BACKGROUND PAPER

Analyses and Projections of Family Households, Living Arrangements, and Home-Based Care Needs of Disabled Older Adults in Sri Lanka, 2012–2060

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KNOWLEDGE SUMMARY

This paper analyzes the available healthy aging survey, the census and other demographic datasets on older adults' health status, the family household structure, and the home-based care needs/costs in Sri Lanka. Our analyses show that female older adults have significant disadvantages in disability status compared with their male counterparts. However, in general, female older adults' socioeconomic status is lower than their male counterparts. This important problem should receive much more attention from the government and society, which should try their best to guarantee that any old age insurance and service programs must benefit older women and men equally.

Based on empirical analyses, we conducted projections of family households, living arrangements, and home-based care needs for disabled older adults in Sri Lanka in 2012–2060 by using the widely recognized and applied ProFamy extended cohort-component method/software and conventionally available data. Our projections show that changes in older adults' disability status are the most important determinants of home-based care needs for disabled older adults during the period 2012–2060 in Sri Lanka. Our analyses also show that, in both cases, as older adults' disability statuses are assumed to improve or deteriorate over time, the home-based care needs for older adults in Sri Lanka will increase substantially because of the inevitable trends of rapid population aging and extremely fast increases of the oldest-old. Consequently, relevant reforms of policies and socioeconomic planning should be taken to respond to the serious challenges of large and rapid increases in home-based care needs.

Our projections found that, if older adults' disability statuses substantially improve or substantially deteriorate, the care needs for disabled elders would remarkably decrease or largely increase. Note that the most effective way to improve elderly health status is not only to cure disease, but also to effectively prevent illnesses. The latter may be more important because older adults who are cured of one illness are likely to suffer another illness and long-term disability, if there is no improvement in their abilities to prevent disease. Therefore, studies of why some older adults remain happy and healthy up to the oldest-old ages and how to reach such pathways of healthy aging should be strengthened further as a priority in healthy aging policy-related research.

Our projection results also show that disabled unmarried elders who are living alone increase substantially faster than those disabled unmarried elders who are living with their

children. The relevant socioeconomic countermeasures should be taken. For example, adult children may be encouraged to live together with or near their old-age parents, which will help older adults to obtain home-based care from children whenever they need. Co-residence with or nearby the children will decrease home-based care expenditures for disabled older adults; living in close proximity would overcome intergenerational conflicts between elders and their co-residing children/grandchildren concerning eating, timing of daily activities and entertainment, which will increase the happiness and health of elderly parents as well as enable the old parents to take care of their grandchildren, resulting in “win-win” outcomes.

I. BACKGROUND AND SIGNIFICANCE

Population and household aging have become a serious challenge in Sri Lanka and other Asian countries. Rapid population and household aging may bring about a heavy burden to the families of the older adults and the whole society, and may erode the foundation of home-based care, which has supported older adults in Sri Lanka and other Asian countries. The decreased availability of children (because of low fertility) plus increased geographic/residential mobility of working-age people associated with economic development will produce a rapid increase in empty-nest (without children living together) older adults households. Many Sri Lanka elderly may face the problems of lacking daily caregiving, which may deteriorate the foundation of home-based care for the older adults.

However, on the other hand, lower fertility and mortality are associated with higher human capital investment per child, which also raises labor productivity. If appropriate policies in response to challenges of population and household aging are in place, the positive changes may outweigh the problems of declining support ratios because of accumulation of human and physical capital (Lee and Mason 2010), and Sri Lanka may be able to successfully face the serious challenges of population and household aging (De Silva 2013). Clearly, applied studies on the dynamics of the health status of older adults, family household structure, and home-based care needs would be very helpful for informed policy-making to face the serious challenges of population and household aging in Sri Lanka and other Asian countries.

Prior studies on home-based care needs of older adults in Sri Lanka were qualitative (Watt et al. 2014, Samaraweera and Maduwage 2016). We aim to fill in this gap, and quantitatively and simultaneously project the family structure, living arrangements, health statuses, and home-based care needs for the older adults in 2012–2060 in Sri Lanka, and provide informative research for sound policy-making.

II. METHODS FOR THE PROJECTIONS

Projections of disability statuses among older adults in developed countries have been relatively popular in recent decades, and generally follow two methodologies. The simple proportional distribution projection method multiplies the age- and gender-specific proportions of disability statuses of older adults at baseline by projected age- and gender-specific numbers of older adults in future years (Suthers et al. 2003). The multistate transitions projection method estimates the age- and gender-specific transition probabilities matrices of disability statuses of older adults based on longitudinal and sophisticated survey data, and combines them with matrices of population forecasts without family statuses (e.g., Lakdawalla et al. 2003).

However, it is widely recognized that care needs are closely related to age, gender, marital status, family structure, living arrangements, and health status of older adults. For example, disabled elders who are unmarried or living alone have much higher care needs for

services in the home than those who live with children and/or a spouse (Grundy 2001). Older adults who co-reside with children tend to receive more informal home-based care than those who live in empty-nest households (Zhang 2004). Most previous projections of home-based care needs in Asia and other countries did not consider simultaneously the different health statuses, dynamic changes of family structures, and living arrangements of older adults. The present study overcomes this limitation by multistate projections of the dynamics of the health status of older adults, family household structure, living arrangements, and home-based care needs in Sri Lanka.

The classic headship-rate method is the most commonly used approach for household projections in Asian countries, although it has been criticized widely by demographers for about three decades (Grundy, 2001; 2013, Mason and Racelis 1992, Murphy 1991, Spicer et al. 1992). The headship-rate method is limited because it is based on the vague and ill-defined concept of household heads (Mason and Racelis 1992, Murphy 1991), no connection to demographic rates because of the nature of its cross-sectional extrapolations (Spicer et al. 1992), and lumps all household members other than heads into one category "non-head" with no projected information. This last limitation makes it impossible to study the household status and living arrangements of the older adults, young adults, and children who are not heads of households. Consequently, the headship-rate method is not appropriate for projections of home-based care needs for disabled older adults, which are directly linked to all older adults in the population and their family household structure and living arrangements.

In contrast to the classic headship-rate method, the extended cohort-component model for projecting household types/sizes and living arrangements, known as ProFamy, projects all individuals in households (including older adults) grouped by cohorts and specified attributes (e.g., gender, age, rural/urban, marital/union status, co-residence status with children and parents), by using commonly available demographic rates as input (Table 1). The ProFamy model was initially developed by Zeng et al. (1998) based on the pioneering innovation of the family status life table model by Bongaarts (1987), and substantially further extended by Zeng, Land, et al. (2006, 2013, 2014).

The ProFamy model and the user-friendly free software have been used to generate: (i) United States (US) household and living arrangement projections by race (Jiang and O'Neill 2007); (ii) implications of changes in US households and living arrangements for the housing industry and policy-making (Smith et al. 2008; 2012); (iii) US household projections and home-based energy consumption and future carbon emissions (Dalton et al. 2008, O'Neill and Chen 2002, Jiang and O'Neill 2007); (iv) household automobile demands in the US (Feng et al. 2011) and Austria (Prskawetz et al. 2004); (v) fertility policy analyses, retirement ages, and elderly care needs/costs studies in the People's Republic of China (PRC) (Zeng 2007, 2011; Zeng et al. 2008; Zeng et al. 2013, 2014; and Feng et al. 2018); (vi) German household and living arrangement projections (Hullen 2000, Hullen and für Bevölkerungsforschung 2003); (vii) household and living arrangement projections in Brazil (Tirza 2017), Mexico (Landy 2017), and India (Feng et al. 2020); and (viii) households and residential energy demands projections in

Pakistan (Hussain and Sadiq 2020).

The ProFamy model/software has also been used to produce household projections at subnational and county/city levels for socioeconomic planning in the US; Germany; Brazil; Iran; the PRC; and Taipei, China (e.g., Jiang and Kuijsten 1999a, 1999b; Yang and Zeng 2000; Hullen and für Bevölkerungsforschung 2003; Smith et al. 2012; Zeng et al. 2013; Tirza 2017; Bagi 2018; and Feng et al. 2019). A notable example is that the local government office employed ProFamy method/software, the US national race-, age-, and gender-specific standard schedules, and the demographic summary parameters at the county level to successfully project households and living arrangements for six counties in Southern California since 2009, with projections renewed every 2 years. The governments of the six counties have effectively used these detailed biennial projections for their socioeconomic planning, budget allocations, and policy analyses on housing, traffic, residential energy demands, elderly care, and other home-base social services (Feng et al. 2020. Up to April 2023, 182 scholars from 36 countries, the United Nations Fund for Population Activities, and the World Bank downloaded and used the ProFamy free software (http://www.profamy.com.cn/ #/home) to do the research projects on household and living arrangement projections for informed decision-making. We will employ ProFamy methods to project the changes in household size/structure and home-based care needs for the disabled older adults in the future decades in Sri Lanka.

III. DATA, MEASURES, AND EMPIRICAL ANALYSES

A. The Data Needed for the Projections

As commented by Willekens (2010), a major strength of ProFamy model is that the family household dynamics are derived from demographic events, and consequently, it requires conventional demographic data that are available from ordinary surveys, vital statistics, and censuses (Table 1). Because its reliance on demographic rates, ProFamy provides a tool to quantitatively assess the effects of demographic changes in marriages/unions, divorces, fertility, mortality, migrations, and children's leaving homes on family household and living arrangement dynamics (Willekens, 2010).

In fact, as demonstrated in Table 1, in addition to the basic data for standard population projections, the major work of data preparation for household and living arrangement projections using ProFamy extended cohort-component method/software is to estimate the age- and parity-specific occurrence/exposure (o/e) rates of marital and nonmarital fertility and the age- and gender-specific o/e rates of marriage/union formation and dissolution, which will be discussed in more details below.

As Keyfitz (1972) pointed out, demographic projections based on trend extrapolation of each age- and gender-specific rate could result in an excessive concession to flexibility and readily produce erratic results. Accordingly, analysts should use the fixed age- and gender-specific standard schedules (section B. of Table 1) and concentrate on projecting future

changing demographic summary parameters (section C. of Table 1) in population, household, and living arrangement projections. Numerous studies have demonstrated that the fixed age- and gender-specific standard schedules and a few changing summary parameters offer an efficient and realistic approach for demographic projections (Brass 1974, Coale et al. 1983). The theoretical foundation of this practice is that the changing demographic summary parameters are crucial to determine dynamics in level and age pattern of the age-specific rates which affect the projections. At the same time, the projection results typically are not highly sensitive to the fixed age- and gender-specific standard schedules. Thus, the national age- and gender-specific standard schedules can be readily employed for household and living arrangement projections at the subnational and county/city levels using the ProFamy method/software, as empirically tested in various studies (Smith et al. 2012; Zeng, Land, et al. 2013; 2014), or even be used for projections or estimations in other countries with similar demographic patterns, as corroborated in Zeng et al. (2000).

Table 1: Data Needed to Project Households and Living Arrangements Using the ProFamy Extended Cohort-Component Method, with a Comparison to Standard Population Projections

Contents of the Needed Data for the Projections	ProFamy Household Projection	Standard Population Projection
A. Baseline population of starting year of projection at national or subnational level		
1. A census micro sample or population register or an exceptionally large survey data file with only a few needed demographic variables, including gender, age, marital/union status, relationship to the householder, and whether living in a private or institutional household 2. Published 100% census tabulations of age- and gender-specific (and marital status-specific, if possible) distributions of the entire population, and aggregated numbers of households	√ (and a few more variables from census data)	√
B. Age- and gender-specific standard schedules at the national level (can be used for projections at subnational and county/city levels)		
1. Age- and gender-(and marital-status, if possible)-specific mortality rates	√	√
2. Age-and gender-specific rates of international immigration and emigration, or age- and gender-specific rates of international net migration	√	√
3. Age- and gender-specific rates of domestic in-migration and out-migration, if the projections are for the subnational regions; 1 and 2 can be estimated by user-friendly R program DemoRates, which is part of the ProFamy user-friendly software package, using the survey data.	√	√
4. Age-specific fertility rates 5. Age- and parity-specific occurrence/exposure (o/e) rates of marital and nonmarital fertility 6. Age- and gender-specific o/e rates of marriage/union formation and dissolution	√ √ √	√

7. Age- and gender-specific net rates of leaving the parental home, estimated based on two adjacent census micro data files and the intra-cohort iterative method (Coale1984, 1985; Stupp 1988; Zeng et al. 1994), using the ProFamy software; 4, 5, 6, and 7 can be estimated by user-friendly R program DemoRates which is part of the ProFamy user-friendly software package, using the survey data.	√	
C. Demographic summary parameters for the nation or subnational regions or counties in the baseline and selected future projection years		
1. Total fertility rates by parity	√	√
2. Gender-specific life expectancies at birth	√	√
3. Gender-specific general rates of in-migration and gender-specific general rates of out-migration	√	√
4. Gender-specific mean ages at first marriage and mean age at first birth	√	
5. General rates of marriages and divorces (general rates of cohabitation union formation and dissolution, if cohabitation status is included and the data are available)	√ √	
6. Proportion of those aged 45–49 who do not live with parents		
7. Age- and gender-specific proportion of persons living in group quarters (collective households)	√	

Note: The data categories of rural/urban (or race) are optional, based on the actual demographic situation and data availability of the country or region or county/city under study. If the categories of rural/urban (or race) are adopted in the application, the data listed in this table will need to be rural/urban-specific or race-specific.
Source: Table 5 of Zeng et al. (2021).

B. The Data Sources and Measures for Present Study in Sri Lanka

The micro sample datasets of the latest Population and Housing Census conducted in 2012 in Sri Lanka with a sample size of 20,359,439 persons will be analyzed in the present study. The Sri Lanka Demographic and Health Survey (DHS) conducted in 2016 will be used to estimate single-, year-, age-, and gender-specific o/e rates of first marriages and single-, year-, age-, and parity-specific o/e rates of fertility. The Sri Lanka DHS 2016 had a total sample size of 9,300 households with 28,721 persons interviewed. The Sri Lanka DHS surveys focused on first marriage, fertility, and reproductive health, but did not include data collections of divorce and remarriages, and thus we could not estimate age- and gender-specific divorce rates and remarriages using the DHS 2016. As there is no survey data so far for estimating age- and gender-specific o/e rates of divorce and remarriages in Sri Lanka, we have to use Chinese urban age- and gender-specific o/e rates of divorce and remarriages as age- and gender-specific model standard schedules of divorce and remarriages for Sri Lanka households and living arrangements projections. This is theoretically justified because the projection results are mainly determined by the summary measures, but are not highly sensitive to the fixed age- and gender-specific standard schedules, as demonstrated in our previous publications (Zeng et al. 2013, 2014).

In the Sri Lanka census, the question "P14. Physical and mental difficulties" inquires on difficulties in the domains of seeing, hearing, walking, cognition, self-care, and communication, with possible answers of not difficult, difficult, or not possible at all. We defined those old adults who answered "not difficult" as "healthy" and those who answered "difficult" or "not possible at all" as "disabled".

The "home-based care needs" refers to age-, gender-, marital status-, and living arrangement-specific distributions of disabled elders. Unlike the applications in some other countries (e.g., the US and the PRC) where the surveys collected data of home-based care costs (referring to the costs of home medical, home nursing, or household-paid services and informal care of unpaid hours provided by family members or friends), the home-based care costs data are not available so far in Sri Lanka. Consequently, we are not able to project home-based care costs for disabled adults in the present study.

C. The Empirical Analyses

Table 2 presents distributions of types of households in Sri Lanka based on the 2012 census data. In Sri Lanka, two-generation household was the major type of household, taking 60.75% of all households, followed by one-generation households and three-generation households. Among one-generation households, a household with a married couple was the main subtype. Of two-generation households, a married couple living with their children was the main form. The three-generation households were mainly comprised of married couple of the mid-generation, grandparents, and grandchildren. The average household size of all types was 3.73 persons.

Table 2: Percent Distributions of Households by Types, Based on 2012 Census Datasets, Sri Lanka

Household Types	Percent
One-generation households	
One person only	7.18
One person and others	2.70
Married couple	10.48
Subtotal of one generation	20.36
Two-generation households	
Married couple and children	47.88
Lone mother and children	6.28
Lone father and children	6.59
Subtotal of two generations	60.75
Three-generation households	
Married couple (mid-generation)	14.90
Lone mother (mid-generation)	2.41
Lone father (mid-generation)	1.58
Subtotal of three generations	18.89

Total	100.00

Source(s): micro sample datasets of the latest Population and Housing Census conducted in 2012.

Among all older adults aged 65+, 67.6% lived with their children and 19.1% lived with spouse only. Institutionalized older adults only consist of a very small part (1.2%) of the whole older adults population (Table 3). Compared to male older adults, female older adults were less likely to live with their spouse only and were more likely to live with children. Similar trends were found in young-old aged 65–79 and oldest-old aged 80+ (Table 3).

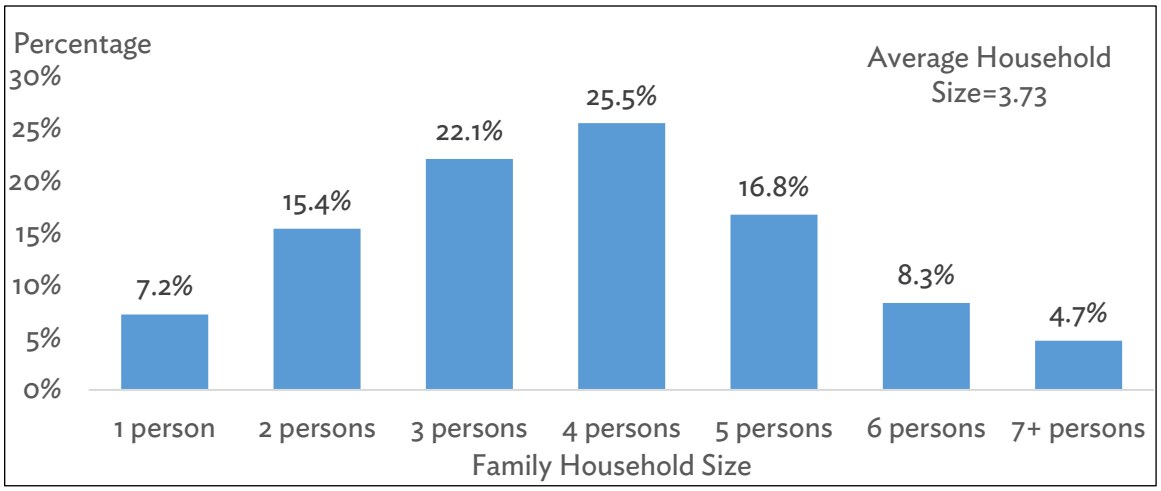
Table 3: Percent Distributions of Living Arrangements of Older Adults, Based on 2012 Census Datasets, Sri Lanka

Age Groups	65+			65–79			80+		
Gender	Male	Female	Both Genders	Male	Female	Both Genders	Male	Female	Both Genders
Living alone	3.1	7.7	5.7	2.9	8.0	5.8	3.9	6.5	5.5
With spouse only	26.6	13.4	19.1	27.7	14.9	20.5	20.5	6.6	12.1
Subtotal of not living with children	29.7	21.0	24.8	30.6	22.8	26.2	24.5	13.0	17.5
Married, with children	57.3	40.5	47.7	58.2	41.4	48.7	52.2	36.5	42.7
Not married with children	6.7	29.9	19.9	5.1	27.7	17.8	14.9	40.2	30.2
Subtotal of living with children	63.9	70.4	67.6	63.3	69.0	66.5	67.0	76.6	72.9
Institutionalized	1.4	1.0	1.2	1.2	0.9	1.0	2.5	1.8	2.1
With others, not with spouse/child	5.0	7.5	6.5	4.9	7.3	6.2	6.0	8.6	7.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source(s): micro sample datasets of the latest Population and Housing Census conducted in 2012.

The average household size in Sri Lanka was 3.73 persons. 4-person households took the highest proportion of all households by 25.5%, followed by 3-person households (22.1%). 2-person and 5-person households took a similar proportion of all households. Large households with 6 or more persons took about 13% of all households.

Figure 1: Family Household Size Distributions, Based on 2012 Census Datasets, Sri Lanka



Source(s): micro sample datasets of the latest Population and Housing Census conducted in 2012.

Table 4 presents the percentages of disabled older adults by age groups, gender, marital status, and living arrangement. In general, the percentages of disabled older adults increased across ages until reaching advanced ages, and then decreases. Among married older adults, the highest percentages of disabled older adults across ages were lower among those not living with children (60.86% in males and 70.50% in females) than among those living with children (64.15% in males and 75.77% in females). Among not-married older adults, the trend was opposite; namely, highest percentages of disabled older adults across ages were higher among those not living with children (88.39% in males and 82.43% in females) than those with children (72.05% in males and 78.47% in females).

Table 4 shows that female older adults had substantially higher proportions of being disabled, except among those who do not live with child(ren), married females aged 90–99, and not-married females aged 65–94 had lower proportions of being disabled. On the other hand, however, the life expectancy at birth of females (78.6) was much higher than that of males (70.0) in Sri Lanka in 2012 (Table 5). These are evidences of the well-known "male-female health-survival paradox"; namely, females have higher life expectancy but less healthy, which was also found in many other countries (Alberts et al. 2014).

Table 4: Percentage of Disabled Older Adults by Age, Gender, Marital Status and Living Arrangements, Sri Lanka, 2012

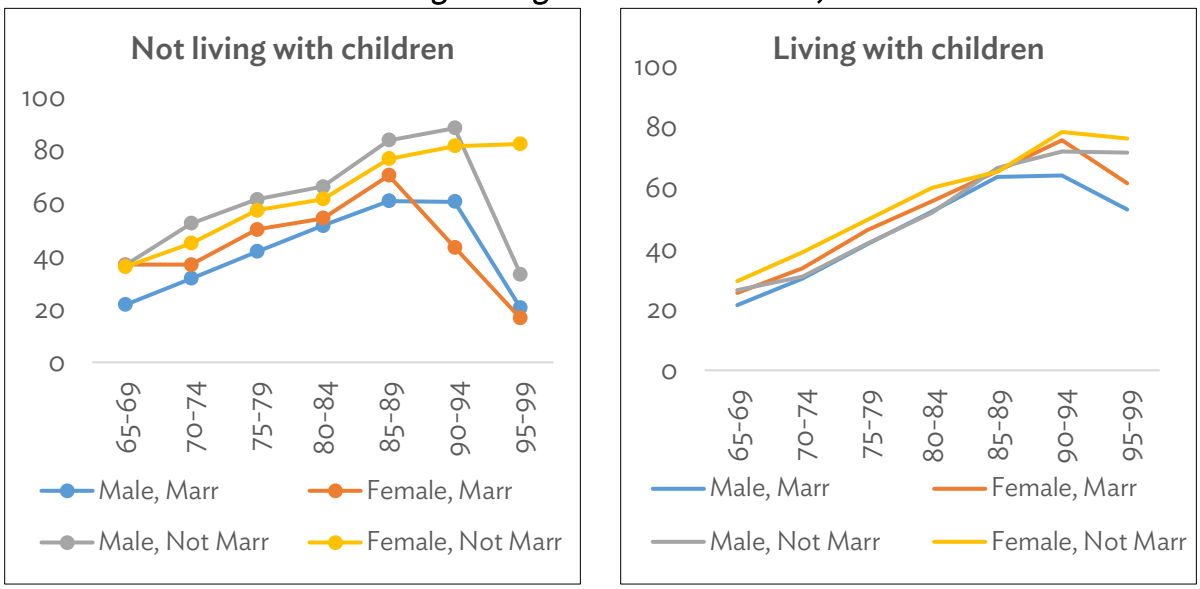
Age	Not Living with Child(ren)				Living with Child(ren)			
	Married		Not Married		Married		Not Married	
	Male	Female	Male	Female	Male	Female	Male	Female
65–69	21.73	36.77	36.55	36.02	21.44	25.45	26.37	29.33
70–74	31.68	36.82	52.45	44.97	30.07	33.48	30.74	38.82
75–79	41.84	50.09	61.52	57.35	41.56	46.27	41.67	49.63
80–84	51.51	54.37	66.30	61.57	52.34	55.76	51.98	60.07
85–89	60.86	70.50	83.80	76.78	63.72	65.59	66.72	65.31
90–94	60.63	43.31	88.39	81.68	64.15	75.77	72.05	78.47

95–99	20.50	16.60	33.21	82.43	52.88	61.61	71.76	76.28

Source(s): micro sample datasets of the latest Population and Housing Census conducted in 2012.

Figure 2 visualizes the percentages of disabled older adults by gender, age groups, marital status and living arrangements. Note that the percentages of disabled older adults increased across ages, but decreased after ages 90–94 (or after ages 85–89 for married females not living with child[ren]), except not-married females. How can such interesting phenomenon be explained? We believe that it may be because of the so-called "mortality selection" (Wrigley-Field 2014). More specifically, those who could survive to ages 90–94 were selectively very strong in lifestyle, biological, and genetic mechanisms, while those who were not so strong died before reaching ages 90–94.

Figure 2: Percentage of Disabled Older Adults by Gender, Age Groups, Marital Status, and Living Arrangements in Sri Lanka, 2012



Note: Marr = married.

Source(s): micro sample datasets of the latest Population and Housing Census conducted in 2012.

IV. THE PROJECTION RESULTS

A. The Projection Scenarios

Table 5 shows the assumptions of the demographic parameters that were applied in our medium projections of households, living arrangement, population, and age/gender structure in 2012–2060 in Sri Lanka, using the ProFamy model/software. Based on the literature and the fact that fertility declines were experienced in other Asian countries, the total fertility rates are assumed to decline from 2.21 in 2012 to 1.84 in 2060; male and female life expectancies are assumed to increase by 9 years and 7 years from 2012 to 2060, respectively; the general marriage

rates and the general divorce rates are assumed to decrease and increase by 36% and 64%, respectively, in 2060 compared with 2012; and the mean age of first marriage and births, and the general rates of immigrations and out-migrations rates are assumed to remain unchanged.

The older adults' disability rates by ages, gender, marital status, and living with children or not (derived from the 2012 census data) are applied to our medium projections of the older adults population by age, gender, marital status, and living with children or not. We also conducted projections of the medium, low, and high scenarios of home-based care needs for disabled older adults. The medium, low, and high scenarios assume that the age-, gender-, marital status-, and living arrangement-specific disability rates keep constant, increase annually by 0.08%, and increase annually by 0.08%, respectively.

Table 5: Assumptions of the Demographic Parameters of Family Household and Living Arrangements Projections in Sri Lanka, 2012–2060

	2012	2020	2030	2040	2050	2060
Total fertility rates	2.21	2.17	2.07	1.99	1.92	1.84
Male life expectancy at birth	72.00	73.51	75.41	77.30	79.19	81.08
Female life expectancy at birth	78.60	79.76	81.20	82.65	84.09	85.54
General marriage rates	0.14860	0.10380	0.09388	0.09430	0.09465	0.09465
General divorce rates	0.00790	0.01093	0.01206	0.01256	0.01300	0.01300
Male mean age of first marriage	29.90	29.90	29.90	29.90	29.90	29.90
Female mean age of first marriage	26.90	26.90	26.90	26.90	26.90	26.90
Mean age of births	28.90	28.90	28.90	28.90	28.90	28.90
Male general of immigration	0.01179	0.01179	0.01179	0.01179	0.01179	0.01179
Female general rates of immigration	0.00839	0.00839	0.00839	0.00839	0.00839	0.00839
Male general rates of out-migration	0.00296	0.00296	0.00296	0.00296	0.00296	0.00296
Female general rates of out-migration	0.00251	0.00251	0.00251	0.00251	0.00251	0.00251

Source(s): projection results of present study.

B. The Aging of Households, Living Arrangements, and Population

The main results of projections in Sri Lanka indicate that the total population size will increase by 33% in 2060 compared with 2012, but the total number of households in 2060 will be 2.65 times as large as that in 2012 (Table 6). The average household size will decline from 3.73 in 2012 to 2.65 in 2060, and the percentage of three-generation households will be 6.5% in 2060, decrease by 65.6% compared with that in 2012 (18.9%). Clearly, changing demographic factors (including higher divorce rate and the vanishing social norms that prescribe co-residence of old parents and adult children) contribute to smaller household size, and continuously and quickly increasing numbers of households in Sri Lanka. On the other hand,

however, population growth has slowed down greatly in Sri Lanka. Consequently, we would seriously underestimate the energy consumption for future years and mislead the policy makers if the forecasting of residential energy use is based on population projections only. Thus, conducting household projections by type and size is crucially important in forecasting future energy demands and strategic planning of environmental protections in Sri Lanka and other Asian countries, and considering population changes only would seriously underestimate future energy demands and mislead policy makers (Bradbury et al. 2014).

There is no doubt at all that population will age quickly in the next few decades in Sri Lanka, and the percentage of oldest-old aged 80+ will increase by 375.4% in 2060 compared with 2012, which is 2.32 times as fast as the increase of the entire older adults population (Table 6). While Sri Lanka's population is aging quickly, especially the oldest-old aged 80+, the household and living arrangements are aging faster than that of the population. In 2012, the percentage of households with at least one older adult aged 65+ among the total number of household is 5.6%, but this number will reach 35% in 2060, which means that there will be more than one-third of households with at least one older adult aged 65+ in 2060. It is even more dramatic that the percentage of oldest-old aged 80+ not living with children in 2060 will increase by 700% compared with 2012.

Table 6: Main Results of Households and Living Arrangements Projections in Sri Lanka, 2012–2060

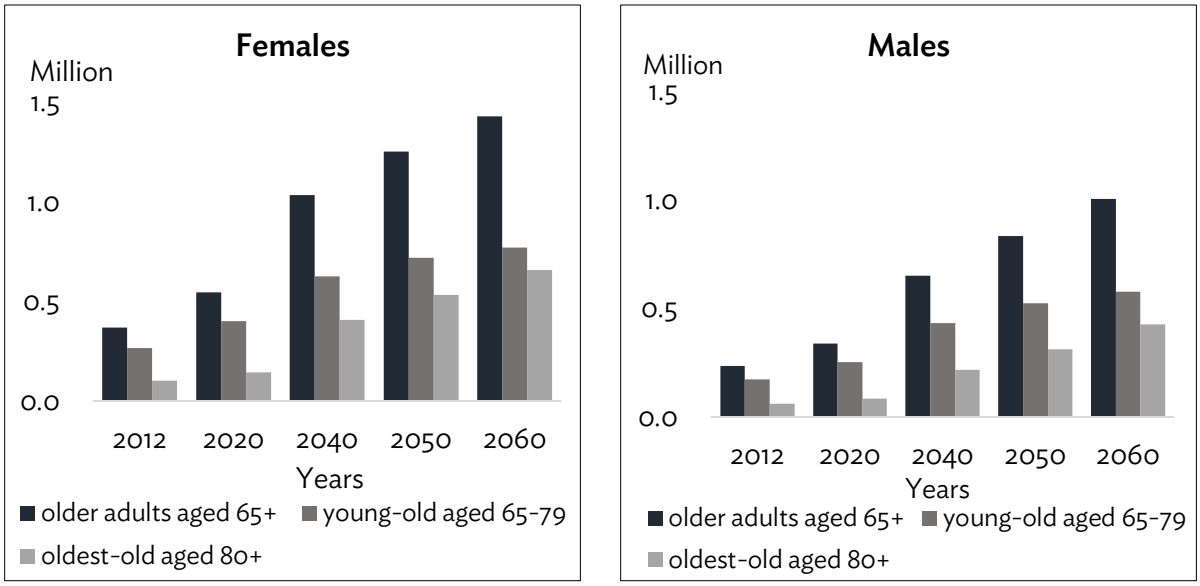
Living arrangements and population aging	2012	2020	2030	2040	2050	2060	% inc. in 2060 vs. 2012
Percent of older adults aged 65+	7.87	10.64	13.70	16.01	18.79	20.61	161.9
Percent of oldest-old aged 80+	1.34	1.68	2.62	3.92	5.06	6.37	375.4
Percent of older adults aged 65+ not-living with child	0.45	0.83	1.09	1.24	1.38	1.46	224.4
Percent of oldest-old aged 80+ not-living with child	0.07	0.16	0.26	0.38	0.47	0.56	700.0
Percent of older adults aged 65+ living alone	1.50	2.20	2.79	3.29	4.00	4.49	199.3
Percent of oldest-old aged 80+ living alone	0.16	0.21	0.31	0.49	0.68	0.94	487.5
Number of older adults aged 65+ (million)	1.60	2.35	3.27	4.07	4.97	5.60	250.0
Number of oldest-old aged 80+ (million)	0.27	0.37	0.63	1.00	1.34	1.73	540.7
Total population size (million)	20.36	22.04	23.89	25.39	26.46	27.16	33.4
Households							
Total number of households (million)	1.07	1.30	1.73	2.13	2.50	2.84	165.4
Percent of households of older adults aged 65+	5.60	10.25	19.73	25.65	31.70	35.44	532.9
Average household size (persons)	3.73	3.54	3.34	3.18	3.05	2.95	-20.9
Percent of one-person households	7.18	8.52	9.87	10.52	11.06	11.52	60.4
Percent of one-person households of older adults aged 65+	2.23	3.13	3.83	4.20	4.59	4.84	117.0
Percent of one-generation households	20.36	21.33	24.83	27.26	29.46	31.50	54.7
Percent of two-generation households	60.75	62.88	62.93	62.99	62.65	62.00	2.1
Percent of three-generation households	18.89	15.79	12.23	9.75	7.89	6.50	-65.6

Source(s): projection results of present study.

C. Projections of the Home-Based Care Needs for Disabled Older Adults by Households Structure and Living Arrangements Statuses Under the Medium Scenario

Figure 3 shows that the numbers of disabled older females aged 65+ are substantially larger than the numbers of disabled older males aged 65+, and the gender differences are larger among disabled oldest-old aged 80+. On average, the numbers of disabled female oldest-old is 75% larger than disabled male oldest-old aged 80+, while the numbers of disabled females aged 65+ are 46% larger than their male counterparts. It reveals that the relative increase of the number of disabled oldest-old is much higher than the young-old aged 65–79 for both females and males (Figure 4). More specifically, there will be 2.4 million disabled older adults aged 65+ in 2060 with 302.5% increase compared with 2012. The numbers of disabled oldest-old will increase dramatically: from 0.168 million in 2012 to 1.087 million in 2060; the number of disabled oldest-old in 2060 will be 6.56 times as large as that in 2012. The relative increases of the numbers of disabled oldest-old in 2060 compared with 2012 are 537% and 587% for females and males, respectively, in contrast to the corresponding relative increase of female and male disabled young-old aged 65–79 being 190% and 233%, respectively (Figure 4 and Table 7).

Figure 3: Numbers of Disabled Older Adults by Gender and Age Group in 2012–2060, Sri Lanka



Source(s): projection results of present study.

Figure 4: Relative Increase (%) of Numbers of Disabled Older Adults by Gender and Age Group in Each of the Selected Years Compared to 2012, Sri Lanka

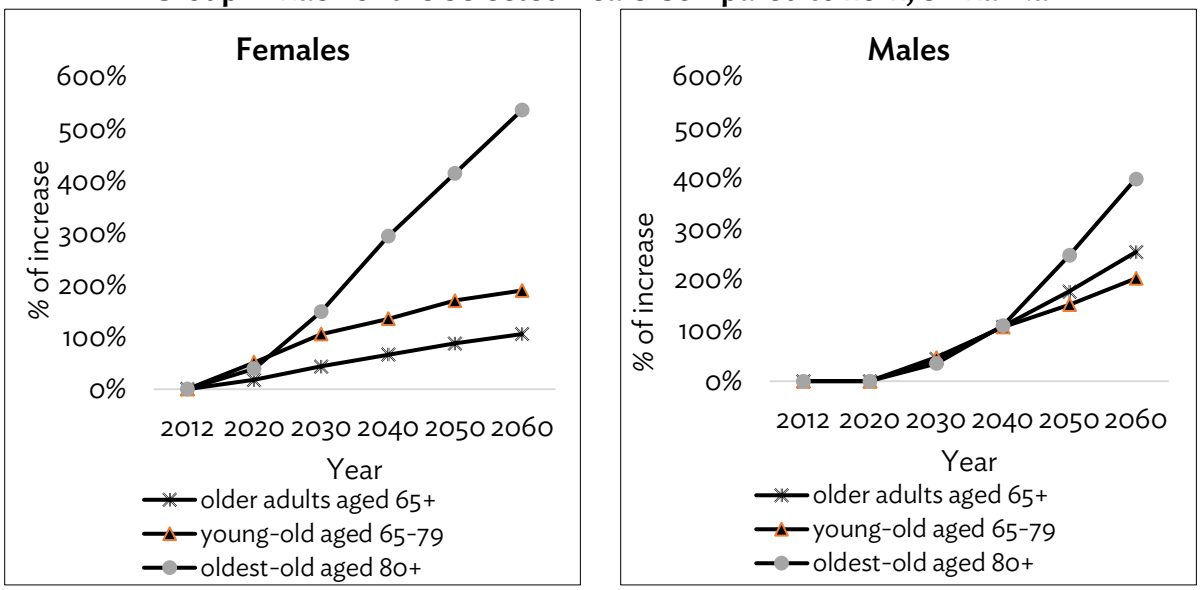


Table 7: Projections of Numbers of Disabled Older Adults Aged 65+ (Million) in 2012–2060 by Gender and Age Group Under the Medium, Low, and High Scenarios of the Disability, and the Relative Increase (%) in 2060 Compared with 2012, Sri Lanka

	Medium Scenario			Low Scenario			High Scenario		
Year	2 Sexes	Female	Male	2 Sexes	Female	Male	2 Sexes	Female	Male
All older adults aged 65+									
2012	0.604	0.369	0.235	0.604	0.369	0.235	0.604	0.369	0.235
2020	0.885	0.547	0.338	0.829	0.513	0.317	0.943	0.583	0.360
2030	1.292	0.804	0.488	1.118	0.696	0.422	1.491	0.928	0.563
2040	1.683	1.032	0.651	1.344	0.824	0.520	2.104	1.290	0.814
2050	2.086	1.251	0.835	1.537	0.922	0.615	2.823	1.693	1.130
2060	2.433	1.429	1.004	1.655	0.972	0.683	3.566	2.094	1.472
% inc. 2060 vs. 2012	302.5%	287.1%	326.6%	173.7%	163.3%	190.2%	490.0%	467.5%	525.4%
Young-old aged 65-79									
2012	0.439	0.266	0.173	0.439	0.266	0.173	0.439	0.266	0.173
2020	0.656	0.402	0.254	0.615	0.377	0.238	0.699	0.429	0.271
2030	0.904	0.547	0.357	0.783	0.473	0.309	1.044	0.631	0.413
2040	1.059	0.625	0.434	0.845	0.499	0.347	1.323	0.781	0.542
2050	1.241	0.718	0.524	0.915	0.529	0.386	1.680	0.971	0.709
2060	1.346	0.769	0.576	0.915	0.523	0.392	1.973	1.128	0.845
% inc. 2060	206.8%	189.7%	233.1%	108.7%	97.0%	126.5%	349.8%	324.7%	388.3%

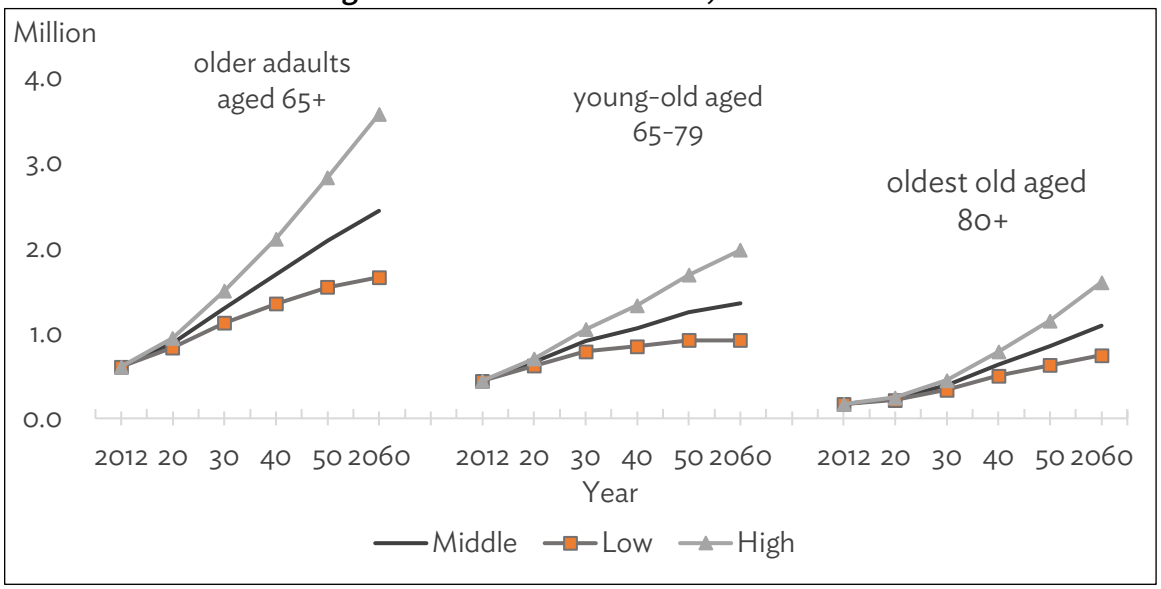
vs. 2012									
Oldest-old aged 80+									
2012	0.166	0.104	0.062	0.166	0.104	0.062	0.166	0.104	0.062
2020	0.228	0.145	0.084	0.214	0.136	0.079	0.243	0.154	0.089
2030	0.388	0.258	0.130	0.336	0.223	0.113	0.447	0.297	0.150
2040	0.625	0.408	0.217	0.499	0.326	0.173	0.781	0.510	0.271
2050	0.844	0.533	0.311	0.622	0.393	0.229	1.143	0.722	0.421
2060	1.087	0.659	0.428	0.739	0.448	0.291	1.594	0.967	0.627
% inc. 2060 vs. 2012	555.6%	536.9%	586.5%	345.8%	333.2%	366.9%	861.0%	833.7%	906.4%

Source(s): projection results of present study.

D. Sensitivity Analysis: The Medium, Low, and High Scenarios of Home-Based Care Needs for Disabled Older Adults

As described in section IV.A, we conducted the low, medium, and high scenarios of future home-based care needs, measured by the numbers of disabled older adults. The projection results presented in Table 7 and Figure 5 show that the numbers of disabled older adults aged 65+, disabled young-old aged 65–79, and disabled oldest-old aged 80+ will rapidly climb from 2.43 million, 1.35 million, and 1.09 million in 2012 to 1.66 million~3.57 million, 0.92 million~1.97 million, and 0.74 million~1.59 million in 2060, under the low, medium, and high scenarios, respectively.

Figure 5: Numbers of Disabled Older Adults by Age Groups Under the Medium, Low, and High Scenarios in 2012–2060, Sri Lanka



Note: "Middle" means medium.
Source(s): projection results of present study.

V. DISCUSSIONS AND POLICY RECOMMENDATIONS

Our analyses show that, compared with male counterparts, female older adults have significant disadvantages in disability status. In general, however, female older adults' socioeconomic status is lower than their male counterparts. This is an important problem that should receive much more attention from the government and society. The government and society should try their best to guarantee that any old age insurance and service programs must benefit older women and men equally.

This study shows that changes in disability status of older adults are the most important determinants of home-based care needs for disabled older adults during the period 2012–2060 in Sri Lanka. Our analysis also shows that, regardless of whether disability statuses of older adults are assumed to improve or deteriorate over time, the home-based care needs for older adults in Sri Lanka will increase substantially because of the inevitable trends of rapid population aging and extremely fast increases of the oldest-old. Consequently, relevant reforms of policies and socioeconomic planning should be taken to respond to the serious challenges of large and rapid increases in home-based care needs.

Our projections found that, if the disability statuses of older adults substantially improve (under the low scenario) or substantially deteriorate (under the high scenario), the care needs for disabled elders would remarkably decrease or largely increase. Note that the most effective way to improve elderly health status is not only to cure disease, but also to effectively prevent illnesses. The latter may be more important because older adults who are cured of one illness are likely to suffer another illness and long-term disability if there is no improvement in their abilities to prevent disease. Therefore, studies of why some older adults remain happy and healthy up to the oldest-old ages and how to reach such pathways of healthy aging should be further strengthened as a priority in healthy aging policy-related research.

Our projection results also show that disabled unmarried elders who are living alone increase substantially faster than those disabled unmarried elders living with children. The relevant socioeconomic countermeasures should be taken. For example, adult children may be encouraged to live together with or near their old-age parents, especially those unmarried old parents, who will help older adults in obtaining home-based care from children whenever they need. Co-residence with or nearby the children will decrease home-based care expenditures for disabled older adults; living in close proximity would overcome intergenerational conflicts between elders and their co-residing children/grandchildren concerning eating, daily activities and entertainment, which will increase the happiness and health of elderly parents as well as enable the old parents to take care of their grandchildren, resulting in "win-win" outcomes.

REFERENCES

Alberts, S., E. A. Archie, L. R. Gesquiere, et al., 2014. The male-female health-survival paradox: a comparative perspective on sex differences in aging and mortality. In National Research Council. 2014. Sociality, Hierarchy, Health: Comparative Biodemography: A Collection of Papers. Washington, DC: The National Academies Press. https://doi.org/10.17226/18822.

Bagi, M. 2018. Household and Living Arrangement Projections for Iran. PhD thesis research. Tehran: Department of Demography, Faculty of Social Sciences, University of Tehran.

Bongaarts, J. 1987. The projection of family composition over the life course with family status life tables. In Bongaarts, J., T. Burch, and K. W. Wachter, eds. Family demography, methods and applications. Oxford: UK: Clarendon Press (pp. 189–212).

Bradbury, M., M.N. Peterson, and J. Liu. 2014. Long-term Dynamics of Household Size and Their Environmental Implications. Population and Environment. DOI: 10.1007/s11111-014-0203-6.

Brass, W. 1974. Perspectives in Population Prediction: Illustrated by the Statistics of England and Wales. Journal of the Royal Statistical Society 137(Series A), 532–583.

Coale, A.J. 1984. Life Table Construction on the Basis of Two Enumerations of a Closed Population. Population Index 50, 193–213.

_____. 1985. An Extension and Simplification of a New Synthesis of Age Structure and Growth. Asian and Pacific Forum 12, pp. 5–8.

Coale, A.J., P. Demeny, and B. Vaughn. 1983. Regional Model Life Tables and Stable Populations. New York: Academic Press.

Dalton, M., B. O'Neill, A. Prskawetz, L. Jiang, and J. Pitkin. 2008. Population aging and future carbon emissions in the United States. Energy Economics, 30, 642–675.

De Silva, W. 2013. The age structure transition and the demographic dividend: An opportunity for rapid economic take-off in Sri Lanka. Sri Lanka Journal of Advanced Social Studies 2(1).

Feng, Q., P. Dommaraju, and Z. Husain. 2020. Households and Living Arrangements Projections for India. Ongoing research project.

Feng, Q., JW. Yeung, Z. Wang, and Y. Zeng. 2018. Age of Retirement and Human Capital in an Aging (the People's Republic of) China, 2015–2050. European Journal of Population. doi:10.1007/s10680-018-9467-3.

Feng, Q., Z. Wang, S. Choi, and Y. Zeng. 2020. Forecast households at the county level: An application of the Profamy extended cohort-component method in six counties of southern California, 2010 to 2040. Population Research and Policy Review 39(2), pp. 253–281.

Feng, Q., Wang, Z., Gu, D., and Zeng, Y. 2011. Household vehicle consumption forecasts in the United States, 2000 to 2025. International Journal of Market Research 53, 593–618.

Grundy, E. 2001. Living arrangements and the health of older persons in developed countries. United Nations Population Bulletin, Special Issue Nos. 42/43, pp. 311–329. URL: http://eprints.lse.ac.uk/53584/

_____. 2013. Opening keynote speech at the "households and living arrangement projections: New method, software and applications." Held at the 27th General Conference of International Union for Scientific Population Studied (IUSSP), 26–31 August, Busan, Republic of Korea.

Hullen, G. 2001. New macrosimulations of living arrangements and households in Germany. In Population Association of America, 2001 Annual Meeting, March, pp. 7–31.

Hullen, G. and B. für Bevölkerungsforschung. 2003. Living arrangements and households: methods and results of demographic projections (No. 109). Bundesinstitut für Bevölkerungsforschung beim Statistischen Bundesamt (BiB). March.

Hussain, S. and M. Sadiq. 2020. Households, Living Arrangements and Residential Energy Demands Projections in Pakistan. Ongoing research project of Population Council Office in Pakistan.

Jiang, L. and B.C. O'Neill. 2007. Impacts of Demographic Trends on US Household Size and Structure. Population and Development Review 33(3): 567–591.

Jiang, L. and A. Kuijsten. 1999a. Effects of Changing Households on Environment – Case Studies in Two Regions of (the People's Republic of) China. Paper Presented at workshop. Population and Environment: Modeling and Simulating This Complex Interaction. Organized by the Max Planck Institute for Demographic Research at Rostock, Germany, 12–13 August 1999.

Jiang, L. and A. Kuijsten. 1999b. Household Projections for Two Regions of (the People's Republic of) China. Paper presented at the European Population Conference, the Hague, The Netherlands, 30 August–3 September 1999.

Keyfitz, N. 1972. On Future Population. Journal of American Statistical Association 67, 347–363.

Lakdawalla, D., D. P. Goldman, J. Bhattacharya, M. D. Hurd, G. F. Joyce, and C. W. A. Panis. 2003. Forecasting the nursing home population. Medical Care 41, 8–20.

Landy, S. 2017. Unfolding Consumption: An Application of Household Projections to Estimate Environmental Implications of Energy Consumption. Paper presented at the IUSSP 28th General Conference Side Meeting on Households/Population Projections and Sustainable Development, 30 October, Cape Town, South Africa.

Lee, R. and A. Mason. 2010. Some macroeconomic aspects of global population aging. Demography 47 (1), S151–S172.

Mason, A. and R. Racelis. 1992. A comparison of four methods for projecting households. International Journal of Forecasting 8, 509–527.

Murphy, M. 1991. Modeling households: A synthesis. In Murphy, M. J. and J. Hobcraft, eds. Population research in Britain, A supplement to population studies (Vol. 45., pp. 157–176). London:

Population Investigation Committee, London School of Economics.

O'Neill, B. C. and B. S. Chen. 2002. Demographic determinants of household energy use in the United States. Population and Development Review 28, pp. 53–88.

O'Neill, B. C. and L. Jiang. 2007. Projecting US household changes with a new household model. IIASA Interim Report. IIASA, Laxenburg, Austria: IR-07-017.

Prskawetz, A., L. Jiang, and B. O'Neill. 2004. Demographic composition and projections of car use in Austria. In Fent, T. and A. Prskawetz, eds. Vienna Yearbook of Population Research (pp. 274–326). Vienna: Austrian Academy of Sciences Press.

Samaraweera, D. and S. Maduwage. 2016. Meeting the current and future health-care needs of Sri Lanka's ageing population. WHO South-East Asia Journal of Public Health 6(2), pp. 96–101.

Smith, S. K., S. Rayer, and E. A. Smith. 2008. Aging and disability: Implications for the housing industry and housing policy in the United States. Journal of the American Planning Association 74, 289–306.

Smith, S. K., S. Rayer, E. Smith, Z. Wang, and Y. Zeng. 2012. Population aging, disability and housing accessibility: Implications for sub-national areas in the United States. Housing Studies 27, 252–266.

Spicer, K., I. Diamond, and M. N. Bhrolcham. 1992. Into the twenty-first century with British households. International Journal of Forecasting 8, 529–539.

Stupp P.w. 1988 A general procedure for estimating intercensal age schedules. Population Index 54, 209–223

Suthers, K., J. K. Kim, and E. Crimmins. 2003. Life expectancy with cognitive impairment in the older population of the United States. Journal of Gerontology: Social Sciences 58, S179–S186.

Tirza, A. 2017. Elderly Population and Their Living Arrangements in the Most Developed State of Brazil. Paper presented at the IUSSP 28th General Conference Side Meeting on Households/Population Projections and Sustainable Development, 30 October, Cape Town, South Africa.

Watt, Melissa H., Bilesha Perera, Truls Østbye, Shyama Ranabahu, Harshini Rajapakse, and Joanna Maselko. 2014. Caregiving expectations and challenges among elders and their adult children in Southern Sri Lanka. Ageing and Society 34, no. 5: 838.

Willekens, F. 2010. Family and Household Demography. In Y. Zeng, ed. Encyclopedia of Life Support Systems Vol 2. Demography (pp. 86–112). Oxford: United Nations Educational, Scientific and Cultural Organization in partnership with EOLSS Publishers.

Wrigley-Field, E. 2014. Mortality deceleration and mortality selection: three unexpected implications of a simple model. Demography Feb;51(1):51-71. doi: 10.1007/s13524-013-0256-7. PMID: 24385199; PMCID: PMC4559263.

Yang, C.L. and Y. Zeng. 2000. Household projections for Taiwan.[1] Taiwanese Journal of Sociology 24, pp. 239–279.

Zeng, Y. 2007. Options of fertility policy transition in (the People's Republic of) China. Population and Development Review 33, 215–246.

_____. 2011. Effects of Demographic and Retirement-Age Policies on Future Pension Deficits, with an Application to (the People's Republic of) China. Population and Development Review 37(3), 553–569.

Zeng, Y. and Z. Wang. 2014. A policy analysis on challenges and opportunities of population/household aging in (the People's Republic of) China. Journal of Population Ageing 7(4), pp. 255–281.

Zeng, Y., A. Coale, M. K. Choe, Z. Liang, and L. Liu. 1994. Leaving Parental Home: Census based Estimates for (the People's Republic of) China, Japan, South Korea,[2] the United States, France, and Sweden. Population Studies 48(1), 65–80.

Zeng, Y., H. Chen, Z. Wang, and K. C. Land. 2015. Implications of changes in households and living arrangements for future home-based care needs and costs for disabled elders in (the People's Republic of) China. Journal of Aging and Health 27(3), pp. 519–550.

Zeng, Y., K., C. Land, Z. Wang, and D. Gu. 2006. U.S. family household momentum and dynamics: Extension of ProFamy method and application. Population Research and Policy Review 25, 1–41.

_____. 2013. Household and living arrangements projections at the sub-national level: An extended cohort-component approach. Forthcoming in Demography 50, 827–852. doi:10.1007/s13524-012-0171-3.

Zeng, Y., K. C. Land, D. Gu, and Z. L. Wang. 2014. Household and Living Arrangement Projections: The Extended Cohort-Component Method and Applications to the U.S. and (the People's Republic of) China. New York: Springer Publisher.

Zeng, Y., J. W. Vaupel, and Z. Wang. 1998. Household projection using conventional demographic data Supplementary Issue: Frontiers of Population Forecasting. Population and Development Review 24, 59–87.

Zeng, Y., Z. Wang, L. Jiang, and D. Gu. 2008. Future trend of family households and elderly living arrangement in (the People's Republic of) China. GENUS: An International Journal of Demography LXIV(1-2), 9–36.

Zeng, Y., Z. Wang, Z. Ma, and C. Chen. 2000. A Simple Method for Estimating α and β: An Extension of Brass Relational Gompertz Fertility Model. Population Research and Policy Review 19(6), 525–549.

Zhang, Z. 2004. Impact of intergenerational support on healthy longevity. PhD thesis. Peking University, Beijing.

[1] ADB recognizes this member as "Taipei,China".
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