Aging in the Americas: Disability-Free Life Expectancy among Adults Age 65 and Older in the United States, Costa Rica, Mexico, and Puerto Rico.

1. INTRODUCTION AND BACKGROUND

1.1 Introduction: Aging in Latin America and the Caribbean will not proceed along known paths already followed by more developed countries (Polloni & McEniry 2007). In particular, the pace by which the age composition of countries in Latin America will shift is nearly unprecedented. A typical country in Latin America will reach a population with 15% of individuals over the age of 60 in less than half the time that this shift took in the US (Palloni, Pinto, & Pelaez 2002, Kinsella & Velkoff 2001). Life expectancy at age 60 has nearly doubled in most countries in Latin America and the Caribbean since 1950 (Palloni et al 2002), and current values compare favorably with estimates for the US and other developed countries. This represents a very rapid change in mortality at older age.

The care of this rising aging population is one of the largest challenges facing countries in Latin America. However, rigorous research on how these additional years are spent is lacking. This population is growing faster and living longer than ever before, but what portion of this additional life is spent in ill health and disability? How do the country-wide levels of disability and rates of chronic non-communicable diseases (NCDs) compare across the region, and to more developed contexts such as the United States? The answers to these questions will impact social welfare and have substantial repercussions for national health systems, retirement and disability patterns, and the demand for long-term care for the aging (World Bank 2011).

My research compares the healthy aging process in three settings in Latin America with the US, resulting in a greater understanding of the process of aging in these varied contexts. I center on understanding the lived experience with disability among the aging population as measured by the activities of daily living (ADL) scale. This research fills in gaps in existing knowledge on the physical health of the aging population in Latin America by utilizing high-quality longitudinal data to conduct far more sophisticated modeling of the aging process than has previously been available in this context. In particular, I estimate the rates of transitions between healthy life, disability, and death in these populations, and use these parameters to estimate the disability-free life expectancy (DFLE) of individuals in the United States, Costa Rica, Mexico, and Puerto Rico. Together, these measures characterize processes of health and disability in the growing elderly population of Latin America, and can provide important insights into how current disability conditions in these populations may impact future demands from health care systems, pension programs, and social services.

1.2 Background: The four contexts compared in this study (three countries—the United States, Costa Rica, and Mexico—and one territory, Puerto Rico) comprise a range of differing economic and demographic conditions, health care systems, and pension systems, making for a number of meaningful and useful comparisons. Each of the four contexts studied here have similar life expectancy at birth and at age 60, though levels of GDP per capita, human development index, and health expenditure per capita vary substantially (Table 1.1).

[Table 1.1 around here]

1.2.1 Mexico: The population aged 65+ in Mexico is one of the most rapidly growing in the world. Though currently this population comprises 9.4% of the total population, by 2040 it is projected to be almost 20% (IDB 2014). Mexico began the process of demographic transition in the 1960's, with a halving of birthrates from 1960 to 2000 (46 births per thousand in 1960 to 21 per thousand in 2000). The current total fertility rate (TFR) is around 2.3 (IDB 2014), while life expectancy has risen to 79 for females and 74 for males (World Bank 2011). Mexico has followed closely with the classical epidemiological transition (Omran 1971), with a marked decline in deaths from infectious disease since the 1980s and an increase in deaths from chronic and degenerative diseases—from 58% of deaths in 1990 to 75% of deaths in 2005 (PAHO, Health in the Americas 2007, Stevens et al 2008)). Mexico has some of the lowest rates of availability of health care resources in Latin America, particularly in hospital beds and physicians per thousand people (World Bank 2013).

Though health conditions have improved, rates of coverage by social security programs are low among the elderly population. Social security coverage is low compared with both higher-income countries and many other Latin American countries—social security institutions generally only apply to workers in the formal sector, and most individuals from the informal sector are not covered. Private sector workers are covered through the Mexican Institute for Social Security (Instituto Mexicano del Seguro Social or IMSS), though registration and enrollment is incomplete (Aguila et al 2011). A patchwork of other social security and pension systems exists for workers employed through the government, armed forces, and other large institutions. Many elderly individuals did not participate in the formal labor market in their early life, and only about half are covered by IMSS health care services. This population either forgoes health insurance or relies on public health programs such as Popular Health Insurance (Seguro Popular de Salud or SPS), where they may incur substantial out-of-pocket expenditures for health care (Aguila et al 2011).

1.2.2 Costa Rica: Costa Rica, located on the Central American isthmus, is a country often cited as a model for other middle income countries. Though the country differs little from most other Latin American countries in terms of GDP per capita, it has achieved a level of life expectancy, access to public health services and sanitation, environmental protection, and social security coverage among the highest in the Americas (Rosero-Bixby 2009). Costa Rica underwent a very rapid demographic transition—life expectancy rose from around the mid 40's in the 1930's to around 70 by 1970, and infant mortality dropped continuously during these years before rapidly declining in the 1970s (Rosero-Bixby 1990). The TFR is around 1.9, lower even than that of the US, and both life expectancy at birth and at age 60 are comparable or even higher than that in the US. The population is still rather young— about 7% of Costa Ricans currently over the age of 65, though this will rapidly grow to over 22% by 2040 (IDB 2014).

Costa Rica has attained these impressive health and development metrics with a surprisingly low level of health expenditure per capita—only $943 per year in 2011, about 11% of the US' spending (World Bank 2013). The Costa Rican Department of Social Insurance (Caja Costarricense de Seguro Social or CCSS) was established in 1941, and universalization of health care coverage in 1973 consolidated the control of medical facilities to the CCSS. The Costa Rican health system is characterized by a focus on primary care and preventative medicine, a decentralization of health services, and emphasis on training and capacity-building in rural clinics (Eriksson et al 1990). The public health insurance system covers about 88% of the population (Saenz, Bermudez, and Acosta 2010), and the government provides no-cost insurance for the destitute population (Rosero-Bixby 2004).

1.2.3 Puerto Rico: Puerto Rico is a commonwealth of the United States, located in the Caribbean. The population is already fairly old compared to other Latin American contexts due to both demographic aging and high rates of out-migration to the US mainland among the younger population, but the older population is projected to keep growing in coming years. Over 16% of the population is currently over the age of 65, and by 2040 this population is estimated to be about 27.4% of the island's total population. Rates of GDP per capita sit between the US and Costa Rica and Mexico. Current TFR is just over 1.6, among the lowest in the Americas and substantially lower than the US.

As US citizens, Puerto Ricans pay Medicare insurance and thus are covered by the Medicare insurance system after the age of 65. Uninsurance rates for the total population are low compared to the mainland US population—only 8% of the population is without health coverage (ACS 2011), though many of the insured rely on public coverage. The Puerto Rican health care system has undergone multiple reforms in the past thirty years, which have mainly focused on shifting the role of government in providing healthcare from being a direct provider of services to being a provider of insurance, with the provision of services shifted to the private system (Santos-Lozada 2013, Mulligan 2010). These reforms provided health insurance to many citizens, though in practice the healthcare system plagued with inefficiencies, corruption, and poor care (Mulligan 2008, Mulligan 2010). In particular, preventative care has suffered substantially—only 14% of the diabetic population has received a deep eye test, only 16% are monitored for nephropathy, and 82% have poor control of their blood sugar. Only around half of the female population at risk had received a mammography or PAPS test. (Comisión para Evaluar el Sistema de Salud del Estado Libre Asociado de Puerto Rico, 2005) Though the low-income population is also ostensibly eligible for Medicaid coverage, the US government has capped the amount of Medicaid aid available to Puerto Rico since 1968, leaving the majority of local health programs to rely on local taxes.

1.2.4 US: The United States is one of the highest income countries in the world, with a fully modern healthcare system and a completed epidemiological transition. About 14% of the population is currently age 65 and older, a figure which will rise to about 21% by 2040. GDP per capita and health expenditure per capita rank among the highest in the world and the US also ranks high on the number of hospital beds and doctors per 1000 individuals (World Bank 2013). The US had essentially completed its epidemiological transition by the 1920's (Omran 1977), meaning that the vast majority of the current 65+ population was never exposed to high rates of communicable disease in early life.

At ages below 65, health insurance in the United States is primarily provided by employers—about 60% of individuals receive employer-sponsored healthcare, 15% get public insurance through Medicaid or other federal programs, 5% get private non-governmental insurance, and about 18% are uninsured (CPS 2005). At 65, individuals are eligible for Medicare, a federal health insurance program for the elderly, and are also eligible for pension payments from Social Security. Even though access to care is high, the US still has persistently high rates of chronic NCDs and poorer health outcomes than many other similarly wealthy nations.

The growing elderly population in Mexico and Costa Rica, and to a lesser extent Puerto Rico, lived their childhoods and much of their adult lives exposed to a vastly different epidemiological context than the elderly population in the US. Though multiple studies have investigated the role of these early-life conditions on individual-level NCDs in low and middle income countries (see McEniry 2013 for a comprehensive overview), the extent to which this affects later life functional ability and DFLE at the population level is not yet known. We know that many countries in Latin America are experiencing a rising burden of non-communicable diseases such as cancer, stroke, diabetes, and hypertension (Palloni & McEniry 2007). However, little is currently known about how this rising burden is affecting the overall level of functional ability among the older population. Though these four populations have similar levels of period life expectancy, does this obscure divergent levels of DFLE?

Evidence on the effect of ***expansion of life expectancy*** on DFLE is somewhat mixed. Current WHO projections assume that the burden of disease will decline among the older population in Latin America in the coming decades, as this population becomes increasingly well-educated and wealthier. This assumption follows from the work of Fries (1983), who argued that, in the US context, increases in life expectancy came about largely through an expansion of healthy life and the postponement of disease and disability until older ages. However, in the case of Latin America, several researchers take the opposite view. A number of Latin America-focused studies (Palloni et al 2006, Monteverde et al 2007, Zunzunegui et al 2009) suggest that the higher disease burden and episodic malnutrition (as well as generally poor nutrition) experienced by Latin America's aging population during early life may contribute to successive cohorts at higher risk of disability and chronic disease, particularly for those who grew up in lower-SES families. This history of substantial health pressures among the cohorts currently reaching old age may lead to a significantly higher proportion of remaining life spent disabled among countries in Latin America when compared to the US.

Though a great deal of study of healthy life expectancy, functional disabilities, and the aging process has been conducted in the US and other developed contexts, research on aging and disabilities is lacking in lower and middle-income countries, largely due to the unavailability of high-quality longitudinal data (Ebrahim et al 2013). Information on population-level health in low and middle-income contexts is key for predicting the health and social service needs of the elderly, and for understanding how these countries are transitioning through the second epidemiological transition. Existing research into health expectancies in Latin America has largely relied on cross sectional data or used longitudinal data from the Study of Health, Well-Being, and Aging in Latin America and the Caribbean (SABE), where extended time periods between waves of data collection (5+ years) likely results in substantially biased estimates (Gill et al 2005, Wolf & Gill 2009).

Even with these data constraints, a small but growing body of literature is emerging on aging and disability in Latin America. Research on demographic factors influencing disability in Latin America has found somewhat mixed results on the role of education: Reyes-Ortiz et al 2006 found a relationship between years of schooling and disability prevalence, though other analyses of longitudinal data in Sao Paulo, Brazil, and urban populations in Mexico found that schooling was not associated with recovery from disability or reduced mortality rates (Beltran-Sanchez & Andrade 2013). Research from Mexico also shows that individuals with diabetes experience a much diminished life expectancy (10 years of reduced LE at age 50), and a higher burden of self-care limitations. Recent work by Hayward et al (2014) finds that Hispanic migrants in the US experience a protracted period of disability in older age, even as they expect to live more total years than White or non-Hispanic Black populations.

Accurate estimates of DFLE in this context are particularly significant for planning for the future of national health systems, retirement and pension programs, and for understanding the future demand for long-term care for the elderly. I focus on DFLE as an easily interpretable metric for comparing population health in a cross-national context. DFLE distinguishes between years that are free of limitations on activities and years with activity limitations, and represents a more nuanced view health and the aging process than simple life expectancy. DFLE combines mortality and morbidity into a single measure, providing a convenient and easily interpretable metric for measuring population-level health (Minicuci et al 2004).

Though we can make informative comparisons of healthcare systems, economic development, and epidemiological histories between these four contexts at the macro level, little existing research has compared processes of health and disability in the aging population across Latin America and the US. In particular, existing research has primarily been limited by the use of cross-sectional data, inhibiting investigation into the complex and dynamic processes of health in an aging population. Little is currently known about how functional ability compares between the middle-income contexts of Costa Rica and Mexico and the higher income contexts of Puerto Rico and the US. My investigation provides a wealth of information about the life course experience with functional limitations in these aging populations, utilizing high-quality longitudinal data to observe and model patterns of transitions between healthy life and ADL limited life.

Drawing on the existing literature on disability and chronic disease, I anticipate that rates of ADL disability and life expectancy in disability will be higher in the three Latin American contexts studied than in the US. However, I anticipate that there will be only small differences in life expectancy at older ages. Though I anticipate that the overall burden of disability may be higher in Mexico, Puerto Rico, and Costa Rica when compared to the US, I also anticipate that these countries will have a somewhat lower burden of non-communicable diseases, with the possible exception of diabetes.

2. DATA AND METHODS

2.1 Data: Data from my analysis come from four sources: The Costa Rican Longevity and Healthy Aging Study (CRELES, or Costa Rica Estudio de Longevidad y Envejecimiento Saludable), a nationally representative longitudinal survey of health and life-course experiences of 2,827 Costa Ricans ages 60 and over collected in 2005, 2007, and 2009; the Mexican Health and Aging Survey (MHAS) collected in 2001 and 2003 (baseline of 15,402 adults ages 50+); the Puerto Rican Elderly: Health Conditions (PREHCO) survey collected in 2002-2003 and 2006-2007 (baseline of 4,291 adults ages 60+); and the United States' Health and Retirement Survey (HRS) from 2004, 2006, 2008, and 2010 (baseline of ~11,000 adults age 51+). Data instruments and collection procedures from CRELES and MHAS are largely based on HRS methodologies (Wong et al 2006, McEniry et al 2013), and PREHCO asks a large suite of highly comparable questions on ADL activities, demographics, chronic conditions, and interactions with the health care system.

I investigate patterns of self-reported physical limitation by using the ADL scale to create two distinct states of physical health: **healthy** individuals with no limitations on their physical activities, and **ADL limited** individuals with one or more limitations on their physical activities. I define ADL limitation as difficulty on any of the following five activities: bathing, eating, getting in/out of bed, toileting, and walking across a room. In each country, my sample consists of all available primary respondents age 65 and older who answered the ADL measures without a proxy. Attrition was low in each sample (generally under 5%), and future analyses will further investigate the potential for bias induced and possible solutions.

In addition to ADL disability, I also investigate differences in the chronic conditions contributing to this burden of disability. In each study, respondents were asked whether a doctor had diagnosed them with hypertension, diabetes, cancer, heart attack/myocardial infarction, stroke, and arthritis. I also utilize measures of BMI, frequency of interaction with health care providers (visits to doctor in past 12 months), and demographic information on age, sex, marital status, and years of education.

2.2 Methods: My investigation of cross-national differences in disability, health, and aging will rely on several methods. Initially, I will compare rates of disability, chronic conditions, and sociodemographic variables across these four contexts to gain a baseline understanding of the health conditions in each country. I will then investigate differences in chronic conditions and sociodemographic variables of individuals who report difficulty on ADL measures. Combined, these tests compare the burden of ADL limitation between these countries, and will provide useful insight into both the burden of specific chronic NCDs in these countries, as well as how this NCD burden relates to ADL limitations.

As a second step, I will use a multi-state life table (MSLT) to translate the longitudinal data from each country into estimates if of DFLE and life expectancy with ADL limitations. This estimation method is based on an adapted version of the Stochastic Population Analysis for Complex Events program (Cai et al 2010). Specifically, to calculate MSLT functions such as healthy and ADL limited health expectancies (HEs), I use microsimulation to created synthetic cohorts of 100,000 65-, 75-, and 85-year-old individuals with the same initial gender and functional limitation distributions as the study populations. I then ''age'' these individuals forward year by year using age- and gender-specific mortality rates and probabilities of transitioning in and out of disability that were estimated from the data. This process is then repeated at each age until death. The resulting synthetic cohort is analyzed to estimate HEs and other life-course health indicators. Point estimates shown are from transition probabilities and HEs estimated from the full sample. In the microsimulation approach, HE estimates are not a deterministic function of the transition rates, and instead result from the interplay between disability status, gender, and age as individuals move year by year through the simulation. Thus, confidence intervals (CIs) from the transition rate calculations are not directly applicable to the HE estimates. CIs for HEs, which reflect both the uncertainty of the estimated parameters and the uncertainty from the microsimulation, were created by re-estimating the above analysis sequence (estimating state-dependent transition probabilities and applying them to a representative 100,000-person cohort using microsimulation) using 499 bootstrap resamples of the original dataset. To obtain the final 95% CIs, I take the central 95% of the distribution of these bootstrapped parameters. All analyses are completed using sample weights normed to the respective national population.

I estimate the conditional probabilities of experiencing a health transition between the three modeled states (healthy, ADL limited, and deceased) as a function of age and gender, using a logistic discrete-time hazard model of the form

$$Log\left(\frac{p_{ij}(age,t)}{p_{ii}(age,t)}\right) = \beta_{0ij} + \beta_{1ij} \times age_t + \beta_{2ij} \times age_t^2 + \beta_{3ij} \times \mathit{female} \quad (1)$$

where $p_{ij}(age, t)$ is the transition probability from current health state i (with i = healthy or ADL limited) to health state j (with j = healthy, ADL limited, or deceased) over the interval from time t − 1 to t, β_{0ij} is the intercept, β_{1ij} and β_{2ij} are the coefficients for age and age squared, and β_{3ij} is the coefficient for female. Transition probability estimates were obtained using PROC SURVEYLOGISTIC in SAS v9.3, accounting for survey weights and sample design.

3. RESULTS

3.1 Sample Characteristics: Table 3.1 presents the baseline sociodemographic and health characteristics of the four samples. All presented results use national-level sample weights to represent the aging population of the countries under study. We see that the basic sample demographics are somewhat different between the four samples—the US over 65 population skews older and more female than in Mexico, Puerto Rico, or Costa Rica. Individuals in the US, Puerto Rico, and Costa Rica were substantially more likely to have visited a doctor in the past year (or, in the US case, two years) than individuals in Mexico at baseline. Almost 60% of the US sample reported having smoked over the course of their lifetime, compared with 45% of Mexican elderly, 42% of Costa Rican elderly, and 34% of Puerto Rican elderly. Rates of doctor-diagnosed NCDs vary somewhat between countries. Hypertension is common across the four samples, though somewhat higher in the US and Puerto Rico. Diagnosis of cancer, stroke, and arthritis are also more common in the US, though this could be due to variation in medical practices or frequency of doctor's visits (particularly in the case of Mexico). Almost 30% of the Puerto Rican elderly population has been diagnosed with diabetes, compared with about 20% for the other countries. In the case of heart attack, the US sample categorized multiple heart conditions together, which likely leads to the substantially higher reported rate (see Appendix X for a comparison of original questions and translations).

[Table 3.1 around here]

Elderly individuals in Mexico and Costa Rica, and to a lesser extent Puerto Rico, had substantially fewer years of formal education than individuals in the US. Older adults in the US and Puerto Rico almost universally receive social security, While only 61% of Costa Ricans and 15% of Mexicans receive a pension from the government at the first wave of data collection. Likewise, most individuals in the US and Puerto Rico are eligible for health insurance through Medicare, and almost all older individuals in Costa Rica receive health care from the CCSS. In Mexico, a much smaller proportion of individuals receive publically provided health insurance, and over 45% of individuals over 65 in the 2001 MHAS sample reported having no insurance.

[Table 3.2 around here]

I also observe that rates of experiencing difficulty on ADLs vary substantially by individual sociodemographic and health characteristics. Table 3.2 displays the proportion of individuals experiencing difficulty on ADLs by sex, marital status, age, education, BMI, and diagnosis status on a variety of NCDs. We see that females are more likely to report ADL difficulty than males, though the magnitude of this difference varies somewhat across countries. Married individuals universally report lower rates of ADL limitations. ADL limitations increase with age and decline with increasing education, though there is substantial variation across countries—the education gradient is quite strong in Mexico, Puerto Rico, and the US, and weaker in Costa Rica. Individuals with BMI of under 20 or over 30 report more ADL difficulty than individuals at a BMI of 20-30. Individuals who have been diagnosed with hypertension, stroke, and heart attack/MI, arthritis, and diabetes report substantially more ADL difficulty. In Mexico, having no health insurance and no public pension are both associated with higher rates of ADL limitation.

3.2 Multi-State Transition Probabilities:

To gain insight into the dynamics of old-age disability in these four populations, we modeled the underlying age-and gender-specific annual transition probabilities between states of physical limitation. Figure 3.1 illustrates the annual transition probabilities between healthy life, ADL limited life, and death by sex, along with the 95% CIs (represented as the thin lines) based on 499 bootstrap resamples. At older ages, particularly above age 85, confidence intervals around the point estimates grow quite large for Mexico, Puerto Rico, and Costa Rica, primarily as a result of limited sample sizes at these advanced ages. As expected, transition probabilities from healthy life to ADL limitation (Panel A) rise sharply with age, though there are substantial differences in the patterns across populations. Annual probability of becoming ADL limited doubles from age 65 to age 85 among both males and females in the US, Costa Rica, and Mexico, but increases only by 1.5 times in Puerto Rican females, and hardly at all for males. Annual probabilities of becoming ADL limited are higher for women, following a widely established pattern in contexts where disability and functional limitation transitions have been studied (Crimmins et al 2011, Oksuzyan et al 2010).

[Figure 3.1 around here]

Rates of recovery from ADL limitation (Panel B) drop substantially with increasing age. At younger ages, individuals of both sexes are relatively likely to recover from stays in ADL limitation. The probabilities of recovery decline with age, however—by about 85, ADL limited individuals are more likely to die within the next year than to recover to healthy life. Substantial variation between countries exists in these transition rates—probabilities of recovery are high in Mexico and low in Puerto Rico, and recovery probabilities in Costa Rica decline more slowly at older ages than in the other populations.

Mortality rates from healthy life (Panel C) and ADL limited life (Panel D) provide evidence that functional limitations have a strong association with mortality. Throughout later life, individuals with ADL limitations have a higher mortality rate, a difference that is particularly pronounced in Mexico and the US and of somewhat smaller magnitude in Costa Rica and Puerto Rico. Point estimates for mortality from healthy status are higher for men than women at almost ages, though this difference is often within the confidence interval.

3.4 Life and Health Expectancies:

Moving from the transition probabilities in Figure 3.1 to the corresponding health expectancies (Table 3.3 and Figure 3.2) translates the age-and sex-specific annual probabilities of transition between disability states into years lived with functional limitation. In addition to revealing remaining total life expectancy for the aging population, the microsimulation-based MSLT approach estimates the duration of remaining life expected to be spent healthy and ADL limited, with confidence intervals determined through 499 bootstrap replications. Specifically, Table 3.3 and Figure 3.2 show the estimated health expectancies across these four populations. Remaining total life expectancy at age 65 is about 20 years for females in each of the four countries, making the total life expectancy about 85 (these figures are about 18 and 83 for males). However, there is some significant country-to-country variation in expected longevity. Individuals in

Costa Rica (particularly males) have the longest life expectancies observed, a finding in keeping with other research on the country (Rosero-Bixby 2008). Costa Rican males at can expect to live almost two years more than their Mexican, Puerto Rican, and American counterparts at age 65, and about one year more at ages 75 and 85. Mexican females' life expectancy lags behind the other populations by about two years at ages 65, 75, and 85, though Mexican males have overall similar life expectancies to the other countries (excepting Costa Rica). Females aged 65 in Puerto Rico and Costa Rica expect to live about one additional ADL limited year compared than their counterparts in the US, though these differences subside at later ages.

[Table 3.3 and Figure 3.2 around here]

Table 3.4 provides the proportion of remaining life at ages 65, 75, and 85 that an individual in the four study populations can expect to live without ADL limitations, along with a 95% confidence interval calculated through the 499 bootstrap replications. Proportion of remaining life spent free of ADL limitations is fairly stable across the four populations, a surprising finding given the variation in income, health infrastructure and expenditure, and health indicators between these four contexts. Overall, males expect to spend about 10% more of their remaining life free of ADL limitations at all ages when compared to females. Mexican women at age 65 are expected to spend proportionately fewer of their remaining years with ADL limitations that the other studied populations (Table 3.4), though their total life expectancy is substantially lower.

[Table 3.4 around here]

4. DISCUSSION

This paper expands the knowledge base on aging and disability in Latin America, using a novel multi-state life table methodology to analyze both the levels of disability by age and the dynamics of disability in later life. I compare the processes of functional limitation in three Latin American populations with the US, estimating the prevalence of functional limitations and the transition rates between different disability states. Rates of transition into disability statuses differ substantially across the life course--rates of recovery from ADL limitations decline very rapidly with age, and across populations individuals 85 and older are more likely to die within the next year than to recover to healthy life. Probabilities of recovery from ADL disability are higher in Mexico and Costa Rica than in the US, and remain high into older ages in Costa Rica.

In addition to documenting the levels of ADL limitation and the transitions between disability states, these analyses estimate the expected years individuals in these populations will live in healthy and ADL limited life. Overall, females in Costa Rica, Puerto Rico, and the US expect to live about 20 additional years at age 65, surpassing the ~18 year LE of Mexican females. Costa Rican individuals have the most years of LE at each age, though these differences are particularly apparent for males at older ages—Costa Rican males expect to live about 2 years longer than their Mexican, Puerto Rican, and American counterparts at age 65, and an additional year at ages 75 and 85. Though total life expectancy for 65-year-old females in Costa Rica, Puerto Rico, and the US is similar, women in Costa Rica and Puerto Rico expect to spend more of their remaining life with ADL limitations. However, the overall similarity in patterns of transition rates and levels of DFLE between the four countries compared here quite striking. GDP per-capita in Costa Rica is only slightly higher than total health expenditure per-capita in the US, but it has attained comparable levels of functional health among the older population. Mexico, with an even lower level of health expenditure, lags only slightly behind.

Combined, these results suggest that the worries of a growing population of elderly individuals with substantial health limitations in Latin America may be unfounded. Though the elderly population of Costa Rica and Mexico (and, to a lesser extent, Puerto Rico) lived many years exposed to a poor childhood conditions and a very different epidemiological context than prevails in these countries today, their functional health in later life is comparable to that in the US. Successive generations entering into later life have spent less and less time subject to poor epidemiological conditions in childhood and young adulthood, and thus health conditions among Latin America's elderly population may indeed improve in coming decades. The worries of oncoming generations of frail and disabled elderly seem unfounded.

In evaluating the results from this MSLT estimation, several limitations need to be considered. Individuals who experience a health transition between waves of data collection in the four surveys used are assumed to experience only a single transition during the period between surveys, which likely misses shorter-term transitions between health statuses. As the focus of this article is on ADL limitations and not acute health conditions, I am confident that this assumption does not substantially bias the health expectancy estimates and their interpretation (Gill et al 2005, Wolf & Gill 2009), though the longer duration between waves in the PREHCO data may have resulted in artificially depressed rates of transitions between states. The MSLT modeling approach is limited in incorporating time varying covariates, thus my analyses could not simultaneously model ADL limitations and the underlying health conditions which may have resulted in these limitations. In common with other life-table based measures, health expectancies (HE) estimates assume stationary transition rates over time, and thus will not match the lived experience of any single cohort. My current analyses follow a first-order Markov chain, and are thus not state-duration-dependent—that is, transition probabilities are not adjusted by duration of stay in a given state. This assumption results from the left-censored nature of the data—though I can determine what functional status individuals had at entry into the dataset, I do not know their duration of stay in that state. Recent work on the Semi-Markov Process (SMP)-EM algorithm (Cai et al 2008) rectifies some of the left-truncation biases introduced by state-duration-dependent modeling, but was deemed too computationally intensive for the current scope of this work.

Table 1.1: Economic and Health Conditions

	Costa Rica	Mexico	Puerto Rico	US
GDP Per Capita 2011 (current US $)	9,386	9,749	27,678	51,749
Health Expenditure per capita, 2011 (current US $)	943	620	--	8,608
LE at birth, Males	77	74	74	76
LE at birth, Females	81	79	82	81
LE at age 60, Males	21	20	20	20
LE at age 60, Females	24	22	25	24
Population, 2011	4,737,680	119,361,233	3,694,093	311,587,816
Human Development Index	62	61	52	3

Sources: World Bank World Development Indicators 2013, UN Population Division World Population Prospects 2006 and 2012, UN Development Programme 2013 Human Development Report

Table 3.1. Baseline Sample Characteristics

	Mexico - MHAS Wave 1 (2001)		Puerto Rico - PREHCO Wave 1 (2002)		Costa Rica - CRELES Wave 1 (2005)		USA - HRS Wave 7 (2004)	
	Prop.	95% CI	Prop.	95% CI	Prop.	95% CI	Prop.	95% CI
Sex								
Female	0.53	(0.49 - 0.56)	0.56	(0.53 - 0.59)	0.52	(0.5 - 0.55)	0.59	(0.58 - 0.6)
Marital Status								
Married/Cohabiting	0.42	(0.38 - 0.45)	0.48	(0.45 - 0.51)	0.59	(0.56 - 0.61)	0.56	(0.55 - 0.58)
Functional Ability								
Difficulty on 1+ ADLs	0.12	(0.1 - 0.15)	0.11	(0.09 - 0.12)	0.09	(0.08 - 0.1)	0.15	(0.14 - 0.16)
Visited Doctor in Past 12 Months	0.64	(0.6 - 0.67)	0.89	(0.87 - 0.9)	0.90	(0.89 - 0.92)	--	--
Visited Doctor in Past 24 Months	--	--	--	--	--	--	0.95	(0.95 - 0.96)
Ever a Smoker[a]	0.45	(0.42 - 0.49)	0.34	(0.31 - 0.36)	0.42	(0.4 - 0.45)	0.57	(0.56 - 0.58)
NCD's								
Hypertension	0.42	(0.39 - 0.45)	0.60	(0.57 - 0.63)	0.50	(0.47 - 0.52)	0.58	(0.57 - 0.59)
Stroke	0.03	(0.02 - 0.04)	0.06	(0.04 - 0.07)	0.03	(0.02 - 0.04)	0.10	(0.09 - 0.1)
Cancer	0.02	(0.01 - 0.03)	0.07	(0.05 - 0.08)	0.06	(0.05 - 0.08)	0.18	(0.17 - 0.19)
Heart Attack/MI[b]	0.04	(0.03 - 0.05)	0.11	(0.09 - 0.12)	0.04	(0.03 - 0.05)	0.29	(0.28 - 0.3)
Diabetes	0.17	(0.15 - 0.2)	0.28	(0.26 - 0.31)	0.21	(0.18 - 0.23)	0.18	(0.17 - 0.19)
Arthritis	0.27	(0.24 - 0.3)	0.49	(0.46 - 0.52)	0.16	(0.14 - 0.18)	0.65	(0.64 - 0.66)
Age								
65-74	0.60	(0.57 - 0.64)	0.64	(0.61 - 0.67)	0.66	(0.64 - 0.69)	0.53	(0.52 - 0.54)
75-84	0.31	(0.28 - 0.34)	0.29	(0.27 - 0.32)	0.28	(0.26 - 0.31)	0.37	(0.36 - 0.38)
85+	0.09	(0.06 - 0.12)	0.07	(0.06 - 0.08)	0.05	(0.04 - 0.06)	0.10	(0.09 - 0.11)
Education								
0-6	0.88	(0.85 - 0.9)	0.44	(0.41 - 0.47)	0.80	(0.78 - 0.83)	0.04	(0.04 - 0.05)
7-11	0.08	(0.06 - 0.1)	0.22	(0.19 - 0.24)	0.09	(0.07 - 0.11)	0.21	(0.2 - 0.22)
12+	0.04	(0.03 - 0.05)	0.34	(0.32 - 0.37)	0.11	(0.09 - 0.13)	0.74	(0.73 - 0.75)
BMI								
<20	0.08	(0.06 - 0.1)	0.06	(0.05 - 0.07)	0.05	(0.04 - 0.06)	0.07	(0.07 - 0.08)
20-30	0.76	(0.73 - 0.79)	0.68	(0.65 - 0.71)	0.70	(0.67 - 0.72)	0.71	(0.7 - 0.72)
30+	0.16	(0.13 - 0.18)	0.26	(0.24 - 0.28)	0.26	(0.23 - 0.28)	0.21	(0.21 - 0.22)
Income								
Public Pension[c]	0.15	(0.13 - 0.18)	0.98	(0.97 - 0.99)	0.61	(0.59 - 0.64)	0.99	(0.98 - 0.99)
Health Insurance								
Public	0.51	(0.48 - 0.55)	0.83	(0.81 - 0.85)	0.95	(0.94 - 0.96)	0.98	(0.97 - 0.98)
Private	0.03	(0.02 - 0.04)	0.15	(0.13 - 0.17)	0.02	(0.01 - 0.03)	0.01	(0.01 - 0.01)
None	0.46	(0.42 - 0.49)	0.01	(0.01 - 0.02)	0.02	(0.02 - 0.03)	0.01	(0.01 - 0.01)
Total Sample Size	3,190		2,619		1,790		9,585	

Notes:

a) Includes all individuals who report having smoked over 100 cigarettes in their lifetime

b) US sample (HRS) also includes wider range of heart conditions; this figure is thus not directly comparable across samp

c) In Mexico, this category includes individuals receiving pensions from IMSS, ISSSTE, other public pensions, or US Social Security. In Puerto Rico and the US, it is comprised of those receiving Social Security. In Costa Rica, it includes all individuals receiving Social Security or government pensions.

Table 3.2. Rates of ADL Difficulty by Sociodemographic and Health Variables

	Mexico - MHAS Wave 1 (2001)		Puerto Rico - PREHCO Wave 1 (2002)		Costa Rica - CRELES Wave 1 (2005)		USA - HRS Wave 7 (2004)	
	% w/ADL Difficulty	95% CI	% w/ADL Difficulty	95% CI	% w/ADL Difficulty	95% CI	% w/ADL Difficulty	95% CI
Sex								
Male	11.39	(6.64 - 16.14)	7.50	(5.42 - 9.57)	8.22	(6.14 - 10.31)	11.34	(10.27 - 12.42)
Female	13.42	(10.34 - 16.51)	13.10	(10.85 - 15.35)	9.80	(7.81 - 11.79)	17.49	(16.39 - 18.58)
Marital Status								
Married/Cohabiting	8.41	(6.3 - 10.52)	9.84	(7.36 - 12.32)	8.15	(6.26 - 10.05)	10.80	(9.93 - 11.68)
Not Married/Cohabiting	15.33	(10.96 - 19.7)	11.39	(9.45 - 13.33)	10.33	(8.12 - 12.54)	20.33	(18.95 - 21.72)
Visited Doctor in Past 12 Months								
No	10.89	(4.81 - 16.97)	5.40	(2.83 - 7.97)	2.35	(0.36 - 4.33)	--	
Yes	13.41	(10.72 - 16.09)	11.15	(9.43 - 12.88)	9.80	(8.22 - 11.38)	--	
Visited Doctor in Past 24 Months								
No	--		--		--		8.67	(5.79 - 11.56)
Yes	--		--		--		15.24	(14.43 - 16.06)
Ever a Smoker[a]								
No	14.65	(10.13 - 19.18)	10.53	(8.59 - 12.47)	8.46	(6.63 - 10.29)	14.64	(13.45 - 15.82)
Yes	9.79	(7.28 - 12.31)	10.78	(8.17 - 13.4)	9.87	(7.56 - 12.18)	15.19	(14.14 - 16.24)
Age								
65-74	7.04	(5.47 - 8.6)	10.55	(8.51 - 12.59)	7.39	(5.59 - 9.19)	10.79	(9.87 - 11.7)
75-84	13.77	(9.86 - 17.67)	9.51	(7.06 - 11.96)	11.00	(8.41 - 13.59)	16.00	(14.63 - 17.38)
85+	44.90	(27.38 - 62.43)	16.40	(9.83 - 22.97)	19.96	(14.47 - 25.45)	33.83	(30.53 - 37.13)
Education								
0-6	13.80	(10.69 - 16.91)	14.20	(11.5 - 16.9)	9.34	(7.77 - 10.91)	26.82	(22.47 - 31.17)
7-11	3.79	(1.76 - 5.82)	9.48	(6.39 - 12.57)	7.78	(2.55 - 13.01)	20.22	(18.3 - 22.14)
12+	1.55	(0.08 - 3.02)	6.84	(4.68 - 9.01)	8.17	(3.08 - 13.26)	12.81	(11.95 - 13.67)
BMI								
<20	11.87	(3.96 - 19.78)	9.54	(2.65 - 16.42)	18.76	(9.87 - 27.66)	25.14	(21.52 - 28.76)
20-30	8.77	(6.7 - 10.84)	9.17	(7.47 - 10.88)	7.09	(5.53 - 8.65)	12.52	(11.65 - 13.38)
30+	10.06	(6.69 - 13.43)	14.74	(11.09 - 18.38)	12.19	(8.79 - 15.59)	19.70	(17.83 - 21.58)
Non-Communicable Diseases								
Hypertension								
No hypertension	9.41	(7.16 - 11.66)	6.70	(4.65 - 8.76)	7.54	(5.62 - 9.45)	11.10	(10.04 - 12.16)
Hypertension	14.14	(10.68 - 17.61)	13.35	(11.13 - 15.56)	10.60	(8.45 - 12.75)	17.77	(16.66 - 18.88)
Stroke								
No Stroke	10.50	(8.58 - 12.41)	9.58	(8.06 - 11.1)	8.56	(7.12 - 9.99)	12.78	(12.01 - 13.55)
Stroke	31.65	(16.11 - 47.19)	28.91	(18.14 - 39.69)	24.49	(12.54 - 36.44)	35.53	(32.09 - 38.96)
Cancer								
No Cancer	11.38	(9.39 - 13.37)	10.79	(9.19 - 12.39)	8.71	(7.25 - 10.17)	14.18	(13.33 - 15.03)
Cancer	11.84	(0.59 - 23.1)	8.30	(1.58 - 15.02)	14.69	(7.5 - 21.88)	18.33	(16.31 - 20.34)
Heart Attack/MI[b]								
No Heart Attack/MI	10.76	(8.84 - 12.69)	8.97	(7.42 - 10.52)	8.91	(7.44 - 10.38)	11.95	(11.1 - 12.8)
Heart Attack/MI	26.97	(12.03 - 41.92)	23.42	(17.18 - 29.65)	11.19	(4.45 - 17.94)	22.05	(20.37 - 23.74)
Diabetes								
No Diabetes	10.10	(8.07 - 12.13)	9.98	(8.15 - 11.82)	8.45	(6.9 - 10.01)	13.34	(12.51 - 14.17)
Diabetes	16.34	(10.9 - 21.78)	12.38	(9.4 - 15.37)	11.50	(7.9 - 15.09)	22.27	(20.14 - 24.41)
Arthritis								
No Arthritis	9.61	(7.35 - 11.88)	5.30	(3.65 - 6.95)	7.38	(5.93 - 8.82)	6.62	(5.7 - 7.54)
Arthritis	16.19	(12.25 - 20.13)	16.08	(13.43 - 18.73)	17.25	(12.58 - 21.93)	19.44	(18.36 - 20.52)
Income								
No Public Pension[c]	13.79	(10.56 - 17.02)	13.11	(4.15 - 22.07)	10.19	(8.27 - 12.11)	14.04	(7.65 - 20.42)
Public Pension[c]	5.71	(3.39 - 8.02)	10.14	(8.51 - 11.77)	7.44	(5.21 - 9.68)	14.90	(14.11 - 15.69)
Health Insurance								
Public	9.69	(7.53 - 11.84)	11.10	(9.35 - 12.84)	9.41	(7.91 - 10.91)	14.98	(14.19 - 15.78)
Private	7.51	(1.47 - 13.55)	8.68	(4.97 - 12.39)	3.84	(0 - 9.15)	11.33	(4.99 - 17.67)
None	15.89	(10.53 - 21.25)	6.05	(0 - 12.34)	0.00	--	12.77	(6.24 - 19.29)
Total Sample Size	3,190		2,619		1,790		9,585	

Notes:

a) Includes all individuals who report having smoked over 100 cigarettes in their lifetime

b) US sample (HRS) also includes wider range of heart conditions; this figure is thus not directly comparable across samples

c) In Mexico, this category includes individuals receiving pensions from IMSS, ISSSTE, other public pensions, or US Social Security. In Puerto Rico and the US, it is comprised of those receiving Social Security. In Costa Rica, it includes all individuals receiving Social Security or government pensions.

Table 3.3: Microsimulation Estimated Healthy, ADL Limited, and Total Life Expectancy for Males and Females Age 65, 75, and 85

	HRS (US)	CRELES (CR)	PREHCO (PR)	MHAS (MX)
Female				
Age 65				
Healthy	15.64	14.65	14.84	15.24
95% CI	(15.16 - 16.02)	(13.34 - 16.24)	(12.92 - 17.04)	(13.45 - 17.87)
ADL Limited	4.75	6.10	5.81	3.08
95% CI	(4.53 - 5.06)	(4.94 - 7.71)	(4.56 - 7.67)	(2.22 - 4.55)
Total	20.38	20.75	20.65	18.32
95% CI	(19.92 - 20.81)	(18.97 - 23.16)	(18.86 - 22.56)	(16.58 - 20.98)
Age 75				
Healthy	9.28	8.99	9.51	8.92
95% CI	(8.96 - 9.59)	(7.92 - 10.26)	(8.22 - 10.94)	(7.31 - 11.27)
ADL Limited	3.97	4.85	4.23	2.70
95% CI	(3.7 - 4.23)	(3.85 - 6.39)	(3.09 - 5.76)	(1.94 - 4.09)
Total	13.25	13.84	13.74	11.62
95% CI	(12.92 - 13.58)	(12.36 - 16.07)	(12.52 - 15.11)	(10.05 - 14.32)
Age 85				
Healthy	4.17	5.18	5.23	4.22
95% CI	(3.86 - 4.46)	(4.27 - 6.66)	(4.16 - 6.59)	(2.67 - 6.86)
ADL Limited	3.31	3.51	2.85	2.11
95% CI	(3.04 - 3.61)	(2.35 - 5.79)	(1.67 - 4.57)	(1.5 - 3.27)
Total	7.48	8.69	8.08	6.33
95% CI	(7.23 - 7.78)	(7.26 - 11.4)	(6.91 - 10.07)	(4.77 - 9.47)
Male				
Age 65				
Healthy	15.04	16.15	15.40	15.68
95% CI	(14.7 - 15.55)	(14.65 - 17.75)	(13.98 - 16.69)	(13.91 - 18.07)
ADL Limited	2.79	3.47	2.58	2.12
95% CI	(2.59 - 3.03)	(2.64 - 4.98)	(1.8 - 3.95)	(1.32 - 2.91)
Total	17.82	19.62	17.99	17.80
95% CI	(17.49 - 18.37)	(18.04 - 21.73)	(16.58 - 19.66)	(15.92 - 20.52)
Age 75				
Healthy	8.96	10.03	9.72	9.60
95% CI	(8.63 - 9.34)	(9.03 - 11.5)	(8.51 - 10.74)	(8.45 - 11.94)
ADL Limited	2.26	2.75	1.84	1.92
95% CI	(2.11 - 2.49)	(2.03 - 4.32)	(1.15 - 3.11)	(1.25 - 2.69)
Total	11.21	12.78	11.56	11.52
95% CI	(10.94 - 11.62)	(11.61 - 14.75)	(10.63 - 12.94)	(10.12 - 14.36)
Age 85				
Healthy	4.27	5.75	5.46	4.48
95% CI	(3.92 - 4.56)	(4.92 - 7.28)	(4.48 - 6.76)	(3.07 - 6.6)
ADL Limited	1.90	1.92	1.06	2.09
95% CI	(1.69 - 2.14)	(1.2 - 3.69)	(0.57 - 2.36)	(1.26 - 3.03)
Total	6.18	7.67	6.52	6.57
95% CI	(5.85 - 6.39)	(6.62 - 10.17)	(5.79 - 8.03)	(5.29 - 8.89)

Table 3.4: Microsimulation Estimated Proportion of Remaining Life Spent Healthy at Age 65, 75, and 85

	HRS (US)	CRELES (CR)	PREHCO (PR)	MHAS (MX)
Female				
Age 65	0.76	0.70	0.72	0.83
95% CI	(0.75 - 0.78)	(0.65 - 0.75)	(0.65 - 0.78)	(0.77 - 0.88)
Age 75	0.70	0.65	0.69	0.77
95% CI	(0.68 - 0.72)	(0.58 - 0.71)	(0.6 - 0.77)	(0.67 - 0.83)
Age 85	0.56	0.60	0.65	0.66
95% CI	(0.52 - 0.59)	(0.46 - 0.7)	(0.51 - 0.78)	(0.54 - 0.78)
Male				
Age 65	0.84	0.82	0.85	0.89
95% CI	(0.83 - 0.86)	(0.76 - 0.86)	(0.79 - 0.9)	(0.84 - 0.92)
Age 75	0.80	0.78	0.83	0.84
95% CI	(0.78 - 0.81)	(0.71 - 0.83)	(0.75 - 0.9)	(0.78 - 0.89)
Age 85	0.69	0.74	0.83	0.70
95% CI	(0.65 - 0.73)	(0.61 - 0.83)	(0.68 - 0.92)	(0.55 - 0.81)

Figure 3.1: Annual Transition Probabilities

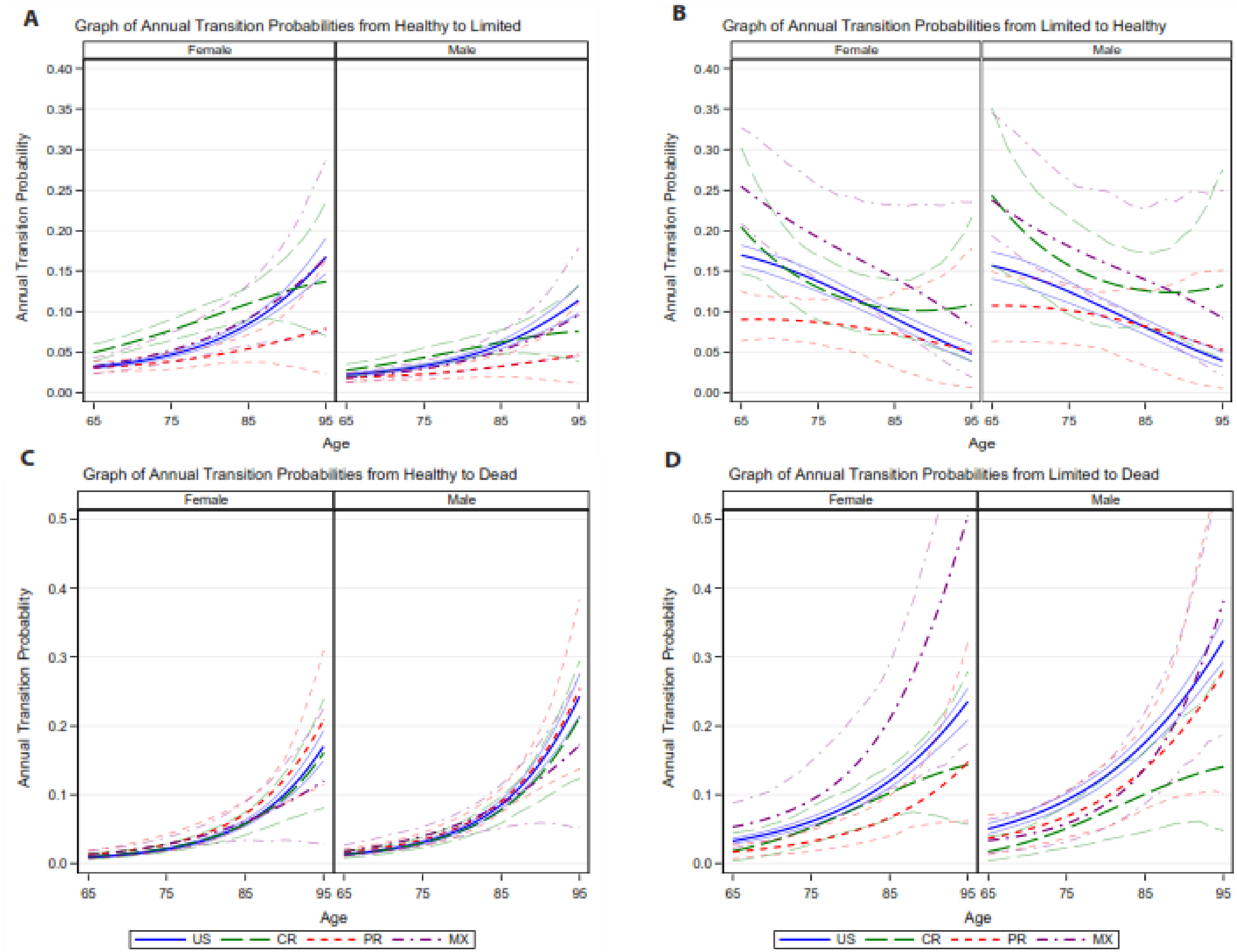
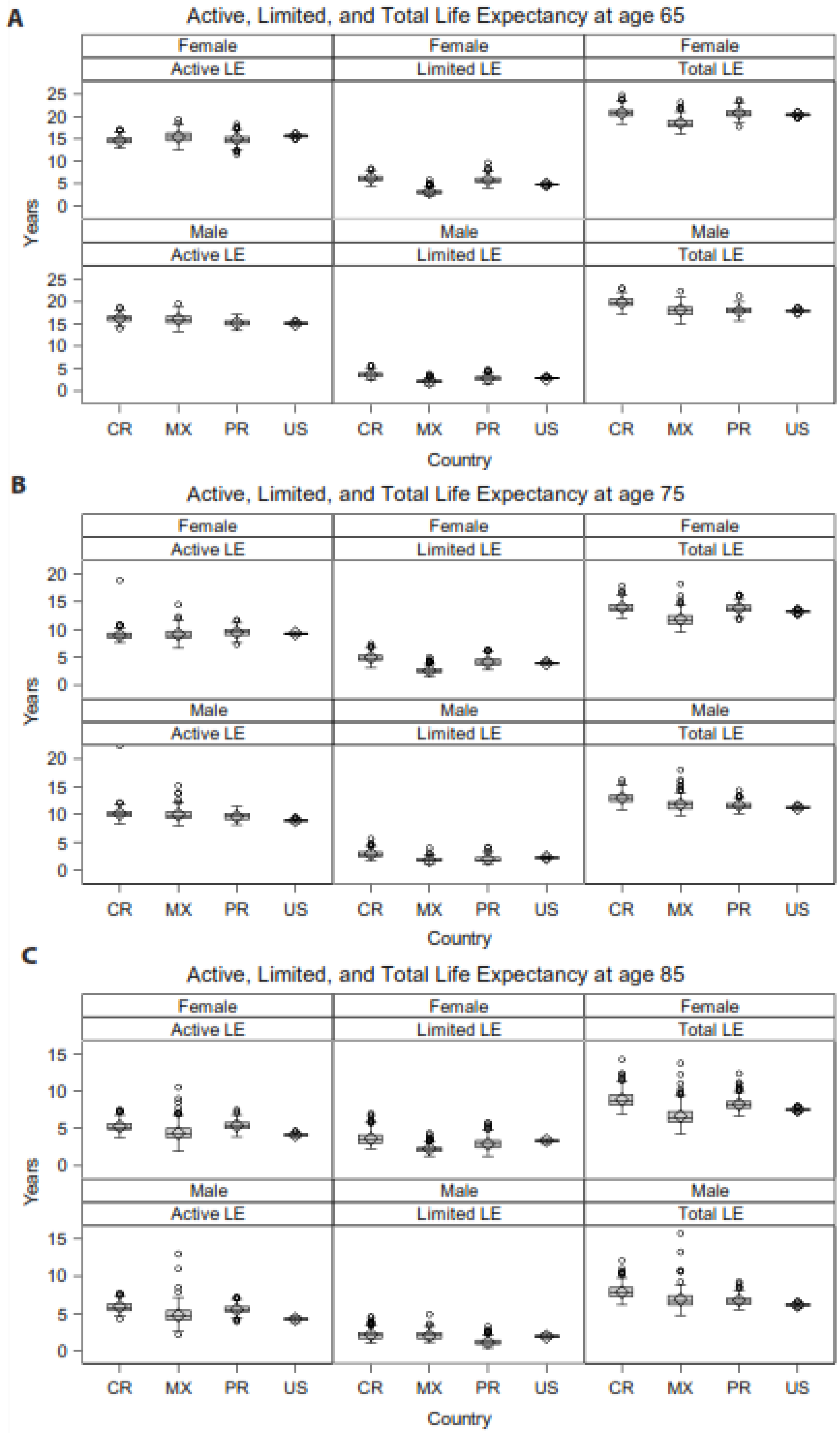


Figure 3.2: Active, Limited, and Total Life Expectancy at Age 65, 75, and 85



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