E. (2012). Social Isolation, Loneliness and Health Among Older Adults. *Journal of Aging and Health*, 24(8), 1346-1363. doi:10.1177/0898264312460275
- Cramm, J. M., & Nieboer, A. P. (2013). Relationships between frailty, neighborhood security, social cohesion and sense of belonging among community-dwelling older people. *Geriatr Gerontol Int*, 13(3), 759-763. doi:10.1111/j.1447-0594.2012.00967.x

- Davis, J., & Lopez-Carr, D. (2010). The effects of migrant remittances on population-environment dynamics in migrant origin areas: international migration, fertility, and consumption in highland Guatemala. *Population and Environment*, 32(2/3), 216-237. Retrieved from <http://www.jstor.org.proxy.lib.umich.edu/stable/40984177>
- De La Rosa, M. (1988). Natural Support Systems of Puerto Ricans: A Key Dimension for Well-Being. *Health and Social Work*, 13(3), 181. Retrieved from <http://proxy.lib.umich.edu/login?url=https://search.proquest.com/docview/1298067018?accountid=14667>
- http://mgetit.lib.umich.edu/?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rft_id=info:sid/ProQ%3Aproquest&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&rft.genre=article&rft.jtitle=Health+and+Social+Work&rft.atitle=Natural+Support+Systems+of+Puerto+Ricans%3A+A+Key+Dimension+for+Well-Being&rft.au=De+La+Rosa%2C+Mario&rft.aualast=De+La+Rosa&rft.aufirst=Mario&rft.date=1988-07-01&rft.volume=13&rft.issue=3&rft.spage=181&rft.isbn=&rft.btitle=&rft.title=Health+and+Social+Work&rft.issn=03607283&rft_id=info:doi/
- Delgado, M. (1995). Puerto Rican Elders and Natural Support Systems. *Journal of Gerontological Social Work*, 24(1-2), 115-130. doi:10.1300/J083V24N01_09
- Delgado, M. (1997). Religion as a Caregiving System for Puerto Rican Elders with Functional Disabilities. *Journal of Gerontological Social Work*, 26(3-4), 129-144. doi:10.1300/J083V26N03_10
- Dias, F., Teixeira, A. L., Guimarães, H. C., Barbosa, M. T., Resende, E. P. F., Beato, R. G., . . . Caramelli, P. (2017). Accuracy of the 15-item Geriatric Depression Scale (GDS-15) in a community-dwelling oldest-old sample: the Pietà Study. *Trends Psychiatry Psychother*, 39(4), 276-279. doi:10.1590/2237-6089-2017-0046
- Dong, H., & Lee, J. Z. (2014). Kinship matters: Long-term mortality consequences of childhood migration, historical evidence from northeast China, 1792–1909. *Social science & medicine (1982)*, 119, 274-283. doi:10.1016/j.socscimed.2013.10.024
- Dong, L., Freedman, V. A., & Mendes de Leon, C. F. (2020). The Association of Comorbid Depression and Anxiety Symptoms With Disability Onset in Older Adults. *Psychosomatic Medicine*, 82(2), 158-164. doi:10.1097/psy.0000000000000763
- Downer, B., Crowe, M., & Markides, K. S. (2017). Influence of Type II Diabetes and High Depressive Symptoms on the Likelihood for Developing Activities of Daily Living (ADL) Disability and Mortality in Older Puerto Ricans. *Journal of Aging and Health*, 29(6), 1079-1095. doi:10.1177/0898264317708882
- Duany, J. (2003). Entre la Isla y la diáspora: Los estudios sobre la migración en Puerto Rico y la Revista de Ciencias Sociales. *Revista de Ciencias Sociales*, 12, 102-119.
- Duany, J. (2011). *Blurred Borders Transnational Migration between the Hispanic Caribbean and the United States*: University of North Carolina Press.
- Dyxhoorn, J., Hollander, A. C., Lewis, G., Magnusson, C., Dalman, C., & Kirkbride, J. B. (2018). Risk of schizophrenia, schizoaffective, and bipolar disorders by migrant status, region of origin, and age-at-migration: a national cohort study of 1.8 million people. *Psychological Medicine*, 1-10. doi:10.1017/s0033291718003227
- Erdem, O., Van Lenthe, F. J., Prins, R. G., Voorham, T. A., & Burdorf, A. (2016). Socioeconomic Inequalities in Psychological Distress among Urban Adults: The Moderating Role of Neighborhood Social Cohesion. *PloS One*, 11(6), e0157119. doi:10.1371/journal.pone.0157119
- Erickson, W., Lee, C., & Von Schrader, S. (2017). Disability Statistics from the American Community Survey (ACS). Retrieved from www.disabilitystatistics.com

- Escobar-Bravo, M.-Á., Puga-González, D., & Martín-Baranera, M. (2012). Protective effects of social networks on disability among older adults in Spain. *Archives of Gerontology and Geriatrics*, 54(1), 109-116. doi:<https://doi.org/10.1016/j.archger.2011.01.008>
- Eva, K., & Fanny, J. (2013). Distortion of regional old-age mortality due to late-life migration in the Netherlands? *Demographic Research*, 29, 105-132. doi:10.4054/DemRes.2013.29.5
- Falcón, L. M., Todorova, I., & Tucker, K. (2009). Social support, life events, and psychological distress among the Puerto Rican population in the Boston area of the United States. *Aging & Mental Health*, 13(6), 863-873. doi:10.1080/13607860903046552
- Fernandez, J. H. S. (1999). EN LA PARADA DE LA GUAGUA: REFLEXIÓN ETNOBIOGRÁFICA SOBRE EL ORIGEN Y DEFINICIÓN DE UN PROBLEMA DE INVESTIGACIÓN.
- Frank, R., & Hummer, R. A. (2002). The Other Side of the Paradox: The Risk of Low Birth Weight among Infants of Migrant and Nonmigrant Households within Mexico. *International Migration Review*, 36(3), 746-765. doi:10.1111/j.1747-7379.2002.tb00103.x
- Freedman, V. A., Grafova, I. B., Schoeni, R. F., & Rogowski, J. (2008). Neighborhoods and disability in later life. *Social Science and Medicine*, 66(11), 2253-2267. doi:<https://doi.org/10.1016/j.socscimed.2008.01.013>
- Freedman, V. A., & Spillman, B. C. (2016). Active Life Expectancy In The Older US Population, 1982–2011: Black-White Differences Persisted. *Health affairs (Project Hope)*, 35(8), 1351-1358. doi:10.1377/hlthaff.2015.1247
- Gao, Q., Prina, A. M., Prince, M., Acosta, D., Luisa Sosa, A., Guerra, M., . . . Mayston, R. (2021). Loneliness Among Older Adults in Latin America, China, and India: Prevalence, Correlates and Association With Mortality. *Int J Public Health*, 66. doi:10.3389/ijph.2021.604449
- Garcia, M. A., Downer, B., Crowe, M., & Markides, K. S. (2017). Aging and Disability Among Hispanics in the United States: Current Knowledge and Future Directions. *Innovation in Aging*, 1(2), igx020-igx020. doi:10.1093/geroni/igx020
- Gerst-Emerson, K., & Jayawardhana, J. (2015). Loneliness as a public health issue: the impact of loneliness on health care utilization among older adults. *American journal of public health (1971)*, 105(5), 1013-1019. doi:10.2105/AJPH.2014.302427
- Ghimire, S., Singh, D. R., Nath, D., Jeffers, E. M., & Kaphle, M. (2018). Adult children's migration and well-being of left behind Nepalese elderly parents. *Journal of Epidemiology and Global Health*. doi:<https://doi.org/10.1016/j.jegh.2018.07.004>
- Guo, M., Chi, I., & Silverstein, M. (2009). Intergenerational Support of Chinese Rural Elders With Migrant Children: Do Sons' or Daughters' Migrations Make a Difference? *Journal of Gerontological Social Work*, 52(5), 534-554. doi:10.1080/01634370902983245
- Gushulak, B. D., Weekers, J., & MacPherson, D. W. (2009). Migrants and emerging public health issues in a globalized world: threats, risks and challenges, an evidence-based framework. *Emerging Health Threats Journal*, 2, e10. doi:10.3134/ehjtj.09.010
- Hajek, A., & König, H.-H. (2017). The association of falls with loneliness and social exclusion: Evidence from the DEAS German Ageing Survey. *BMC Geriatrics*, 17(1), 204-204. doi:10.1186/s12877-017-0602-5
- Hamilton, E. R., & Choi, K. H. (2015). The mixed effects of migration: Community-level migration and birthweight in Mexico. *Social Science and Medicine*, 132, 278-286. doi:<https://doi.org/10.1016/j.socscimed.2014.08.031>
- He, G., Xie, J.-f., Zhou, J.-d., Zhong, Z.-q., Qin, C.-x., & Ding, S.-q. (2016). Depression in left-behind elderly in rural China: Prevalence and associated factors. *Geriatrics & Gerontology International*, 16(5), 638-643. doi:<https://doi.org/10.1111/ggi.12518>

- Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015). Loneliness and social isolation as risk factors for mortality: a meta-analytic review. *Perspectives on Psychological Science, 10*(2), 227-237. doi:10.1177/1745691614568352
- Holt-Lunstad, J., Smith, T. B., & Layton, J. B. (2010). Social relationships and mortality risk: a meta-analytic review. *PLoS Medicine, 7*(7), e1000316. doi:10.1371/journal.pmed.1000316
- House, J. S., Landis, K. R., & Umberson, D. (1988). Social relationships and health. *Science, 241*(4865), 540-545.
- Idler, E. L., Russell, L. B., & Davis, D. (2000). Survival, functional limitations, and self-rated health in the NHANES I Epidemiologic Follow-up Study, 1992. First National Health and Nutrition Examination Survey. *American Journal of Epidemiology, 152*(9), 874-883.
- Ingleby, D., & Kotsioni, I. (2012). *Inequalities in Health Care for Migrants and Ethnic Minorities: CORONET BOOKS - USA*.
- IOM. (2018). *World Migration Report 2018*. Retrieved from Geneva:
- Ishikawa, R. Z., Cardemil, E. V., & Falmagne, R. J. (2010). Help Seeking and Help Receiving for Emotional Distress Among Latino Men and Women. *Qualitative Health Research, 20*(11), 1558-1572. doi:10.1177/1049732310369140
- Jensen, M. P., Smith, A. E., Bombardier, C. H., Yorkston, K. M., Miró, J., & Molton, I. R. (2014). Social support, depression, and physical disability: Age and diagnostic group effects. *Disability and Health Journal, 7*(2), 164-172. doi:<https://doi.org/10.1016/j.dhjo.2013.11.001>
- John, G., David, M., & Steven, S. (2011). THE IMPACTS OF INTERNATIONAL MIGRATION ON REMAINING HOUSEHOLD MEMBERS: OMNIBUS RESULTS FROM A MIGRATION LOTTERY PROGRAM. *The review of economics and statistics, 93*(4), 1297-1318. doi:10.1162/REST_a_00129
- Jylhä, M. (2009). What is self-rated health and why does it predict mortality? Towards a unified conceptual model. *Social Science and Medicine, 69*(3), 307-316. doi:10.1016/j.socscimed.2009.05.013
- Kanaiaupuni, S. M., & Donato, K. M. (1999). Migradollars and mortality: The effects of migration on infant survival in Mexico. *Demography, 36*(3), 339-353. doi:10.2307/2648057
- Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A., & Jaffe, M. W. (1963). STUDIES OF ILLNESS IN THE AGED. THE INDEX OF ADL: A STANDARDIZED MEASURE OF BIOLOGICAL AND PSYCHOSOCIAL FUNCTION. *JAMA, 185*, 914-919.
- Knodel, J., & Saengtienchai, C. (2007). Rural parents with urban children: social and economic implications of migration for the rural elderly in Thailand. *Population, Space and Place, 13*(3), 193-210. doi:<https://doi.org/10.1002/psp.436>
- Koladjo, B. F., Escolano, S., & Tubert-Bitter, P. (2018). Instrumental variable analysis in the context of dichotomous outcome and exposure with a numerical experiment in pharmacoepidemiology. *BMC Medical Research Methodology, 18*(1), 61-61. doi:10.1186/s12874-018-0513-y
- Kuhn, R., Everett, B., & Silvey, R. (2011). The effects of children's migration on elderly kin's health: a counterfactual approach. *Demography, 48*(1), 183-209. doi:10.1007/s13524-010-0002-3
- Lahey, B., & Orehek, E. (2011). Relational regulation theory: a new approach to explain the link between perceived social support and mental health. *Psychological Review, 118*(3), 482-495. doi:10.1037/a0023477
- Landale, N. S., Gorman, B. K., & Oropesa, R. S. (2006). Selective migration and infant mortality among Puerto Ricans. *Matern Child Health J, 10*(4), 351-360. doi:10.1007/s10995-006-0072-4
- Landi, F., Onder, G., Carpenter, I., Cesari, M., Soldato, M., & Bernabei, R. (2007). Physical activity prevented functional decline among frail community-living elderly subjects in an international observational study. *Journal of Clinical Epidemiology, 60*(5), 518-524. doi:10.1016/j.jclinepi.2006.09.010

- Li, T., Wu, B., Yi, F., Wang, B., & Baležentis, T. (2020). What Happens to the Health of Elderly Parents When Adult Child Migration Splits Households? Evidence from Rural China. *International Journal of Environmental Research and Public Health*, 17(5). doi:10.3390/ijerph17051609
- Liao, J., & Scholes, S. (2017). Association of Social Support and Cognitive Aging Modified by Sex and Relationship Type: A Prospective Investigation in the English Longitudinal Study of Ageing. *American Journal of Epidemiology*, 186(7), 787-795. doi:10.1093/aje/kwx142
- Litwin, H., & Stoeckel, K. J. (2013). Social network and mobility improvement among older Europeans: the ambiguous role of family ties. *European journal of ageing*, 10(3), 159-169. doi:10.1007/s10433-013-0269-5
- Lu, Y. (2012). Household migration, social support, and psychosocial health: the perspective from migrant-sending areas. *Social science & medicine (1982)*, 74(2), 135-142. doi:10.1016/j.socscimed.2011.10.020
- Lu, Y., Hu, P., & Treiman, D. J. (2012). Migration and depressive symptoms in migrant-sending areas: findings from the survey of internal migration and health in China. *Int J Public Health*, 57(4), 691-698. doi:10.1007/s00038-011-0314-0
- Lu, Y., & Qin, L. (2014). Healthy migrant and salmon bias hypotheses: a study of health and internal migration in China. *Social Science and Medicine*, 102, 41-48. doi:10.1016/j.socscimed.2013.11.040
- Luo, Y., Hawkey, L. C., Waite, L. J., & Cacioppo, J. T. (2012). Loneliness, health, and mortality in old age: A national longitudinal study. *Social science & medicine (1982)*, 74(6), 907-914. doi:10.1016/j.socscimed.2011.11.028
- M. Antman, F. (2012). *The Impact of Migration on Family Left Behind*.
- Marc, L. G., Raue, P. J., & Bruce, M. L. (2008). Screening Performance of the 15-Item Geriatric Depression Scale in a Diverse Elderly Home Care Population. *The American Journal of Geriatric Psychiatry*, 16(11), 914-921. doi:<https://doi.org/10.1097/JGP.0b013e318186bd67>
- Mariana, T. G., Wallis, E. A., Irina, L. G. T., & Luis, M. F. (2017). Harmonizing Beliefs With Realities: Social Support Among Older Puerto Ricans With Disabilities. *SAGE Open*, 7(2), 2158244017715337. doi:10.1177/2158244017715337
- Markides, K. S., & Coreil, J. (1986). The health of Hispanics in the southwestern United States: an epidemiologic paradox. *Public health reports (Washington, D.C. : 1974)*, 101(3), 253-265. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/3086917>
- <https://www.ncbi.nlm.nih.gov/pmc/PMC1477704/>
- Massa, K. H. C., & Chiavegatto Filho, A. D. P. (2021). Income Inequality and Self-Reported Health Among Older Adults in Brazil. *Journal of Applied Gerontology*, 40(2), 152-161. doi:10.1177/0733464820917561
- Matos-Moreno, A., & Mendes de Leon, C. (2018). SOCIAL DETERMINANTS OF LATE-LIFE DISABILITY IN PUERTO RICO. *Innovation in Aging*, 2(suppl_1), 998-998. doi:10.1093/geroni/igy031.3688
- McEnry, M., & Palloni, A. (2010). Early life exposures and the occurrence and timing of heart disease among the older adult Puerto Rican population. *Demography*, 47(1), 23-43. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/20355682>
- <https://www.ncbi.nlm.nih.gov/pmc/PMC3000006/>
- McLaughlin, D., Leung, J., Pachana, N., Flicker, L., Hankey, G., & Dobson, A. (2012). Social support and subsequent disability: it is not the size of your network that counts. *Age and Ageing*, 41(5), 674-677. doi:10.1093/ageing/afs036
- Melendez, E., Hinojosa, J., & Roman, N. (2017). Post-Hurricane Maria Exodus from Puerto Rico and School Enrollment in Florida. *Centro for Puerto Rican Studies*. Retrieved from

<https://centropr.hunter.cuny.edu/sites/default/files/CentroReport-RB2017-02-POST-MARIA-FL-PR-EXODUS%20%281%29.pdf>

- Melvin, D. (1997). Interpretation of Puerto Rican Elder Research Findings: A Community Forum of Research Respondents. *Journal of Applied Gerontology*, 16(3), 317-332.
doi:10.1177/073346489701600307
- Mendes de Leon, C. F., Eschbach, K., & Markides, K. S. (2011). Population trends and late-life disability in Hispanics from the Midwest. *Journal of Aging and Health*, 23(7), 1166-1188.
doi:10.1177/0898264311422100
- Mendes de Leon, C. F., Glass, T. A., Beckett, L. A., Seeman, T. E., Evans, D. A., & Berkman, L. F. (1999). Social Networks and Disability Transitions Across Eight Intervals of Yearly Data in the New Haven EPESE. *The journals of gerontology. Series B, Psychological sciences and social sciences*, 54B(3), S162-S172. doi:10.1093/geronb/54B.3.S162
- Mendes de Leon, C. F., Seeman, T. E., Baker, D. I., Richardson, E. D., & Tinetti, M. E. (1996). Self-efficacy, physical decline, and change in functioning in community-living elders: a prospective study. *Journals of Gerontology. Series B: Psychological Sciences and Social Sciences*, 51(4), S183-190.
- Monteverde, M., Noronha, K., & Palloni, A. (2009). Effect of Early Conditions on Disability among Elderly in Latin America and the Caribbean. *Population studies*, 63(1), 21-35.
doi:10.1080/00324720802621583
- Mora, M. T., Dávila, A., & Rodríguez, H. (2017). Population, migration, and socioeconomic outcomes among island and mainland Puerto Ricans : La Crisis Boricua. In A. E. Dávila & H. n. Rodríguez (Eds.).
- Mulasso, A., Roppolo, M., Giannotta, F., & Rabaglietti, E. (2016). Associations of frailty and psychosocial factors with autonomy in daily activities: a cross-sectional study in Italian community-dwelling older adults. *Clinical Interventions in Aging*, 11, 37-45. doi:10.2147/CIA.S95162
- Mulvaney-Day, N. E., Alegria, M., & Sribney, W. (2007). Social cohesion, social support, and health among Latinos in the United States. *Social Science and Medicine*, 64(2), 477-495.
doi:10.1016/j.socscimed.2006.08.030
- Myers, G. C., & Morris, E. W. (1966). Migration and fertility in Puerto Rico. *Population studies*, 20(1), 85-96. doi:10.1080/00324728.1966.10406086
- Nagi, S. Z. (1976). An epidemiology of disability among adults in the United States. *Milbank Memorial Fund Quarterly: Health and Society*, 54(4), 439-467.
- Newmyer, L., Verdery, A. M., Margolis, R., & Pessin, L. (2020a). Measuring Older Adult Loneliness Across Countries. *The Journals of Gerontology: Series B*. doi:10.1093/geronb/gbaa109
- Newmyer, L., Verdery, A. M., Margolis, R., & Pessin, L. (2020b). Measuring Older Adult Loneliness across Countries. *The journals of gerontology. Series B, Psychological sciences and social sciences*. doi:10.1093/geronb/gbaa109
- Nummela, O., Seppänen, M., & Uutela, A. (2010). The effect of loneliness and change in loneliness on self-rated health (SRH): A longitudinal study among aging people. *Archives of Gerontology and Geriatrics*, 53(2), 163-167. doi:10.1016/j.archger.2010.10.023
- Palloni, A., Dávila, A. L., & Sanchez-Ayendez, M. (2013). *Puerto Rican Elderly: Health Conditions (PREHCO) Project, 2002-2003, 2006-2007*.
- Parreñas, R. S. (2005). The Gender Paradox in the Transnational Families of Filipino Migrant Women. *Asian and Pacific Migration Journal*, 14(3), 243-268. doi:10.1177/011719680501400301
- Payne, E. H., Gebregziabher, M., Hardin, J. W., Ramakrishnan, V., & Egede, L. E. (2018). An empirical approach to determine a threshold for assessing overdispersion in Poisson and negative binomial models for count data. *Communications in Statistics - Simulation and Computation*, 47(6), 1722-1738. doi:10.1080/03610918.2017.1323223

- Perez, C., & Ailshire, J. A. (2017). Aging in Puerto Rico: A Comparison of Health Status Among Island Puerto Rican and Mainland U.S. Older Adults. *Journal of Aging and Health*, 898264317714144. doi:10.1177/0898264317714144
- Perez, L. G., Arredondo, E. M., McKenzie, T. L., Holguin, M., Elder, J. P., & Ayala, G. X. (2015). Neighborhood Social Cohesion and Depressive Symptoms Among Latinos: Does Use of Community Resources for Physical Activity Matter? *J Phys Act Health*, 12(10), 1361-1368. doi:10.1123/jpah.2014-0261
- Philip, K. E. J., Polkey, M., Hopkinson, N. S., Steptoe, A., & Fancourt, D. (2020). Social isolation, loneliness and physical performance in older-adults: fixed effects analyses of a cohort study. *Scientific Reports*, 10(1), 13908-13908. doi:10.1038/s41598-020-70483-3
- Pocklington, C., Gilbody, S., Manea, L., & McMillan, D. (2016). The diagnostic accuracy of brief versions of the Geriatric Depression Scale: a systematic review and meta-analysis. *International Journal of Geriatric Psychiatry*, 31(8), 837-857. doi:10.1002/gps.4407
- Puschmann, P., Donrovich, R., & Matthijs, K. (2017). Salmon Bias or Red Herring? Comparing adult mortality risks (ages 30-90) between natives and internal migrants: Stayers, returnees and movers in Rotterdam, the Netherlands, 1850-1940. *Human nature (Hawthorne, N.Y.)*, 28(4), 481-499. doi:10.1007/s12110-017-9303-1
- Rasulo, D., Spadea, T., Onorati, R., & Costa, G. (2012). The impact of migration in all-cause mortality: The Turin Longitudinal Study, 1971–2005. *Social science & medicine (1982)*, 74(6), 897-906. doi:10.1016/j.socscimed.2011.10.045
- Razum, O. (2008). Migrant Mortality, Healthy Migrant Effect. In W. Kirch (Ed.), *Encyclopedia of Public Health* (pp. 932-935). Dordrecht: Springer Netherlands.
- Rivera-Hernandez, M., Leyva, B., Keohane, L. M., & Trivedi, A. N. (2016). Quality of care for white and hispanic medicare advantage enrollees in the united states and puerto rico. *JAMA Internal Medicine*, 176(6), 787-794. doi:10.1001/jamainternmed.2016.0267
- Rivera, F. I. (2007). Contextualizing the experience of young Latino adults: acculturation, social support and depression. *J Immigr Minor Health*, 9(3), 237-244. doi:10.1007/s10903-006-9034-6
- Rodríguez, R. F., Figueroa, J. R., & Negrón, R. R. (2012). *Puerto Rico 2000-2010: Mas alla del Censo / Beyond the Census*: Createspace Independent Pub.
- Santos-Lozada, A. R., Kaneshiro, M., McCarter, C., & Marazzi-Santiago, M. (2020). Puerto Rico exodus: long-term economic headwinds prove stronger than Hurricane Maria. *Population and Environment*, 42(1), 43-56. doi:10.1007/s11111-020-00355-5
- Scarrano, F. (2015). *PUERTO RICO: cinco siglos de historia*: MCGRAW-HILL INTERAMERICAN.
- Sheikh, J. I., & Yesavage, J. A. (1986). Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. *Clinical Gerontologist: The Journal of Aging and Mental Health*, 5(1-2), 165-173. doi:10.1300/J018v05n01_09
- Shryock, H. S., & Siegel, J. S. (2013). *The Methods and Materials of Demography*. Retrieved from \
- Singer, P. (1972). Migraciones internas: consideraciones teóricas sobre su estudio. *Migración y desarrollo*, 1.
- Song, Q. (2017). Facing “Double Jeopardy”? Depressive Symptoms in Left-Behind Elderly in Rural China. *Journal of Aging and Health*, 29(7), 1182-1213. doi:10.1177/0898264316659964
- Stuck, A. E., Walthert, J. M., Nikolaus, T., Büla, C. J., Hohmann, C., & Beck, J. C. (1999). Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Social Science and Medicine*, 48(4), 445-469. doi:[https://doi.org/10.1016/S0277-9536\(98\)00370-0](https://doi.org/10.1016/S0277-9536(98)00370-0)
- Sudharsanan, N., & Bloom, D. E. (2018). The Demography of Aging in Low- and Middle-Income Countries: Chronological versus Functional Perspectives - Nikkil Sudharsanan and David E. Bloom. In (pp. 309-338): National Academies Press.

- Thomas, F. (2016). *Handbook of Migration and Health*: Edward Elgar Publishing.
- Thomas, F., & Gideon, J. (2013). *Migration, health and inequality* Zed Books.
- Toro Adorno, Y., Rodríguez Gómez, J. R., & López Córdova, N. M. (2021). Bienestar de Adultos Mayores Cuyas Familias Han Emigrado a Estados Unidos y Algunas de sus Fortalezas Emocionales para Mantener ese Cambio. *Scientific International Journal*, 18(1), 37-49.
- Torres, J. M., Rudolph, K. E., Sofrygin, O., Glymour, M. M., & Wong, R. (2018). Longitudinal associations between having an adult child migrant and depressive symptoms among older adults in the Mexican Health and Aging Study. *International Journal of Epidemiology*, dyy112-dyy112. doi:10.1093/ije/dyy112
- Torres, J. M., Rudolph, K. E., Sofrygin, O., Wong, R., Walter, L. C., & Glymour, M. M. (2019). Having an Adult Child in the United States, Physical Functioning, and Unmet Needs for Care Among Older Mexican Adults. *Epidemiology*, 30(4), 553-560. doi:10.1097/ede.0000000000001016
- Torres, J. M., Sofrygin, O., Rudolph, K. E., Haan, M. N., Wong, R., & Glymour, M. M. (2020). US Migration Status of Adult Children and Cognitive Decline Among Older Parents Who Remain in Mexico. *American Journal of Epidemiology*, 189(8), 761-769. doi:10.1093/aje/kwz277
- Trovato, F. (2012). *Population and Society: Essential Readings*: Oxford University Press.
- Ueshima, H. (2007). Explanation for the Japanese Paradox: Prevention of Increase in Coronary Heart Disease and Reduction in Stroke. *Journal of Atherosclerosis and Thrombosis*, 14(6), 278-286. doi:10.5551/jat.E529
- United Nations, D. o. E. a. S. A., Population Division. (2019). World Population Prospects 2019. from Online Edition
- Unsar, S., Dindar, I., & Kurt, S. (2015). Activities of daily living, quality of life, social support and depression levels of elderly individuals in Turkish society. *Journal of the Pakistan Medical Association*, 65(6), 642-646.
- Velazquez Estrada, A. L. (2018). Perfil del Migrante 2016. Retrieved from www.estadistica.pr
- Vera Rodríguez, H. (2014). Análisis de la Situación de los Adultos Mayores en Puerto Rico. *Pontificia Universidad Católica de Puerto Rico*. Retrieved from [https://www.researchgate.net/publication/271517225 Analisis de la Situacion de los Adultos Mayores en Puerto Rico](https://www.researchgate.net/publication/271517225_Analisis_de_la_Situacion_de_los_Adultos_Mayores_en_Puerto_Rico)
- Verheij, R. A., van de Mheen, H. D., de Bakker, D. H., Groenewegen, P. P., & Mackenbach, J. P. (1998). Urban-rural variations in health in The Netherlands: does selective migration play a part? *Journal of Epidemiology and Community Health*, 52(8), 487-493. doi:10.1136/jech.52.8.487
- White, A. M., Philogene, G. S., Fine, L., & Sinha, S. (2009). Social Support and Self-Reported Health Status of Older Adults in the United States. *American Journal of Public Health*, 99(10), 1872-1878. doi:10.2105/AJPH.2008.146894
- Xu, H., Vorderstrasse, A. A., McConnell, E. S., Dupre, M. E., Ostbye, T., & Wu, B. (2018). Migration and cognitive function: a conceptual framework for Global Health Research. *Glob Health Res Policy*, 3, 34. doi:10.1186/s41256-018-0088-5
- Zayas, L. E., Wisniewski, A. M., & Kennedy, T. (2013). Instrumental Activity of Daily Living Limitations and Supports in a Clinic Population of Low-Income Puerto Rican Elderly Adults with Chronic Diseases. *Journal of the American Geriatrics Society*, 61(10), 1789-1795. doi:10.1111/jgs.12461