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Functional limitation trajectories and their determinants among women in the Philippines

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Abstract

BACKGROUND—Limited evidence exists regarding how functional limitation patterns of women in developing countries unfold through midlife and into old age, a critical period during which the tendency to develop severe problems is fomented.

OBJECTIVE—Functional limitation prevalence and patterns through midlife into early old age, and their determinants, are examined among women in the Philippines.

METHODS—Data from the Cebu Longitudinal Health and Nutrition Study are monitored from 1994 to 2015. Patterns are categorized using group-based trajectory modeling. Predictors of group membership are modeled.

RESULTS—About half responding to all survey waves report functional limitation at least once over the study period. Movements in and out of functional limitation states are common. Between age 30 and 70, trajectories are categorized into four groups: 1) robust, 2) late onset, 3) early onset, and 4) recovery. Being married, living in a nuclear household, higher successful birth ratio, and higher education associate with favorable trajectories. More births, higher age at first birth, wealth, and urbanicity associate with less favorable trajectories.

CONCLUSION—Many possible routes into and out of functional limitation exist. The manifold patterns can be grouped into common trajectories. A number of earlier life characteristics associate with these trajectories.

CONTRIBUTION—This is the first analysis to ascertain common functional limitation trajectories and earlier life predictors among women as they age in a high fertility developing country setting. Recognizing these is an important step toward understanding global health given aging of the population and the likelihood of functional problems developing in women as they move into old age.

1. Introduction

1.1 Population aging and functional limitation

High fertility in past generations coupled with recent declines in mortality is resulting in a precipitous growth in the global population now moving into later adult and early old age (Lee 2011; UNFPA and HelpAge International 2012; Zimmer and McDaniel 2013). Because the incidence and prevalence of physical functioning disorders increases with age, this aging of the population goes hand in hand with growing numbers living with disability and functional limitation. Consequently, recognizing how functional health problems develop and evolve over time and what factors associate with healthy functional trajectories is consequently critical for understanding broad trends in global health.

Functional limitation, as it is typically defined in the disablement literature, is a difficulty or complete inability in performing basic physical tasks requiring upper or lower body movements such as walking a reasonable distance, carrying a reasonable weight, or climbing a flight or two of stairs (Guralnik and Ferrucci 2003; Nagi 1976). Having a functional limitation in midlife is predictive of later life disability, typically defined as the incapacity to conduct tasks necessary for daily survival like bathing and getting in and out of bed (Johnson and Wolinsky 1993; Lawrence and Jette 1996; Verbrugge and Jette 1994; Zimmer et al. 2014). Regrettably, disability prevalence tends to be highest across middle and lower income countries experiencing the most rapid rates of population aging (Kinsella and Phillips 2005; World Health Organization 2011, 2015). Further, while research on sex differences in functionality is fairly nascent in middle and lower income countries, a modest amount of investigation suggests that women in these settings carry a substantial disability burden (Miszkurka et al. 2012).

Utilizing 21 years of follow-up panel data of women in the Philippines, this current set of analyses has three aims. The first is to describe prevalence of functional limitation among the sample being studied. Next is a categorization of common patterns or trajectories in functional limitation experienced by these women as they age through middle life and into early old age. The third is to examine potential predictors of more versus less favorable trajectories.

The women studied are part of the Cebu Longitudinal Health and Nutrition Survey (CLHNS). Evidence suggests that the period after childbirth is particularly consequential for the development of functional problems in later life (Adair et al. 2011; Murray et al. 2011). CLHNS data involves a cohort of women that were pregnant in 1983, gave birth that year or early in 1984, and have been monitored until 2015. This makes CLHNS data especially relevant. Cebu is a province of the Philippines that was characterized by relatively high fertility at the time these women were recruited. Because they were pregnant during enlistment, the sample is by selection a higher fertility cohort than the general population. There are no comparable samples of childbearing women followed for this length of time and no research that examines the unfolding of functional limitations for women aging from mid-age to early old age. This data therefore provides a singular opportunity to examine long-term patterns in functional limitation of women in a developing country setting during a critical period of their lives.

Previous research has indicated that continued functional deterioration is not a necessary outcome of aging (Crimmins and Saito 1993; Hardy and Gill 2004; Wolf, Mendes de Leon, and Glass 2007). Many functional disorders are acute, temporary, and modifiable. Still, trajectory research has suggested that while some people recover, the overwhelming patterns moving through old age are toward decline in functional health (Deeg 2005; Haas 2008; Martin, Zimmer, and Lee 2015; Onder et al. 2002). Given the implications of childbirth for later life health and a likely link between earlier and later life functional status, we might expect that functional limitation trajectories of women in the CLHNS would tend toward either persistent robustness or chronic decline over time.

1.2 Predictors of functional limitation trajectories

After establishing common trajectories in functional limitation, the current study will examine predictors of these patterns, seeking to determine characteristics associated with more and less healthy trajectories. The CLHNS allows for a number of potential predictors measured at or near the initiation of the study, permitting examination of the association of earlier life characteristics and later life functional health. The predictors included are discussed in this section along with some preliminary ideas about their likely effects.

Available predictors are divided into four domains. The first is demographic characteristics. Besides a woman's age, this study considers marital disruption and household type. Marital history and transitions have been connected to health outcomes particularly through stress and social support (Hughes and Waite 2009; Williams and Umberson 2004). A study of women at ages similar to the current sample indicated evidence of health deterioration after the death of a spouse (Wilcox et al. 2003). Nearly all women in the current study were married at first observation. Marital status at final observation indicates a marital disruption. Because the Philippines has the distinctive characteristic of not legalizing divorce, a disruption almost always means that the spouse died and the woman being observed is a widow. Household type is defined as nuclear versus extended. Extended households generally are larger in size. While it has not been studied often, household type and size earlier in life has been shown to associate with health. One notion is that women in nuclear households are more likely to be autonomous, which has in turn been found to relate to maternal health (McCarthy and Maine 1992).

The second domain includes several childbearing or reproductive characteristics: total number of live births, ratio of successful births to total pregnancies, and age at first birth. Studies have linked these to a variety of later life health outcomes (Grundy and Tomassini 2005; Hanson, Smith, and Zimmer 2015; Kvåle, Heuch, and Nilsen 1994; Smith et al. 2009; Spence 2008). With very few exceptions (Yi and Vaupel 2004), these studies have considered samples in higher income countries. Older age at first birth has been shown to associate with opportunities for education and employment. Earlier parenthood restricts such opportunities with deleterious outcomes for health. In contrast, early pregnancy has been shown to have some health advantages such as being protective for breast cancer (MacMahon, Cole, and Brown 1973). The general health of a mother is thought to associate with fecundability and thus both total number of live births and a higher ratio of births brought to term versus total pregnancies (Waldron, Weiss, and Hughes 1998). Higher ratios

may also indicate more protective living environments (Hawkes 2010; Uhlenberg and Cooney 1990).

The third is socioeconomic status (SES) characteristics: education, wealth, and urbanicity. Mounting evidence suggests that features such as low wealth and poor education in earlier life have detrimental accumulative impacts throughout, while also associating with diminished opportunities and less favorable socioeconomic conditions. (Galobardes, Lynch, and Davey Smith 2004; Luo and Waite 2005; Pudrovska and Anikputa 2014; Ross and Wu 1996). While the current data does not contain measures of the respondent's childhood (SES), there are measures of SES at the time of her childbearing. Along with individual measures of SES, evidence suggests community level characteristics are consequential (Wen, Hawkey, and Cacioppo 2006; Wight et al. 2008). Communities with more amenities and resources are healthier environments in which to age. In the current study a measure of urbanicity, which quantifies the concentration of amenities typically found in urban communities, is used as a community measure of SES.

Finally, the study considers three measures of health status: having a chronic condition, body mass index (BMI), and self-rated health. Midlife health has been shown to be associated with and have lingering effects on functional health into old age (Ben Shlomo and Kuh 2002; Rantanen et al. 1999; Reilly and Kelly 2011; Willis et al. 2012). Although it is possible to recover from earlier life ailments, poor health in early life is a sign of weak physical condition. Poor health in early life may interact with chronic conditions that accumulate throughout life. Earlier life BMI has been shown to be a clear predictor of later life health, relating to such conditions as heart disease and diabetes as well as general functional disorders (Himes 2000; Reynolds, Saito, and Crimmins 2005; Tirosh et al. 2011). Self-rated health is a global indicator of health status that can encapsulate a host of issues not captured by BMI and chronic conditions (Idler and Benyami 1997; Jylha 2009).

This above review suggests several hypotheses regarding earlier life characteristics and functional health trajectories that are tested in the current study. Those that continue to be married throughout the observation period and those living in nuclear households earlier in life are expected to have more favorable trajectories. While associations with age of first birth and number of total births are uncertain, higher successful birth ratio is expected to relate to healthier trajectories. Higher SES across all three indicators is hypothesized to associate with more favorable trajectories. Better health – as indicated by lack of chronic conditions, lower BMI, and excellent self-rated health – is anticipated to relate to healthier trajectories as later life unfolds.

2. Data and methods

2.1 Sample

CLHNS was launched in 1983 with a baseline sample of about 3,000 women, all of whom lived in Metropolitan Cebu, Philippines and all of whom gave birth between May 1, 1983 and April 30, 1984 (Adair et al. 2011). Metro Cebu is the second largest metropolitan area in the Philippines next to Metro Manila. In 1983 the area contained 270 administrative units or '*barangays*' which consisted of both rural villages and urban neighborhoods. Sampling

involved a single stage cluster design beginning with a random selection of 17 urban and 16 rural barangays. In each barangay, households were enumerated and all pregnant women were asked to take part in the study. There was less than a 4% refusal rate. CLHNS data has been employed for hundreds of published analyses (Several important examples include: Adair and Cole 2003; Adair, Popkin, and Guilkey 1993; Croteau-Chonka et al. 2011; McDade et al. 2001).

Study participants were followed over time with waves of data collection taking place every several years. In 1994 functional limitation items were collected for the first time, making this Wave 1 for the current analysis. Waves 2 to 6 are based on subsequent data collected in 1998, 2002, 2005, 2012, and 2015. As such, functional limitation items were observed among this panel of women over a 21-year period. There was a 2007 wave but it was dropped because analyses indicated this wave was anomalous, likely a function of the fact that it was a 'tracking' survey rather than a full survey and procedures for data collection, coding, cleaning, and editing differed from other waves.

The age of the women in the CLHNS at the time they gave birth in 1983/1984 was between 14 and 48. For some this was their first live birth, but others had one or more children born previously. In order to keep the analysis focused on those passing through middle age, the study is limited to those in a 20-year age range between 19 and 38 at baseline in 1983. These women were born between 1945 and 1964. They were aged 30 to 49 when functional limitation measures were first collected in Wave 1. By Wave 6, at the time of the last observation in 2015, they were between ages 51 and 70. Identifying middle age as 30 to 50 and early old age as 51 to 70, all women in this study passed through parts of middle and early old age during observation. In 1994, at Wave 1, there were 2,049 of these women. The analysis dropped 148 with missing observations (85 with no follow-up data after Wave 1 and 63 with missing observations prior to death, for reasons explained later), leaving a valid sample of 1,901. Of these, 92 women are known to have died during the study period and another 564 had some missing data. The remaining 1,245 cases were observed at each of the six waves. The analytical techniques we employ allow us to keep those that died and those with two or more valid observations in the sample. Table 1 shows the number of observations at Wave 1, dividing the sample into four birth cohorts, and the ages of the women at each observation if they survived. The youngest person in the sample was age 30 when first observed and 51 when last observed; the oldest person was 49 when first observed and 70 when last observed.

2.2 Functional limitation

Functional limitation is recorded across six waves using items that asked women if they were able to do the following without any difficulty: walk a distance of one kilometer, climb a flight of stairs or walk up a hill, and carry a weight of 5 kg for a short distance. These items compare well with studies of older persons around the world often employed for the purpose of determining rates and patterns of functional limitation (e.g., Freedman, Martin, and Schoeni 2002; Nogueira and Reis 2014; Ofstedal et al. 2007). In each wave, respondents are coded dichotomously as reporting or not reporting difficulty with at least one task.

2.3 Predictors

Twenty-one-year functional limitation trajectories are modeled by a series of predictors representing domains of demographics, childbearing, SES, and health. By a ‘predictor’ we generally refer to a variable that is associated with functional limitation trajectories. We try to avoid language of causation, although given that most of our predictors are measured prior to the very first functional limitation observation, there is a case to be made for causality in some instances. Since CLHNS data date from time of pregnancy in 1983, measures from the baseline survey are, in fact, direct non-retrospective indicators of earlier life characteristics.

Besides age, the demographic domain consists of marital status at Wave 6 and household type at baseline. Nearly all participants were married when they gave birth in 1983/1984. Marital status at Wave 6 therefore indicates whether a marital disruption occurred before the end of the observation period. With no divorce in the Philippines, not married at Wave 6 is usually indicative of widowhood. Household type is dichotomized into nuclear (consisting of respondent and/or spouse and children) or extended.

The childbearing domain includes the total number of live births measured at Wave 6, the ratio of successful births to total lifetime pregnancies measured at Wave 6, and age of the woman at time of birth of her first child determined at baseline.

The SES domain includes respondent’s education at Wave 1, household wealth measured at baseline, and urbanicity of barangay measured at baseline. Education is categorized as elementary or less (0 to 6 years), high school (7 to 10 years), and college (11 or more years). With a technique popularized using household data from Demographic and Health Surveys, wealth is a composite index measure that is a linear sum of assets owned or not owned by the household, with each asset weighted by a Principal Component Analysis (Filmer and Pritchett 2001; Fry, Firestone, and Charkraborty 2014). The composite is calculated from 26 assets such as a car, television, and cookware. The index is normalized to have a mean of zero and a standard deviation of one. The urbanicity score is based on the work of Dahly and Adair (2007) who used CLHNS to quantify the urban environment. The measure is at the level of the barangay and is based on population density plus a collection of amenities categorized into communication (mail, newspaper, telephone, cell phone, internet, and cable service), education (primary, secondary, vocational schools, and colleges), transportation (bus, jeepney, and taxi service classified as continuous and daily, and paved roadways), health (hospital, private medical, pharmacies, maternal health clinic, family planning clinic, puericulture center, and rural health unit) and markets (grocery store, gas station, and drug store). The scale has been tested for reliability and validity and against a more standard urban/rural dichotomy (Dahly and Adair 2007). A higher score indicates more amenities within the barangay and therefore is a proxy of both urbanicity and community level SES.

Health measures are all taken at Wave 1. They consist of BMI, chronic conditions, and self-rated health. BMI is weight in kilograms divided by height in meters squared. In this study, BMI is coded as a dichotomy with scores of 25 and over indicating high BMI. Chronic conditions are based on a list of diseases such as diabetes, heart disease, and cancer. The measure is dichotomized as a condition that is reported or not reported. Self-rated health is

based on a single survey item asking women to rate their health on a three-point scale: poor, good, and excellent. Poor is an infrequent response and therefore the measure is dichotomized into excellent versus good or poor. Table 2 provides descriptive statistics for predictors.

2.4 Analytical strategy

The first analytical stage is a description of functional limitation prevalence of the sample over time. Functional limitation prevalence is examined for different birth cohorts based on age at first observation at Wave 1 in 1994 and across waves.

The second stage involves a modeling strategy to divide the sample into groups that have common patterns in functional limitation as they age from middle into old age. For instance, some will not have functional limitations in any wave and may be grouped into a category of ‘robust’ women; others will have limitations in anywhere from one to all six waves. Given the dichotomous measurement of functional limitation (i.e., has or does not have a functional limitation), the number of possible distinct patterns of onset, recovery, and progression of functional limitation for those that respond to all six waves is equal to 2^6 or 64.

Preliminary analyses show that almost all possible sequences of movements into and out of functional limitation over time and age are possible and therefore summarizing common patterns is complex. About 48% of respondents have no limitations at any wave, but among the other 52%, almost all possible trajectories are reported. For instance, 158 women out of the sample of 1,901 respond in each of the six waves and report limitation in two waves. Of these, 32 report limitations in Waves 5 and 6, 8 report limitations in Waves 4 and 6, 7 report limitations in Waves 3 and 6, and so on.

In order to make sense of this variation and to determine categories to use in the next analytical stage, it is necessary to cluster individuals into groups representing similar patterns or trajectories over time. One way of doing this would be subjectively establishing *a priori* typologies (for instance, those without limitations at any wave; with limitations in early waves; with limitations in late waves; with limitations in both early and late waves). While such a strategy may result in ‘sensible’ groups, there are disadvantages. Subjective categorization makes it difficult to incorporate those dying or missing observations, meaning the sample size is reduced in a non-random way; subjective categorization cannot possibly consider all the available data but rather usually requires waves to be clumped; using subjective categorization there is no test for affirming the existence of each group or for estimating the probabilities of being in one group versus another.

The current analysis avoids these shortcomings by employing the group-based trajectory modeling (GBTM) approach first introduced by Nagin and colleagues. It is currently available as a plugin using STATA version 14 (Jones and Nagin 2012; Nagin 1999, 2005; Nagin and Tremblay 2001; Roeder, Lynch, and Nagin 1999). This approach has been used previously for studying trajectories in functional limitation and other similar outcomes (Connor 2006; Gill et al. 2010; Liang et al. 2010; Zimmer et al. 2012). The technique has been shown to be suitable for capturing underlying onset, progression, and recovery of functional health problems (Zimmer et al. 2014). Based on finite mixture modeling, the

GBTM approach divides individuals into groups using a maximum likelihood procedure. The groups in this analysis are formed based on the probability of having a functional limitation at any age given the range represented in the data, which in this case is 30 to 70. Trajectory patterns of each group are a function of a parameter vector that can be modeled up to a 5th order polynomial function of age (although anything more than a 2nd order polynomial is inordinately complex for the current data). Parameters are assumed to have a logistic distribution since the dependent variable, functional limitation, has values 0 and 1. Outputs include the number of groups that best describe the data, parameters that determine the shape of the trajectory by age, and the proportion of the sample that fits into each group. Like other procedures that cluster or group observations or indicators, the determination of number of groups is partially based on pragmatic interpretation and partially on fit statistics. In this case, they include Bayesian Information Criterion (BIC) and post-estimation procedures. The GBTM approach used here allows the cause of missing observations to be distinguished as due to death or simply missing as long as ‘alive and missing’ and ‘deceased’ are not reported for the same person across different waves (Haviland, Jones, and Nagin 2011). Therefore, the few respondents with missing observations followed by a known death are deleted from the analysis (89 cases).

After common trajectory groups are defined, membership assignment is used as a dependent variable in the third stage, which uses a multinomial regression to estimate the association between earlier life predictors and functional limitation trajectory. The GBTM approach provides posterior probabilities, which is the chance that each individual belongs to each group. Individuals are assigned to the group for which they have the highest posterior probability. Since the probability of fitting into a particular group is not always 100%, there is the possibility of error. To assure unbiased standard errors in the regression procedure, weights are constructed equal to the posterior probability. Two models are tested. The first includes all predictors except for the health variables (BMI, chronic conditions, and self-rated health). The second adds the health variables. The reason for two models is that the health characteristics are measured at Wave 1 and are not necessarily exogenous to group membership.

3. Results

3.1 Functional limitation prevalence

Functional limitation prevalence for each wave for women belonging to four birth cohorts is shown in Figure 1. The youngest cohort consists of those aged 30 to 34 at Wave 1 who, if they survived, were between 51 and 55 by Wave 6; the oldest consists of those aged 45 to 49 at Wave 1 who, if they survived, were between 66 and 70 by Wave 6. The figure uses all available data for each wave, not just information on those observed at all waves. Therefore, deceased and those missing at any wave are considered in prevalence calculations for waves in which their observations were recorded. The average prevalence for all age groups across all waves is 0.17. The figure shows that at each wave older women have higher prevalence than younger. At Wave 1 differences across age groups are not very pronounced, ranging from 0.15 for the youngest group to 0.19 for the oldest. At Wave 6 differences are much

wider. The prevalence of limitation in Wave 6 is 0.14 for those 51 to 55; 0.20 for those 56 to 60; 0.28 for those 61 to 65; and 0.38 for those 66 to 70.

An expectation might be that over time prevalence would increase steadily for each cohort, since over time those in the cohort are aging. However, this is not necessarily the case over the first few waves. The reason is that there is an underlying trend towards lower prevalence of functional limitation from wave to wave. This is shown in Figure 2, which plots prevalence by age in five-year groups, using stacked person-wave observations wherein each measure of age and functional limitation at each wave is considered as a single observation. The sample in Wave 1 falls into four five-year age groups (30 to 34, 35 to 39, 40 to 44, and 45 to 49). As more waves of data are collected, the age range of the women gets older. The figure demonstrates that regardless of wave there is a sharp increase in the tendency to report a limitation at higher ages. But, there is also a general trend toward lower prevalence as time passes from Wave 1 until Wave 6 (Wave 6 seems to be the exception). Take, for example, the age group 45 to 49, who appear in five waves. The prevalence of functional limitation from Wave 1 onward for women of this age is .19, .28, .14, .14, and .10 respectively. As another example, women age 50 to 54, who began appearing in the data in Wave 2, have prevalence respectively across waves of .32, .23, .16, .14, and .14 by Wave 6.

The trend of decreasing prevalence over time was confirmed in a supplementary logistic regression predicting functional limitation probability using stacked person-wave observations. Adjusting for age, prevalence is highest in Waves 1 and 2, significantly lower in Waves 3 and 4, and significantly lower again in Waves 5 and 6. At the same time, adjusting for wave, the age of the mother is a significant predictor of having a functional limitation with older age resulting in higher prevalence.

Prevalence is examined further in Table 3, which shows the percent distribution of the number of waves in which individuals report limitations. Since those dropping out due to death or missing at any wave are not at risk of having limitations in every wave, these cases are dropped. The number dropped due to death or missing observations is also reported in the last two rows of the table. The percent that are observed without limitation in all six waves is 55.4, 50.3, 38.9, and 35.1 for the four birth cohorts, which again shows that older women are less likely to be limitation free. Increasingly smaller percentages report limitations in an increasingly greater number of waves, with the tendency to report limitations in more waves being higher for older women.

Supplementary analysis showed that for those that report limitations in one or more waves, the specific waves vary greatly such that there is substantial movement both into and out of limitation. Table 4 illustrates this point. It shows the specific waves in which limitations are reported only for those women observed in all six waves who report limitations in two of the six. There are 158 such women in total. The largest percent, 20.3%, report these limitations in the last two waves. Almost half report a limitation in the last wave. However, it is very likely that limitations are reported in earlier waves and that recovery was experienced at some point. For instance, the second largest proportion consists of those that report a limitation in Wave 2 and then not again until Wave 6 (10.1%). Some report functional limitation in the first two waves and then not again (7.0%). While two limitations are used

for heuristic purposes, the same degree of variation is found for those reporting any number of limitations over time.

3.2 Functional limitation trajectories

The above indicates that many different patterns into and out of functional limitation exist such that it is difficult to describe typical trajectories without a modeling approach to cluster observations. GBTM modeling is employed for this using age as the independent variable and the reporting of a functional limitation as the dependent variable. Table 5 provides the results of the best fitting four-group GBTM model and Figure 3 translates these results into probabilities. A four-group solution was determined to be the most efficacious since it provides the greatest number of distinct trajectories without obvious overlaps. A .698 average posterior probability indicates generally high confidence in the classification of women into these groups. A median posterior probability of .750 indicates that there is higher than 75% confidence of classification in more than half the sample. The parameters determine the shape of the trajectory by age. Group 1 is described by an intercept only and therefore suggests an unchanging probability. Group 2 is a linear declining trajectory. Group 3 is described by a negative linear and positive quadratic term indicating a declining probability at younger ages and a rising probability with increasing age. Group 4 is a linear positive trajectory.

Figure 3 illustrates the patterns of four groups, which are named (from Group 1 to Group 4) robust, recovery, late onset, and early onset. The robust group has a near zero probability of functional limitation at any age. Functionally, this is clearly the healthiest group and consist primarily of those women in the sample that do not report a limitation at any time throughout middle age and into early old age. Looking at group size, 53.6% of the sample best fit into the robust group. Not coincidentally, about the same proportion report no limitations in all six waves. The recovery group consists of women likely to have a limitation in middle age. This probability declines as they move into old age. These women likely suffer from conditions at time of observation that are temporary. 14.5% fit into this classification. The late onset group are women with a relatively low probability of a limitation in middle age, with increasing probabilities as they enter early old age. This group has a 50% chance of a limitation by age 64 and a 82% chance by age 70. 28.1% are categorized as late onset. The somewhat higher probability of a limitation at younger ages for this group are probably not coincidental. This may indicate that the probability of the onset of a limitation in old age is somewhat related to the probability earlier in life. The early onset group is characterized by rapidly rising probabilities of a functional limitation from age 30 onward. The chance of a limitation for this group reaches 50% by age 48, 16 years earlier than the late onset group, thus these women are likely to enter early old age having already experienced an onset. By age 70 nearly 100% of this group is functionally limited. This is the smallest sized group with only 4% of the sample. Note that a three-group solution, which actually has a better BIC but does not distinguish the sample as well, looks fairly similar except that the distinction between late and early onset is not present.

3.3 Predictors of functional limitation trajectories

Results of the multinomial regression predicting group membership are shown in Table 6. Coefficients provide an estimate in the form of log odds of the chance of being in each specific group in contrast to the robust group. Therefore, variables with negative coefficients can be interpreted generally as protective. That is, it indicates a lower chance of being in the recovery, early onset, or late onset group relative to robust.

Looking at Model 1, which does not include health predictors, and summarizing across the contrasts, the following factors appear to be protective by increasing the chance of being in the robust group and decreasing the chance of being in other groups: remaining married over the 21-year observation period, living in a nuclear household arrangement at baseline, and having higher education. The following appear to be detrimental by increasing the chance of being in a group other than the robust group: a greater number of live births, coming from a higher wealth household, and living in a barangay with a higher urbanicity score. Further, higher age at birth of first child is associated with a greater chance of being in the late onset group, while having a higher successful birth ratio is protective against being in the early onset group. Some of these associations are consistent with expectations, but some are not. In particular, total number of children born, wealth, and urbanicity scores run contrary to hypotheses. In supplementary analyses each predictor was examined unadjusted. This confirmed the direction of the associations, even for results like wealth and urbanicity that are inconsistent with expectations.

When adding health indicators, the other predictors do not change much. Health variables indicate that those in the robust group are more likely to have a BMI less than 25 and do not have a chronic condition at Wave 1. It is notable that the coefficient for chronic condition is much higher for the recovery versus robust contrast than for the other contrasts, an indication that the recovery group consists of women that have a health condition early in life from which they may recover. This may be, for instance, an injury or temporary illness. Similarly, the recovery group is related to poorer self-rated health at Wave 1.

4. Discussion and conclusion

Around the world, those entering late midlife and early old age are a rapidly growing population segment, especially in low and middle income countries. Women in these countries in this age range are at high risk for onset of functional problems, thus threatening to expand the global burden of disability (Murray and Lopez 1997; World Health Organization 2011). Midlife is a critical period for these women since during this time many will experience onset and progression of functional limitation, which is a precursor of disability in later life (Miszkurka et al. 2012; Verbrugge and Jette 1994). The current study examines functional limitation in women from Cebu, Philippines as they age through midlife and into early old age. Each woman in the sample had a pregnancy and successful birth in 1983 or early 1984 when they were between 19 and 38 years old. Each was followed over a number of survey waves until they were between 51 and 70 years old. Their functional limitation status was recorded six times over a 21-year period from 1994 to 2015. The nature of this longitudinal panel data provides an opportunity to examine functional limitation

prevalence, to ascertain common functional limitation patterns, and to correlate these patterns with characteristics measured earlier in life.

The overall prevalence of functional limitation among the sample across all ages and waves is 17%. As expected, it is lower for those in younger age groups and higher for those in older age groups, peaking at a prevalence of 38% among those aged 66 to 70 at Wave 6. At the same time, there are fluctuations over the years indicating a declining tendency to report functional limitation from 1994 to 2015. There is also substantial movement into and out of limitation from survey wave to wave. About half of the total sample observed for all six waves did not report a functional limitation at any time. While it is difficult to draw comparisons with studies of functional limitation elsewhere for a number of reasons, that half of this fairly young sample reported limitations at some point suggests a fairly high prevalence.

At the same time, movements into and out of functional limitation are frequent. For those with limitations over the course of six waves of data collection, most reported these at some points and not others. This suggests that aging through midlife into old age often involves repeatedly experiencing onset and recovery from functional health problems. Therefore, there are manifold possible patterns of functional limitation over time that are subjectively hard to describe. In the current study these were collapsed into common trajectories using GBTM modeling. A four-group model indicates that the most populous group is also functionally the healthiest, consisting of women that are unlikely to experience a limitation at any time between age 30 and 70. Those that are likely to experience a late onset – that is, they tend to be limitation free until their 60s – are the next largest group. This is followed by a recovery group that is likely to have a limitation in their 30s but not in their 60s. The smallest group, and likely the least favorable, is an early-onset group that is limitation-free in their 30s but likely to experience an onset by age 48 and nearly certain to have a limitation in their 60s.

A multinomial regression assessed factors best able to predict group membership. Living in a nuclear family at time of birth of the indexed child and remaining married throughout the observation period is deemed to be generally protective. The salutary influence of being married in older age is consistent with much previous literature (Wilcox et al. 2003; Williams and Umberson 2004). That being in a nuclear family setting relates to better functional health is intriguing though not exceptional. While it has not been often studied, other investigations have linked household type at the time a woman gives birth to her health (McCarthy and Maine 1992; Saikia and Singh 2009). The supposition is that nuclear households and subsequently smaller households may be a proxy for nontraditional attitudes, personal freedom, and autonomy – factors that tend to influence maternal health favorably. A woman that has greater autonomy tends to seek medical attention more frequently and likely takes care of her own health needs more conscientiously throughout life.

Of the childbirth characteristics, having fewer children is shown to be protective. There are several possible explanations for this. Smaller family size may be related to increased opportunities for education and employment, factors which are beneficial to health. Smaller

family size may be an indication of female autonomy. Kington, Lillard, and Rogowski (1997) discuss maternal depletion that is associated with higher order births and its cumulative impact on health into old age, which could be especially common in a developing country context where it may be difficult to obtain quality health care. Smith and Kington (1997) suggest that a greater likelihood of reporting health problems could be a function of greater awareness of health issues that manifests with more frequent contact with the health care system, itself related to higher order parity.

At the same time, when holding number of births constant, a younger age at first birth is protective but only of late onset of functional limitation; a result that is in agreement with at least one recent study that linked reproductive characteristics to later life health trajectories (Hanson, Smith, and Zimmer 2015). A high successful birth ratio, a general indication of the health of the mother, is protective of early onset of functional limitations, which is likely the least auspicious trajectory.

Results related to the SES characteristics are somewhat perplexing. A substantial body of research links higher SES with better health outcomes, and higher early-life SES with better later life health outcomes. The current analysis supports this notion using education as an indicator. However, contrary findings with wealth and urbanicity suggest that the association in the current context is complex and may vary across indicators. Similar associations are found with wealth and urbanicity unadjusted for education and are also reported in other independent research using this data (Lee, Perez, and Duazo 2013). These seemingly paradoxical findings are however not totally without explanation. Evidence for the protective effects of higher early-life SES has almost exclusively come from the United States and other high income countries. Whether these associations are consistent in other settings is uncertain. Some studies find unhealthy behaviors, such as smoking, poor diets and exercise regimes, and greater exposure to environmental hazards among urbanites and wealthier people in societies that are moving quickly out of low income status; a situation that does characterize the district of Cebu from which the current data originates (Bradley et al. 1992; Du et al. 2004; Stephens 1996; Zhai and McGarvey 1992). In these circumstances those who are wealthier and living in more urban places may be at higher risk for health problems related to lifestyle, such as hypertension and diabetes. Another possible connection with the current setting is that the type of labor that is typically undertaken by rural lower income women may be more physically intensive, which could benefit longer term functional health outcomes, as has been suggested elsewhere in developing country settings (Yi et al. 2002). The rural areas of Cebu from which this data comes are typically mountainous and have poor transportation links. The necessity of walking long distances with elevation changes may also be beneficial. The potential of selectivity factors cannot be ignored. It may be that those less healthy but wealthier can and do decide to live in more urban areas. It may also be that wealthier and those living in more urban areas have a greater tendency to report health problems due to having more contact with a health care system and subsequently greater health awareness.

That health indicators relate to patterns in functional limitation is not surprising and suggests that poor health earlier in life lingers into early old age (Ben Shlomo and Kuh 2002). At the same time, there is endogeneity involved in the health measures since they come from Wave

1 rather than from baseline and therefore are not independent of the first measure of functional status. It is likely for this reason that chronic conditions are highly correlated with recovery and early onset.

Results herein could be shaped by the context of Cebu, Philippines and might differ in different parts of the world. Still, the examination of functional limitation among aging women in a high fertility lower income setting is an important step toward a better understanding of global health. These parts of the world are experiencing the most rapid rates of population aging, and the highest likelihood of functional problems is experienced by women in older age groups. That lower fertility within families is protective of women's health is perhaps relevant given that many of these countries are going through fertility transition. While studies would be of interest elsewhere where the role of women, marital customs, and normative household structures is different, available data over such long periods of time is unfortunately rare and therefore it would be difficult to reproduce this analysis. The CLHNS indeed provides a unique opportunity. Our examination suggests a fairly high prevalence and many different possible patterns into and out of functional limitation as women age through mid-life and early old age in this developing country setting.

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References

- Adair LS and Cole TJ (2003). Rapid child growth raises blood pressure in adolescent boys who were thin at birth. *Hypertension* 41(3): 451–456. doi:10.1161/01.HYP.0000054212.23528.B2. [PubMed: 12623942]
- Adair LS, Popkin BM, Akin JS, Guilkey DK, Gultiano S, Borja J, Perez L, Kuzawa CW, McDade T, and Hindin MJ (2011). Cohort profile: The Cebu longitudinal health and nutrition survey. *International Journal of Epidemiology* 40(3): 619–625. doi:10.1093/ije/dyq085. [PubMed: 20507864]
- Adair LS, Popkin BM, and Guilkey DK (1993). The duration of breast-feeding: How is it affected by biological, sociodemographic, health sector, and food industry factors? *Demography* 30(1): 63–80. doi:10.2307/2061863. [PubMed: 8440399]
- Ben Shlomo Y and Kuh D (2002). A life course approach to chronic disease epidemiology: Conceptual models, empirical challenges and interdisciplinary perspectives. *International Journal of Epidemiology* 31(2): 285–293. doi:10.1093/intjepid/31.2.285. [PubMed: 11980781]
- Bradley JB, Stephens T, Harpham T, and Cairncross S (1992). *A review of environmental health impacts in developing country cities*. Washington, D.C.: The World Bank.
- Connor J (2006). *Multivariate mixture models to describe longitudinal patterns of frailty in American seniors*. [doctoral dissertation]. Pittsburgh: Department of Statistics, Carnegie Mellon University.
- Crimmins EM and Saito Y (1993). Getting better and getting worse: Transitions in functional status among older Americans. *Journal of Aging and Health* 5(1): 3–36. doi: 10.1177/089826439300500101.
- Croteau-Chonka DC, Marvelle AF, Lange EM, Lee NR, Adair LS, Lange LA, and Mohlke KL (2011). *Genome wide association study of anthropometric traits and evidence of interactions with age and*

- study year in Filipino women. *Obesity* 19(5): 1019–1027. doi:10.1038/oby.2010.256 [PubMed: 20966902]
- Dahly DL and Adair LS (2007). Quantifying the urban environment: A scale measure of urbanicity outperforms the urban-rural dichotomy. *Social Science and Medicine* 64(7): 1407–1419. doi: 10.1016/j.socscimed.2006.11.019. [PubMed: 17196724]
- Deeg DJH (2005). Longitudinal characterization of course types of functional limitations. *Disability and Rehabilitation* 27(5): 253–261. doi:10.1080/09638280400006507. [PubMed: 16025752]
- Du S, Mroz TA, Zhai F, and Popkin BM (2004). Rapid income growth adversely affects diet quality in China - Particularly for the poor! *Social Science and Medicine* 59(7): 1505–1515. doi:10.1016/j.socscimed.2004.01.021. [PubMed: 15246178]
- Filmer D and Pritchett L (2001). Estimating weath effects without expenditure data - or tears: An application to educational enrollments in states of India. *Demography* 38(1): 115–132. doi: 10.1353/dem.2001.0003. [PubMed: 11227840]
- Freedman VA, Martin LG, and Schoeni RF (2002). Recent trends in disability and functioning among older Americans: A critical review of the evidence. *Journal of the American Medical Association* 288(24): 3137–3146. doi:10.1001/jama.288.24.3137. [PubMed: 12495394]
- Fry K, Firestone R, and Charkraborty NM (2014). Measuring equity with nationally representative wealth quintiles. Washington, D.C.: PSI.
- Galobardes B, Lynch JW, and Davey Smith G (2004). Childhood socioeconomic circumstances and cause-specific mortality in adulthood: Systematic review and interpretation. *Epidemiological Review* 26(1): 7–21. doi:10.1093/epirev/mxh008.
- Gill TM, Gahbauer EA, Han L, and Allore HG (2010). Trajectories of disability in the last year of life. *New England Journal of Medicine* 362(13): 1173–1180. doi:10.1056/NEJMoa0909087. [PubMed: 20357280]
- Grundy E and Tomassini C (2005). Fertility history and health in later life: A record linkage study in England and Wales. *Social Science and Medicine* 61(1): 217–228. doi:10.1016/j.socscimed.2004.11.046. [PubMed: 15847974]
- Guralnik JM and Ferrucci L (2003). Assessing the building blocks of function: Utilizing measures of functional limitation. *American Journal of Preventive Medicine* 25(3): 112–121. doi:10.1016/S0749-3797(03)00174-0.
- Haas S (2008). Trajectories of functional health: The ‘long arm’ of childhood health and socioeconomic factors. *Social Science and Medicine* 66(4): 849–861. doi:10.1016/j.socscimed.2007.11.004. [PubMed: 18158208]
- Hanson HA, Smith KR, and Zimmer Z (2015). Reproductive history and later-life comorbidity trajectories: A Medicare-linked cohort study from the Utah Population Database. *Demography* 52(6): 2021–2049. doi:10.1007/s13524-015-0439-5. [PubMed: 26527471]
- Hardy SE and Gill TM (2004). Recovery from disability among community-dwelling older persons. *Journal of the American Geriatrics Society* 291(13): 1596–1602. doi:10.1001/jama.291.13.1596.
- Haviland AB, Jones BL, and Nagin DS (2011). Group-based trajectory modeling extended to account for nonrandom participant attrition. *Sociological Methods and Research* 40(2): 367–390. doi: 10.1177/0049124111400041.
- Hawkes K (2010). How grandmother effects plus individual variation in frailty shape fertility and mortality: Guidance from human–chimpanzee comparisons. *Proceedings of the National Academy of Sciences* 107(Supplement 2): 8977–8984. doi:10.1073/pnas.0914627107.
- Himes CL (2000). Obesity, disease, and functional limitation in later life. *Demography* 37(1): 73–82. doi:10.2307/2648097. [PubMed: 10748990]
- Hughes ME and Waite LJ (2009). Marital biography and health at mid-life. *Journal of Health and Social Behavior* 50(3): 344–358. doi:10.1177/002214650905000307. [PubMed: 19711810]
- Idler EL and Benyami Y (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior* 38(1): 21–37. doi:10.2307/2955359. [PubMed: 9097506]
- Johnson RJ and Wolinsky FD (1993). The structure of health status among older adults: Disease, disability, functional limitation, and perceived health. *Journal of Health and Social Behavior* 34(2): 105–121. doi:10.2307/2137238. [PubMed: 8277124]

- Jones BL and Nagin DS (2012). A Stata plugin for estimating group-based trajectory models. Pittsburgh: Heinz College Research, Carnegie Mellon University (working paper).
- Jylha M (2009). What is self-rated health and why does it predict mortality? Towards a unified conceptual mode. *Social Science and Medicine* 69(3): 307–316. doi:10.1016/j.socscimed.2009.05.013. [PubMed: 19520474]
- Kington R, Lillard L, and Rogowski J (1997). Reproductive history, socioeconomic status, and self-reported health status of women aged 50 years or older. *American Journal of Public Health* 87(1): 33–37. doi:10.2105/AJPH.87.1.33. [PubMed: 9065223]
- Kinsella K and Phillips DR (2005). Global aging: The challenge of success. *Population Bulletin* 60(1): 3–40.
- Kvåle G, Heuch I, and Nilsen S (1994). Parity in relation to mortality and cancer incidence: A prospective study of Norwegian women. *International Journal of Epidemiology* 23(4): 691–699. doi:10.1093/ije/23.4.691. [PubMed: 8002181]
- Lawrence RH and Jette AM (1996). Disentangling the disablement process. *Journal of Gerontology: Social Sciences* 51(4): S173–S182. doi:10.1093/geronb/51B.4.S173.
- Lee NR, Perez TL, and Duazo P (2013). Examining disability patterns over time in Cebuano women. Paper presented at the annual meeting of the Philippine Population Association, Cebu City, 2 7–8, 2013..
- Lee RD (2011). The outlook for population growth. *Science* 333(6042): 569–573. doi:10.1126/science.1208859. [PubMed: 21798936]
- Liang J, Wang C-N, Xu X, Hsu H-C, Lin H-S, and Lin Y-H (2010). Trajectory of functional status among older Taiwanese: Gender and age variations. *Social Science and Medicine* 71(6): 1208–1217. doi:10.1016/j.socscimed.2010.05.007. [PubMed: 20667642]
- Luo Y and Waite LJ (2005). The impact of childhood and adult SES on physical, mental, and cognitive well-being in later life. *Journal of Gerontology: Social Sciences* 60(2): S93–S101. doi:10.1093/geronb/60.2.S93.
- MacMahon B, Cole P, and Brown J (1973). Etiology of human breast cancer: A review. *Journal of the National Cancer Institute* 50(1): 21–42. doi:10.1093/jnci/50.1.21. [PubMed: 4571238]
- Martin LG, Zimmer Z, and Lee J (2015). Foundations of activity of daily living trajectories of older Americans. *Journal of Gerontology: Social Sciences* 72(1): 129–139. doi:10.1093/geronb/gbv074.
- McCarthy J and Maine D (1992). A framework for analyzing the determinants of maternal mortality. *Studies in Family Planning* 23(1): 23–33. doi:10.2307/1966825. [PubMed: 1557792]
- McDade TW, Beck MA, Kuzawa C, and Adair LS (2001). Prenatal undernutrition, postnatal environments, and antibody response to vaccination in adolescence. *The American Journal of Clinical Nutrition* 74(4): 543–548. [PubMed: 11566655]
- Miszkurka M, Zunzunegui MV, Langlois ÉV, Freeman EE, Kouanda S, and Haddad S (2012). Gender differences in mobility disability during young, middle and older age in West African adults. *Global Public Health* 7(5): 495–508. doi:10.1080/17441692.2011.630676. [PubMed: 22085342]
- Murray CJL and Lopez AD (1997). Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. *The Lancet* 349(9063): 1436–1442. doi:10.1016/S0140-6736(96)07495-8.
- Murray ET, Hardy R, Strand BH, Cooper R, Guralnik JM, and Kuh D (2011). Gender and life course occupational social class differences in trajectories of functional limitations in midlife: Findings from the 1946 British birth cohort. *Journal of Gerontology: Biological Sciences and Medical Sciences* 66(12): 1350–1359. doi:10.1093/gerona/glr139.
- Nagi SZ (1976). An epidemiology of disability among adults in the United States. *Milbank Memorial Fund Quarterly* 54(3): 439–467. doi:10.2307/3349677.
- Nagin DS (1999). Analyzing developmental trajectories: A semiparametric, group-based approach. *Psychological Methods* 4(2): 139–157. doi:10.1037/1082-989X.4.2.139.
- Nagin DS (2005). *Group-based modeling of development*. Cambridge: Harvard University Press. doi: 10.4159/9780674041318.
- Nagin DS and Tremblay RE (2001). Analyzing developmental trajectories of distinct but related behaviors: A group-based method. *Psychological Methods* 6(1): 18–34. doi:10.1037/1082-989X.6.1.18. [PubMed: 11285809]

- Nogueira D and Reis E (2014). Longevity and health: Trends in functional limitations and disability among older adults in Portugal, 1985–2005. *Ageing International* 39(3): 195–209. doi:10.1007/s12126-013-9186-3.
- Ofstedal MB, Zimmer Z, Hermalin AI, Chan A, Chuang Y-L, Natividad J, and Tang Z (2007). Short-term trends in functional limitation and disability among older Asians: A comparison of five Asian settings. *Journal of Cross-Cultural Gerontology* 22(3): 243–261. doi:10.1007/s10823-006-9025-z. [PubMed: 17273937]
- Onder G, Pennix BWJH, Lapuerta P, Fried LP, Ostir GV, Guralnik JM, and Pahor M (2002). Change in physical performance over time in older women: The Women’s Health and Aging Study. *Journal of Gerontology: Biological Sciences and Medical Sciences* 57A(5): 289–293. doi:10.1093/gerona/57.5.M289.
- Pudrovska T and Anikputa B (2014). Early-life socioeconomic status and mortality in later life: An integration of four life-course mechanisms. *Journal of Gerontology: Social Sciences* 69(3): 451–460. doi:10.1093/geronb/gbt122.
- Rantanen T, Guralnik JM, Foley D, Masaki K, Leveille S, Curb D, and White L (1999). Midlife hand grip strength as a predictor of old age disability. *Journal of the American Medical Association* 281(6): 558–560. doi:10.1001/jama.281.6.558. [PubMed: 10022113]
- Reilly JJ and Kelly J (2011). Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: Systematic review. *International Journal of Obesity* 35(7): 891–898. doi:10.1038/ijo.2010.222. [PubMed: 20975725]
- Reynolds SL, Saito Y, and Crimmins EM (2005). The impact of obesity on active life expectancy in older American men and women. *Gerontologist* 45(4): 438–444. doi:10.1093/geront/45.4.438. [PubMed: 16051906]
- Roeder K, Lynch KG, and Nagin DS (1999). Modeling uncertainty in latent class membership: A case study in criminology. *Journal of the American Statistical Association* 94(447): 766–776. doi:10.1080/01621459.1999.10474179.
- Ross CE and Wu C-L (1996). Education, age and the cumulative advantage in health. *Journal of Health and Social Behavior* 37(1): 104–120. doi:10.2307/2137234. [PubMed: 8820314]
- Saikia N and Singh A (2009). Does type of household affect maternal health? Evidence from India. *Journal of Biosocial Science* 41(3): 329–353. doi:10.1017/S0021932008003209. [PubMed: 19036173]
- Smith JP and Kington R (1997). Demographic and economic correlates of health in old age. *Demography* 34(1): 159–170. doi:10.2307/2061665. [PubMed: 9074837]
- Smith KR, Mineau GP, Garibotti G, and Kerber R (2009). Effects of childhood and middle-adulthood family conditions on later-life mortality: Evidence from the Utah Population Database, 1850–2002. *Social Science and Medicine* 68(9): 1649–1658. doi:10.1016/j.socscimed.2009.02.010. [PubMed: 19278766]
- Spence NJ (2008). The long-term consequences of childbearing: Physical and psychological well-being of mothers in later life. *Research on Aging* 30(6): 722–751. doi:10.1177/0164027508322575. [PubMed: 19122886]
- Stephens C (1996). Healthy cities or unhealthy islands? The health and social implications of urban inequality. *Environment and Urbanization* 8(2): 9–30. doi:10.1177/095624789600800211.
- Tirosh A, Shai I, Afek A, Dubnov-Raz G, Ayalon N, Gordon B, Derazne E, Tzur D, Shamis A, and Vinker S (2011). Adolescent BMI trajectory and risk of diabetes versus coronary disease. *New England Journal of Medicine* 364(14): 1315–1325. doi:10.1056/NEJMoa1006992. [PubMed: 21470009]
- Uhlenberg P and Cooney TM (1990). Family size and mother-child relations in later life. *The Gerontologist* 30(5): 618–625. doi:10.1093/geront/30.5.618. [PubMed: 2276634]
- UNFPA and HelpAge International (2012). *Ageing in the twenty-first century: A celebration and a challenge*. New York: United Nations Population Fund and Help Age International.
- Verbrugge LM and Jette AM (1994). The disablement process. *Social Science and Medicine* 38(1): 1–14. doi:10.1016/0277-9536(94)90294-1.
- Waldron I, Weiss CC, and Hughes ME (1998). Interacting effects of multiple roles on women’s health. *Journal of Health and Social Behavior* 39(3): 216–236. doi:10.2307/2676314. [PubMed: 9785695]

- Wen M, Hawkey LC, and Cacioppo JT (2006). Objective and perceived neighborhood environment, individual SES and psychosocial factors, and self-rated health: An analysis of older adults in Cook County, Illinois. *Social Science and Medicine* 63(10): 2575–2590. doi:10.1016/j.socscimed.2006.06.025. [PubMed: 16905230]
- Wight RG, Cummings JR, Miller-Martinez D, Karlamangla AS, Seeman TE, and Aneshensel CS (2008). A multilevel analysis of urban neighborhood socioeconomic disadvantage and health in late life. *Social Science and Medicine* 66(4): 862–872. doi:10.1016/j.socscimed.2007.11.002. [PubMed: 18160194]
- Wilcox S, Evenson KR, Aragaki A, Wassertheil-Smoller S, Mouton CP, and Loevinger BL (2003). The effects of widowhood on physical and mental health, health behaviors, and health outcomes: The Women's Health Initiative. *Health Psychology* 22(5): 513–522. doi:10.1037/0278-6133.22.5.513. [PubMed: 14570535]
- Williams K and Umberson D (2004). Marital status, marital transitions, and health: A gendered life course perspective. *Journal of Health and Social Behavior* 45(1): 81–98. doi: 10.1177/002214650404500106. [PubMed: 15179909]
- Willis BL, Gao A, Leonard D, DeFina LF, and Berry JD (2012). Midlife fitness and the development of chronic conditions in later life. *Archives of Internal Medicine* 172(17): 1333–1340. doi: 10.1001/archinternmed.2012.3400. [PubMed: 22928178]
- Wolf DA, Mendes de Leon CF, and Glass TA (2007). Trends in rates of onset of and recovery from disability at older ages: 1982–1994. *Journal of Gerontology: Social Sciences* 62(1): 3–10. doi: 10.1093/geronb/62.1.S3.
- World Health Organization (2011). World report on disability: Summary, 2011. Geneva: World Health Organization <http://www.refworld.org/docid/50854a322.html>
- World Health Organization (2015). World report on ageing and health. Geneva: WorldHealth Organization.
- Yi Z and Vaupel JW (2004). Association of late childbearing with healthy longevity among the oldest-old in China. *Population Studies* 58(1): 37–53. doi:10.1080/0032472032000175437. [PubMed: 15204261]
- Yi Z, Vaupel JW, Zhenyu X, Chunyuan Z, and Yuzhi L (2002). Sociodemographic and health profiles of the oldest old in China. *Population and Development Review* 28(2): 251–273. doi:10.1111/j.1728-4457.2002.00251.x.
- Zhai S and McGarvey ST (1992). Temporal changes and rural-urban differences in cardiovascular disease risk factors and mortality in China. *Human Biology* 64(6): 807–819. [PubMed: 1427740]
- Zimmer Z, Martin LG, Jones BL, and Nagin DS (2014). Examining late-life functional limitation trajectories and their associations with underlying onset, recover, and mortality. *Journal of Gerontology: Social Sciences* 69(2): 275–286. doi:10.1093/geronb/gbt099.
- Zimmer Z, Martin LG, Nagin DS, and Jones BL (2012). Modeling disability trajectories and mortality of the oldest-old in China. *Demography* 49(1): 291–314. doi:10.1007/s13524-011-0075-7. [PubMed: 22246796]
- Zimmer Z and McDaniel S (2013). Global ageing in the twenty-first century: An introduction In: Zimmer Z and McDaniel S *Global ageing in the twenty-first century: Challenges, opportunities and implications*. Surrey: Ashgate.

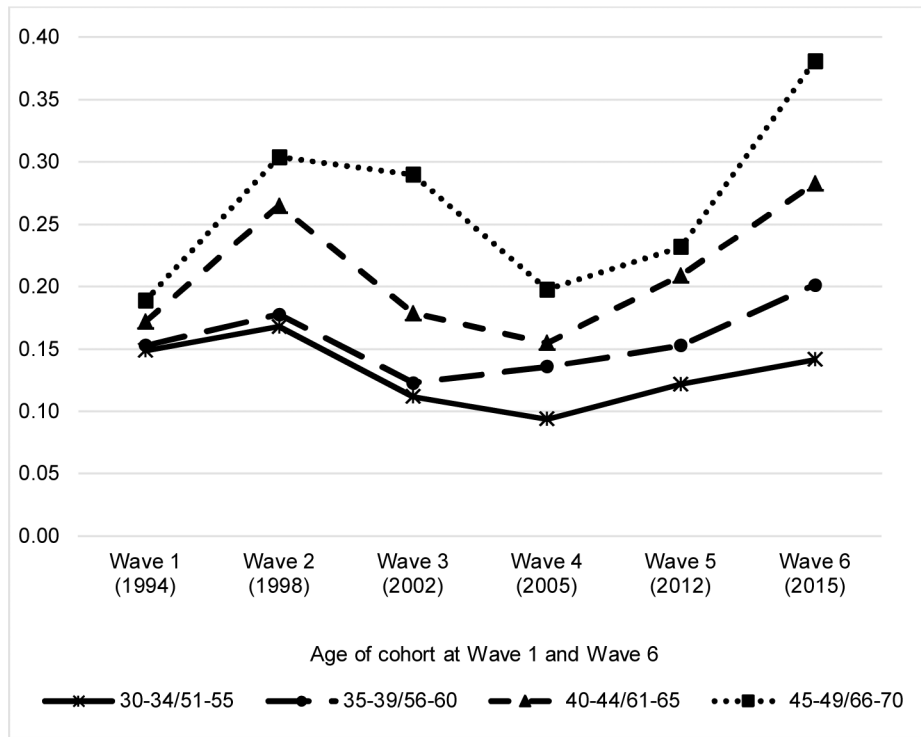


Figure 1:
Functional limitation prevalence for four birth cohorts by wave

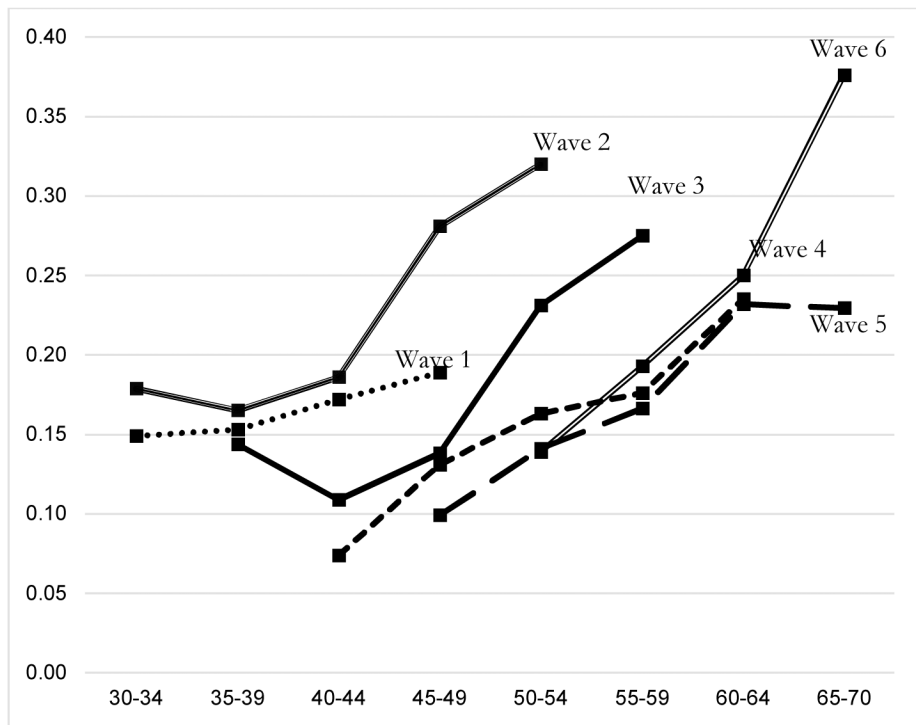


Figure 2:
Functional limitation prevalence by age showing differences across waves

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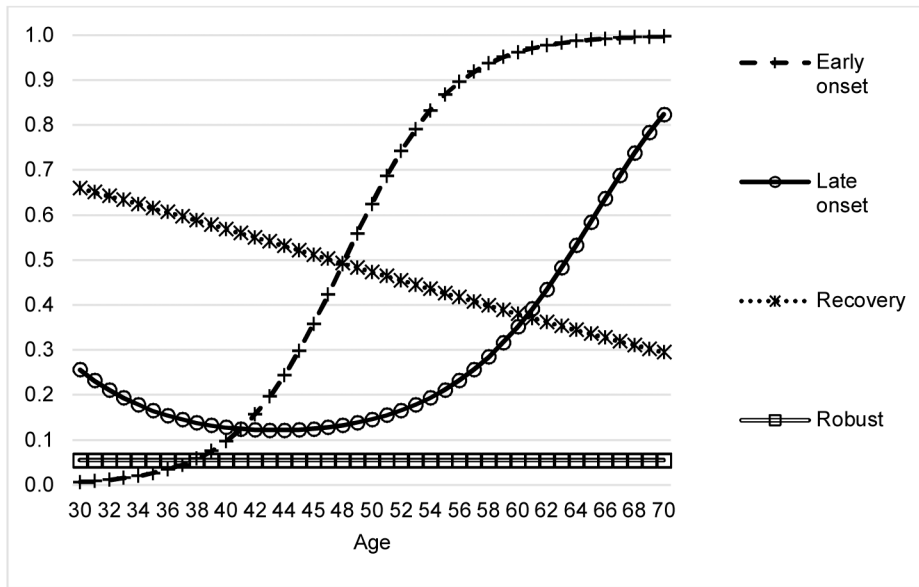


Figure 3:
Estimated probabilities of functional limitation by age

Table 1:

Age of sample at data collection points and N at Wave 1 for four birth cohorts

Birth cohort	Age at...							N Wave 1
	Baseline 1983	Wave 1 1994	Wave 2 1998	Wave 3 2002	Wave 4 2005	Wave 5 2012	Wave 6 2015	
1960–1964	19–23	30–34	34–38	38–42	41–45	48–52	51–55	590
1955–1959	24–28	35–39	39–43	43–47	46–50	53–57	56–60	647
1950–1954	29–33	40–44	44–48	48–52	51–55	58–62	61–65	436
1945–1949	34–38	45–49	49–53	53–57	56–60	63–67	66–70	228
1945–1964	19–38	30–49	34–53	38–57	41–60	48–67	51–70	1,901

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Table 2:Descriptive statistics for predictors showing means and standard deviations¹

Domains	Mean or percent	Standard deviation
Demographic		
% Married at Wave 6	0.731	0.444
% In nuclear household at baseline	0.387	0.487
Childbirth		
Mean total live births by Wave 6	5.271	2.448
Mean successful births ratio at Wave 6	0.911	0.128
Mean age at first birth	20.923	3.409
Socioeconomic status		
Education at Wave 1		
% Primary education	0.559	0.496
% High school	0.294	0.455
% College	0.148	0.355
Mean wealth score at baseline	0.000	1.000
Mean urbanicity score at baseline	29.387	12.909
Health		
% High BMI at Wave 1	0.301	0.459
% Chronic condition Wave 1	0.371	0.483
% Excellent self-rated health Wave 1	0.471	0.499

¹Means for dichotomous variables are also proportions.

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Table 3:

Distribution of number of waves in which a functional limitation is reported for four birth cohorts among those observed all six waves

Age at Wave 1/Wave 6	Birth cohorts				Total
	30–34/51–55	35–39/56–60	40–44/61–65	45–49/66–70	
N	377	437	283	148	1,245
Number of waves in which a limitation is reported					
0	55.4	50.3	38.9	35.1	47.5
1	26.0	24.9	26.2	25.0	25.5
2	9.3	12.6	15.2	16.9	12.7
3	4.5	7.8	10.6	14.2	8.2
4	3.2	2.7	5.7	3.4	3.6
5	1.3	1.1	2.5	4.1	1.8
6	0.3	0.5	1.1	1.4	0.6
Total	100.0	100.0	100.0	100.0	100.0
N died before final wave (% of total)	22 (3.7)	24 (3.7)	26 (6.0)	20 (8.8)	92 (4.8)
N missing one+ wave (% of total)	191 (32.4)	186 (28.8)	127 (29.1)	60 (26.3)	554 (29.7)

Table 4:

Distribution of patterns of functional limitation by wave for those reporting limitations in two waves among those observed all six waves (N=158)¹

Limitation reported in wave number...						Percent
1	2	3	4	5	6	
				✓	✓	20.3
			✓		✓	5.1
		✓			✓	4.4
	✓				✓	10.1
✓					✓	6.3
			✓	✓		3.8
		✓		✓		5.1
	✓			✓		7.6
✓				✓		2.5
		✓	✓			3.8
	✓		✓			7.0
✓			✓			4.4
	✓	✓				10.1
✓		✓				2.5
✓	✓					7.0
Total						100.0

¹Check marks used to indicate the wave in which a limitation is reported

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Table 5:

Maximum likelihood parameter estimates for functional limitation trajectories (standard errors in parentheses)^a

	Group 1 Robust	Group 2 Recovery	Group 3 Late onset	Group 4 Early onset
Intercept	-2.844	0.165	-1.976	-1.406
Linear parameter		-0.384 (.185)	-0.049 (.150)	2.739 (1.019)
Quadratic parameter			0.501 (.153)	
Group size	53.6%	14.5%	28.1%	3.8%
BIC	-4,585.0			
Average posterior probability	0.698			
Median posterior probability	0.750			
N	1,901			

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Table 6:

Multinomial logistic regression predicting group membership showing log odds

	Model 1			Model 2		
	Recovery vs Robust	Early onset vs Robust	Late onset vs Robust	Recovery vs Robust	Early onset vs Robust	Late onset vs Robust
Demographic characteristics						
Married at Wave 5	-0.402***	-0.547*	-0.289**	-0.337**	-0.159	-0.285*
Nuclear household	-0.110*	-0.215	-0.347**	-0.123	-0.529*	-0.322**
Childbirth characteristics						
Number live births	0.037*	0.114*	0.046	0.023	0.113*	0.046
Successful births ratio	-0.240	-2.108***	-0.448	0.268	-2.009*	-0.351
Age at birth of first child	0.001	0.045	0.073**	-0.015	0.044	0.070***
Socioeconomic status characteristics						
Education at Wave 1						
Primary	---	---	---	---	---	---
High school	-0.117	-0.213	-0.196	0.093	-0.168	-0.202
College	-0.008	-1.466***	-0.748	-0.084	-1.509***	-0.783***
Wealth score at baseline	0.430***	0.538***	0.250***	0.397***	0.452***	0.222***
Urbanicity score at baseline	0.042***	0.052***	0.032***	0.043***	0.050***	0.031***
Health characteristics						
BMI				0.581***	1.059***	0.419***
Chronic condition				1.905***	1.116***	0.639***
Excellent self-rated health				-0.517***	-0.126	-0.151
Constant	-2.714	-3.845	-3.410	-3.756	-4.660	-3.687
Log-likelihood		-1635.3			-1511.1	
$-2 \times \text{Log-likelihood}^I$		193.0***			248.4***	

* .05 < p < .10

** .01 < p < .05

*** p < .01

^I model 1 compared to intercept-only, model 2 compared to model 1.