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Breakthroughs in Epidemiology

Healthy longevity in the Asia–Pacific: a cross-national population-based modeling study

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Abstract

Population aging in the Asia–Pacific will not proceed along the paths already followed by more developed countries, but differences in later-life health across the Asia–Pacific region are poorly understood. Using data from five harmonized longitudinal surveys in the region, we examine gender and cross-national differences in life expectancy (LE) and health expectancies (HEs) at age 50 in Australia, Japan, South Korea, China, and Indonesia. We adopt a microsimulation-based multistate life table model to provide estimates of HEs across four dimensions of health, including life expectancy free of poor self-related health, ADL disability, functional limitations, and chronic diseases. We find that older adults in the Asia–Pacific are experiencing substantially different regimes of health in later life, with cross-national differences arising across measures of health, over age, and between men and women. Older adults China and Indonesia experience more lifetime with physical limitations compared to those in Australia or Japan. Older adults in China spend a markedly higher proportion of remaining LE with chronic diseases compared to other countries. Our results provide much-needed evidence examining current conditions across the region, deepening understanding of how Asia–Pacific populations are currently fairing in terms of later-life health and functioning.

Key words: mortality; cross-national comparison; Asia–Pacific; health expectancy; disability.

Introduction

Despite its importance for understanding population health, current levels of health expectancies (HEs) are poorly understood in many Asia–Pacific contexts. HE measures provide an estimate of the number of years an average individual can expect to spend in good or poor health. By combining mortality and morbidity into a single measure, HE measures provide a concise metric for comparing population-level health cross-nationally. However, little cross-national research on HEs exists in the region.[1,2] Most studies in the Asia–Pacific region are confined to single countries, and cross-national comparability is hampered by differences in the health outcomes used to estimate HE.[3-9] Much of the research in the region has focused on health in aging in China, South Korea, and Australia, contributing evidence on persistent gender differences and substantial socioeconomic inequalities in mortality, disability, and disability-free life expectancy in these countries.[10-17]

Although the body of research on healthy life expectancy in the region has expanded in recent years, cross-nationally comparative work is still limited, and most comparable research that is available is based on either sequalae-based health-adjusted life expectancy (HALE) or estimated using Sullivan's method.[18-21] These approaches have the benefit of using simple calculations from prevalence data that is more readily available. However, health expectancy estimates based only on prevalence information miss out on the dynamics of well-being experienced by older adults. Accurately accounting for these transitions leads to a more nuanced understanding of the lived experience with ill-health and avoids generating biased population-level estimates.[22] One recent cross-national study has employed multi-state modeling to understand health transitions with a more global focus, but the only countries in the Asia–Pacific included were China and South Korea.[23]

In this paper, we estimate and compare life expectancy (LE) and HE measures across a set of five countries in the Asia–Pacific. We adopt a microsimulation-based multistate life table (MSLT) method to provide detailed estimates of LE and HEs in three established and recently transitioned high-income countries (HICs) (Australia, Japan, and South Korea), and two middle-income countries (MICs) in East and Southeast Asia (China and Indonesia). Our analyses use harmonized longitudinal health and aging surveys in the Health and Retirement Study family to compare HEs across multiple dimensions of health including life expectancy free of activities of daily living (ADL) disability, functional limitations, poor self-related health, and chronic diseases, and systematically examine gender and cross-national differences in HEs. The overarching goal of this paper is to explore how the proportion of remaining life lived with and without poor health among older adults differs across countries in the Asia–Pacific. We incorporate a multidimensional view of health in aging to shed light on cross-national similarities and differences in later-life wellbeing. This

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research represents a step forward in the scholarship on cross-national and gender differences in healthy life expectancy in the Asia–Pacific.

Data and methods

Data

Data from multiple waves of five representative sample surveys were used to explore LE and HEs in the Asia–Pacific: the 2001–2014 annual waves of the Household, Income, and Labour Dynamics in Australia Survey (HILDA),[24] the 2007, 2009, 2011, and 2013 waves of the Japanese Study of Aging and Retirement (JSTAR),[25] the 2006–2018 biannual Korean Longitudinal Study of Aging (KLOSA),[26] the 2011, 2013, 2015, and 2018 waves of the China Health and Retirement Longitudinal Study (CHARLS),[27] the 2007 and 2014 waves of the Indonesia Family Life Survey (IFLS).[28] JSTAR, KLOSA, CHARLS, and IFLS are all Health and Retirement Study (HRS) sister studies, and collect largely comparable data on health, disability, and sociodemographics. HILDA, although not an HRS sister study, collects a detailed module on respondent health every four years (2009 and 2013) that is closely comparable to the HRS sister studies, and has been previously used in analyses harmonized to other HRS sister studies[29].

Information about each study's sampling design and mortality assessment are provided in Table S1, and information on sample size and baseline characteristics are detailed in Table S2. Of note, the baseline sample of JSTAR included individuals from 5 pre-chosen municipalities, all of which are located in the eastern part of Japan. As such, caution is need in the interpretation our results pertaining to Japan, as JSTAR is not nationally representative.[25] To focus on healthy longevity among older adults, we restricted our sample to individuals 50 years or above and excluded individuals who were missing information on age or sex.

HEs were estimated for four domains: ADL disability, physical limitation, self-rated health, and chronic diseases. ADL disability was defined as self-reported limitations in one or more ADL activities including bathing, eating, getting in/out of bed, toileting, and walking across room.[30] Limitation on the ADL activities represents profound disability and is generally conceptualized to mean that an individual is unable to live independently. Small variations were present on the ADL items included: CHARLS did not ask a question on walking across a room and IFLS did not ask a question on eating; ADL disability is defined as self-reported limitation on any of the remaining four activities in these studies. Our primary results report estimates using all available ADL items for each country, with estimates from an analysis using only the three ADL items available in all surveys (bathing, toileting, and transferring) available in Supplemental Materials. The specific questions used in each survey are detailed in Table S3.

Physical limitation is defined as self-reported difficulty in one or more of the following 5 activities: walking 1 block or 100 meters, getting up from a chair, climbing several flights of stairs, stooping, kneeling, and crouching, or lifting and carrying 5 kg of weight.[31] We note that there are some differences in the survey questionnaires. Physical limitations questions in IFLS include only four items while omitting the question on stair climbing. Our primary results report estimates using all available physical limitation items for each country, with estimates from an analysis using only the four items available in all surveys (walking a block, getting up from a chair, kneeling or crouching, or carrying a 5-kg bag) available in Supplemental Materials. The specific questions used in each survey are detailed in Table S4. KLOSA does not include comparable questions on physical limitation.

All five surveys include similar questions on self-rated health, although the scale used in each survey differs slightly. We categorized self-rated health into two groups: "excellent/very good/good" and "fair/poor." In IFLS, we grouped those who responded "somewhat unhealthy" and "unhealthy" to the self-rated health question as having "fair/poor" health. The specific questions used in each survey are detailed in Table S5.

We define the presence of chronic diseases as self-reported doctor-diagnosed conditions. Information on the presence of chronic diseases is reported in response to the question "Has a doctor ever told you that you had any of the following conditions (cancer, diabetes, lung disease, heart disease, … and stroke)?" in all five surveys. Life expectancy free of chronic morbidities is defined as life expectancy without any of these five conditions. These conditions represent the top 5 causes of death from chronic non-communicable disease in most high-income countries[32] and are expected to exert increasing pressure on the sustainability of health care systems worldwide as population age. The specific questions used in each survey are detailed in Table S6.

Rates of missing outcome data varied across the five countries under study (see Table S2). Individuals with missing outcome data were excluded from analysis. To adjust for potential bias due to survey refusal or loss to follow up, our analyses include stabilized inverse probability of attrition weights.[33] Weights were estimated using logistic regression. Our missingness model in the inverse probability weight calculation included sociodemographic variables including age, gender, marital status, urban residence, educational attainment, household wealth, ever smoke, and ever had alcohol.

Each dataset follows older adults longitudinally and contains detailed information on (1) socio-demographics (age and sex), (2) health (disability, functional limitation, health conditions, self-rated health), and (3) mortality. Deaths occurring between sample waves were reported by a family member during a follow-up wave of data collection. The HILDA survey was matched to the National Death Index in 2014.[34] The IFLS, KLOSA, and HILDA surveys report exact date of death for deceased individuals, while CHARLS and JSTAR record year of death.

Methods

We used multistate life table models (MSLT) to jointly investigate health and survival across the life course in a dynamic perspective.[35,36] This method relies on weighted data from nationally representative sample surveys to estimate MSLT functions such as total LE, disability-free LE and disabled LE, and combines microsimulation with bootstrapping to generate estimates that, when combined with individual-level weights and sample design variables, are generalizable to the population level. In the MSLT model, as in reality, individuals can relapse and remit through different states of disability and health. In the base model, the annual transition probabilities of transitioning between these states are modeled as a function of age and gender, using a multinomial logistic discrete-time hazard model including age, age^2, gender, and an age∗gender interaction. A graphical representation of the model state spaces for each of our outcome variables is provided in Figure S1.

Our analyses use a microsimulation approach to calculate MSLT functions such LE and HEs, based on the SPACE suite of SAS programs.[36,37] We initially create synthetic cohorts of 100 000 individuals with the same initial gender and health-state distribution as the study population (These initial distributions are provided in Table S1.) These individuals are then "aged" forward year by year

using age- and gender-specific mortality rates and probabilities of transitioning in and out of health states, estimated as described above. This process is then repeated until death, and confidence intervals are estimated using 499 bootstrap resamples from the original data set.

The resulting synthetic cohort, representing the life courses of 100 000 individuals subjected to the prevailing rates of mortality and onset/recovery from health conditions, can then be used to estimate healthy, limitation-free, morbidity-free and disability-free LE (known as health expectancies, HEs), and total LE. In addition to estimating full LE and HE values, this synthetic cohort can also be used to estimate life and health expectancies bounded between two ages, also known as partial HEs and LEs.[38] These partial measures represent the average number of total and healthy life years lived between two ages in a population. Investigating LE and HE values bounded within specific age groups allows us to investigate processes of health during discrete portions of the life-course, providing a greater understanding of where in the aging process differences in health arise between countries.

Results

Cross-national differences in total and healthy life expectancies

Figure 1 and Table S7 present life and health expectancies across four domains of health at age 50 across the five countries included in these analyses. Total LEs vary considerably across countries, with the largest gap observed between Japan and Indonesia. Note that total LE estimates change somewhat within each country depending on the measure of health used due to random fluctuations introduced in the microsimulation and differences in sample size due to missing data on health outcomes. Male LEs were overall similar in Japan, Australia, and South Korea, while Japanese women had a substantial LE advantage over the other countries.

Our primary results focus on proportionate differences in HEs (Figure 1), and we find substantial heterogeneity in heathy longevity across countries. Men and women in Japan, South Korea, and Indonesia report spending a larger fraction of their remaining life free of ADL disabilities as compared to older adults in Australia and China. Table S8 provides estimates of LE and HEs using only the three ADL items available in all surveys (bathing, toileting, and transferring).

Patterns of physical limitation are quite different from those of ADL limitation. Older adults in the two MICs (China and Indonesia) are more heavily burdened with physical limitations compared to those in the two established HICs in the region (ie, Australia and Japan). To illustrate, at age 50, older women in Japan can expect to live 66% (95% CI, 62%–73%) of their remaining lives free of physical limitation, compared to 43% (95% CI, 40%–46%) in Indonesia and 27% (95% CI, 25%–28%) in China. Table S8 provides estimates of LE and HEs four physical limitation items available in all surveys (walking a block, getting up from a chair, kneeling or crouching, or carrying a 5-kg bag).

Patterns of self-rated health are similar across Australia, China, and Indonesia, with between 50%–62% of remaining life at age 50 spent in good self-rated health. However, we find substantial differences in healthy LE between South Korea and Japan—while older adults in Japan report spending about 85% of remaining LE at age 50 in good health, only 48% (95% CI, 46%–50%) and 36% (95% CI, 34%–39%) of LE at age 50 is spent with good self-rated health among Korean men and women, respectively.

We observe large heterogeneity in life expectancies free of major chronic diseases across countries. As a proportion of remaining life, men and women in Indonesia, Australia, and South Korea can expect to live considerably longer fraction of their total LE free of morbidities compared to older adults in Japan and China. It is somewhat surprising that, despite their substantially shorter total LE, older Indonesians can not only expect to live higher proportions of their remaining lives free of the 5 chronic diseases, but also live more absolute morbidity-free years compared to older adults in the other 4 countries. It is possible that Indonesia's high-morbidity-free LE is a result of under-diagnosis of chronic diseases in the country.[39,40]

Cross-national differences in healthy longevity in discrete portions of the life-course

The microsimulation-based MSLT approach additionally allows us to investigate cross-national differences in healthy longevity during discrete portions of the life-course. From a population health perspective, knowing where in the life-course health declines occur is key for developing more targeted strategies for ameliorating them. In this section, we estimate partial HEs investigate whether differences in health arise during middle age (ages 50–59) or in later life (ages 60–69, 70–79, or 80+). We focus our analyses on cross-national differences in the proportion of life spent healthy in each of these decades of age. Results are presented in Figure 2.

For both men and women, cross-national variations in the proportions of partial LE spent free of physical limitations emerge strongly in ages 50–59, persist into older ages (60–79), and become narrower only in the oldest age group (80+). Adults in Japan, especially Japanese women, can expect to live significantly higher proportions of their lives free of physical limitations compared to Australia, China, and Indonesia in all age groups expect for the 80+ ages. Meanwhile, adults in China are lagging behind other countries with respect to physical limitation in ages 50 through 79.

In contrast, cross-national differences in the proportions of life spent free of more severe ADL disabilities are narrow and insignificant in ages 50 to 59 and emerge more strongly in ages 70+ for men and 60+ for women. Similar to physical limitation, adults in China can expect to spend significantly higher proportions of their lives with ADL disabilities compared to other countries in these older age groups.

Figure 2 highlights variations in self-rated health across age groups in the studied countries. Japanese adults can expect to live significantly higher proportions of their lives with self-rated good health compared to Australia, South Korea, China, and Indonesia in all age groups. In most countries except for China, the proportion of life spent healthy declines over each decade of age. This decline is particularly pronounced in South Korea, so that by ages 60 and above, South Korea lags significantly behind other countries with respect to self-rated health. In contrast, adults in China can expect to live only about 50% of their lives between ages 50 and 59 in self-rated good health, but this percentage increases to around 60% in older age groups.

We find limited cross-national variation in the proportions of remaining morbidity-free life at all ages among women in Japan, Australia, Indonesia, and South Korea. Women in China are disadvantaged in comparison, and this disadvantage emerges strongly during working ages 50 to 59 and persists into older ages. Indonesian men can expect to live a higher proportion of life free of the major chronic diseases in the two older age groups: 60–69 and 70–79.

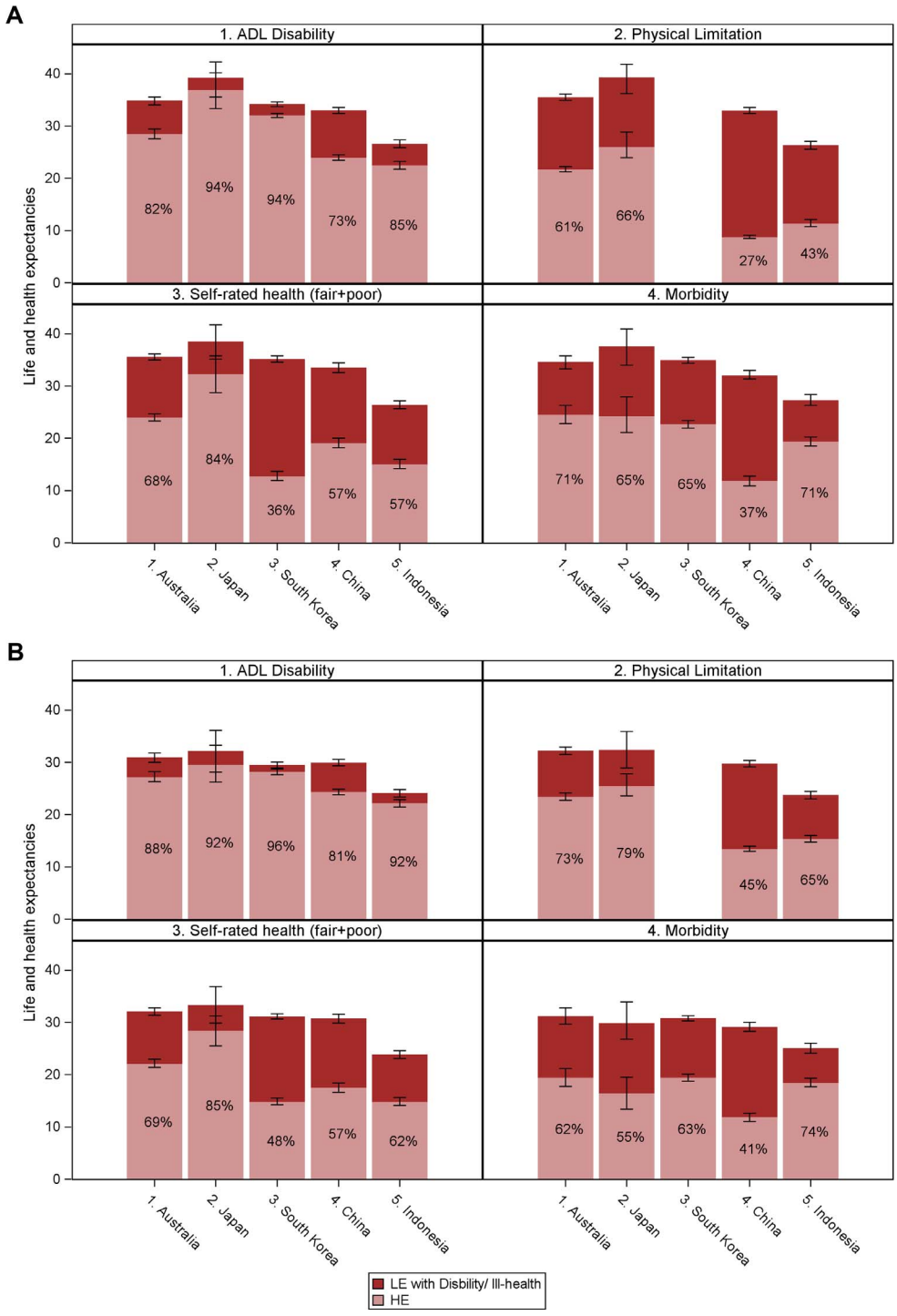

Figure 1. Life and health expectancies at age 50 in Australia, Japan, South Korea, China, and Indonesia. Panel A: Women. Panel B: Men. Note: Bars represent 95% confidence intervals.

Gender differences in healthy longevity

Figure 3 shows female to male ratios (with 95% CIs) in HEs by health outcomes. Values above 1 indicate female advantage while values below 1 indicate female disadvantage. Across most studied countries, women can expect to live significantly lower proportions of remaining life without ADL disabilities and physical limitations compared to men. Japan stands out as the only exception where gender differences in the proportion of ADL-free LE are not significant. With respect to self-rated health, we find no evidence of significant gender differences in the proportion of remaining life lived in self-rated good health at age 50 in Japan, Australia, and China. However, female disadvantage in the proportion of remaining life lived in self-rated good health is significant in South Korea, and to a lesser extent, Indonesia.

With respect to the proportions of remaining life spent without major chronic diseases, we find evidence of female advantage in the HICs (Japan, Australia, and South Korea) and female disadvantage in the MICs, especially China. Women in Australia and Japan enjoy rather pronounced advantages in the proportions of remaining life disease free as compared to men. At the same time,

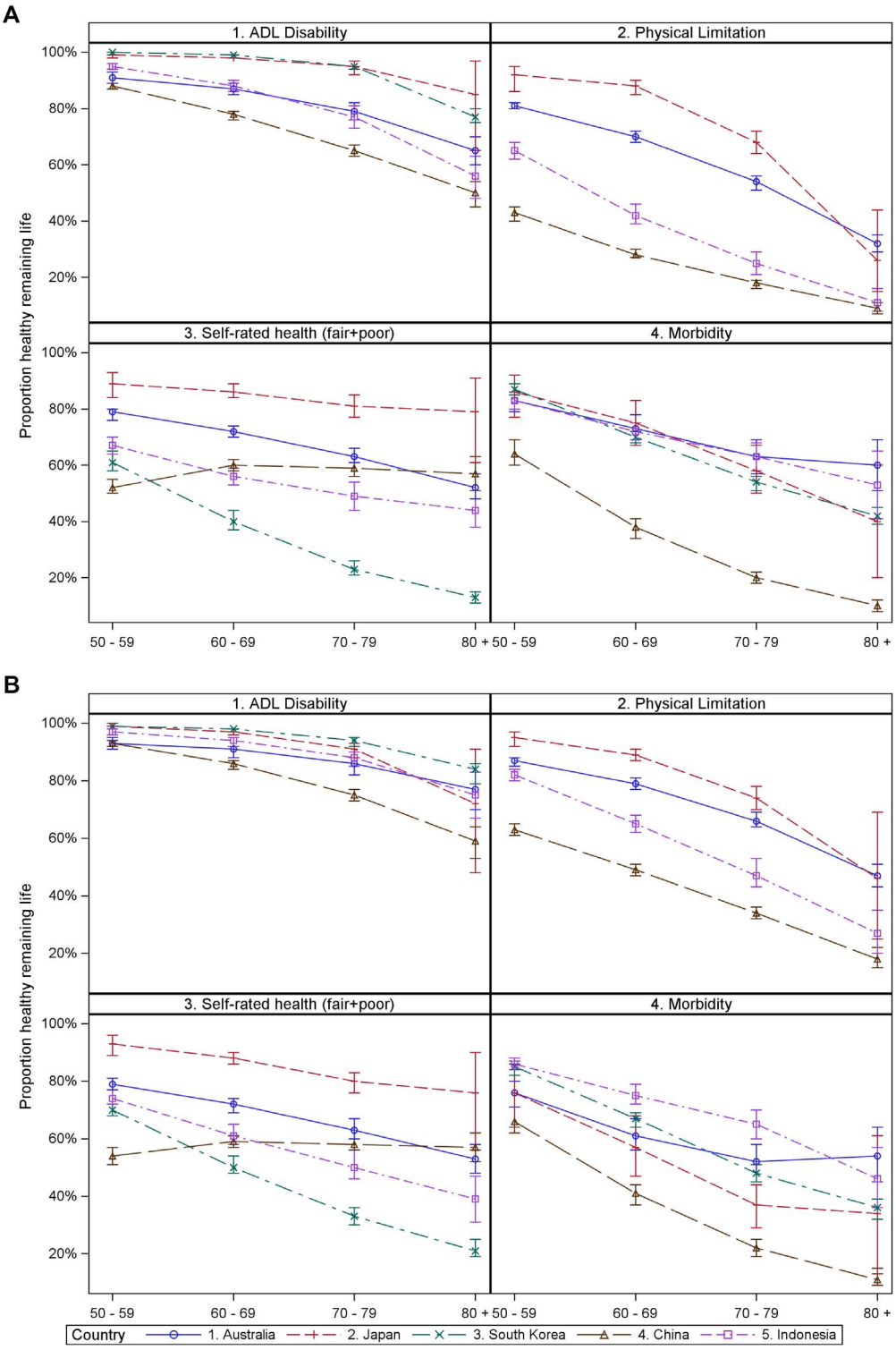

Figure 2. Proportion of health remaining life by age groups in Australia, Japan, South Korea, China, and Indonesia. Panel A: Women. Panel B: Men. Note: bars represent 95% confidence intervals.

we find significant female disadvantage in China: Chinese women can expect to live significantly lower proportions of their remaining life at 50 without the chronic diseases compared to men. Similarly, women in Indonesia can expect to live lower proportion of their remaining life free of chronic diseases compared to men, although gender differences in Indonesia are less pronounced and not statistically significant.

Discussion

In this paper, we explore healthy longevity in the Asia–Pacific using cross-nationally comparative data, contributing new findings to a research area that has been critically understudied. Our analysis explores differences in healthy (self-rated), limitation-free, disability-free, and morbidity-free life expectancy in the Asia–Pacific and expands understanding later-life health

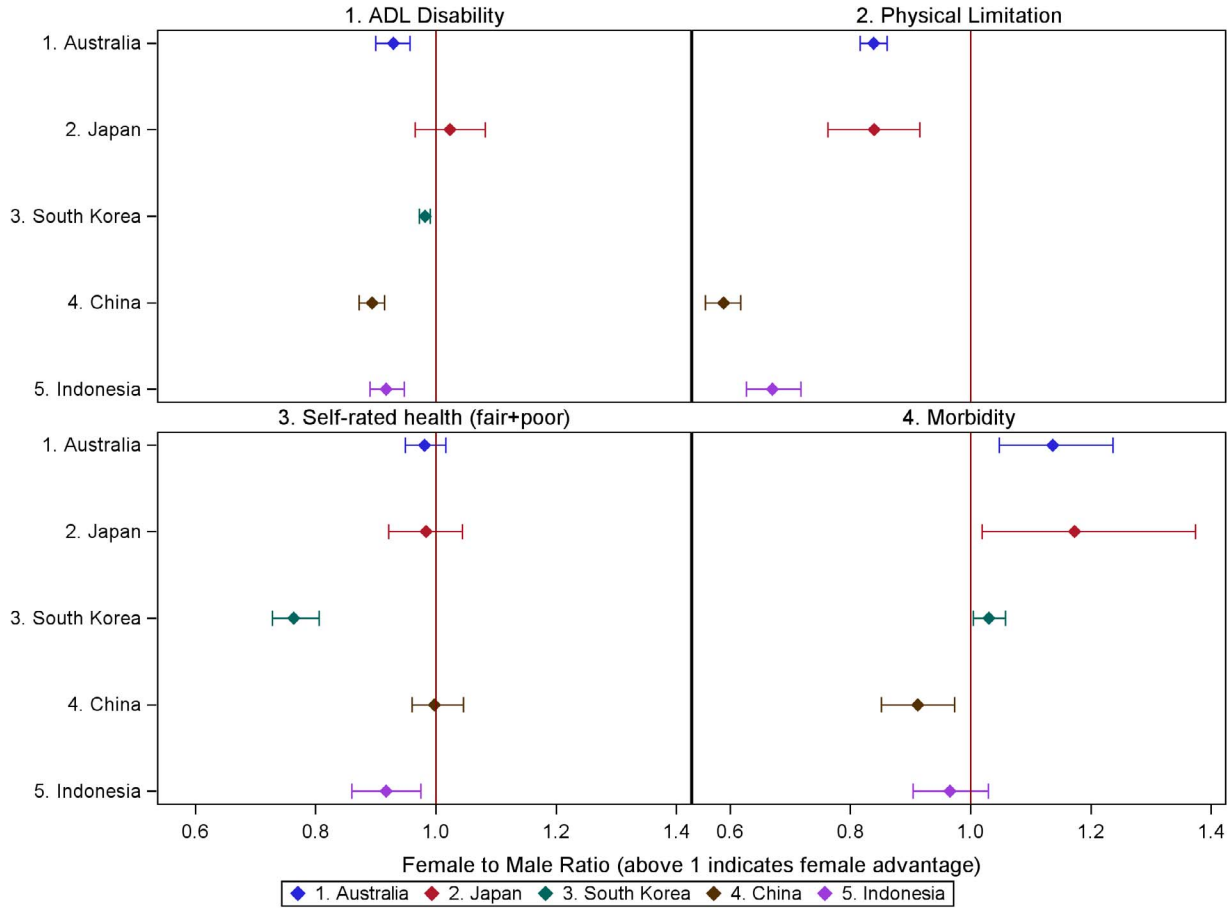

Figure 3. Female to male ratio: proportion of healthy remaining life at age 50. Note: Bars represent 95% confidence intervals.

outcomes in the region. Overall, we find that older adults in the Asia–Pacific are experiencing substantially different regimes of health in later life, with cross-national differences arising across different measures of health, over age, and between men and women. Our analyses uncover a number of interesting contrasts—LE with ADL disability is substantially higher in China and Australia than in the other countries studied, but LE with good physical functioning is much lower in China as compared to Australia. Our results highlight the need for cross-national studies to approach comparisons of later-life health from multiple directions, as there is considerable variation in which countries are leading and lagging in healthy longevity across outcomes.

We used partial LE and HE estimates within each decade of age to investigate cross-national variation in the pace of age-related health declines. Cross-national differences in physical limitation are largest at younger old ages (with the gap widest between Japan and China), but diminish over age. In contrast, cross-national differences in ADL disability grow over age. Although prior research generally explores these dimensions of age-related physical functioning separately, our findings suggest that these two measures may be more effectively used in combination, to more fully characterize age-related changes in functioning. By older ages, a large fraction of any population will have functional limitations, but context and supports can introduce variation in whether these limitations lead to disability.[41] One of the more troubling findings from these analysis concerns the markedly higher proportion of LE lived with chronic morbidities in China as compared to other countries. Given the rapid aging of the Chinese population, this long period of life spent with chronic morbidities has the potential to lead to a substantial burden on the health system.

Our results suggest that self-rated health is perhaps the most difficult measure to interpret in cross-national context. SRH is known to be a very useful measure for within-country research and is highly predictive of mortality.[42] However, differences in reporting norms make interpretation challenging across countries, and cross-national patterns of LE in good SRH appear quite different from other measures of health. We also found gender differences in the ages where cross-national differences in HEs arose, with substantial heterogeneity in LE spent with chronic disease among younger men but similar trends for women (excepting in China). This investigation of the age-patterning of HEs also highlights country-level differences in HEs across measures, and in differences in the pace of change over age. For example, South Korean men and women report the least amount of LE burdened with ADL disability, and the slowest pace of decline over age. However, these same individuals also report the greatest proportion of LE in poor self-rated health, and the fastest pace of decline over age. This seeming disconnect between reported ADL disability and self-rated health highlights the challenges of cross-national work.

We find considerable gender differences across the five countries under study. Excepting Japan, females report more ADL limited life, and in line with prior literature females report worse physical functioning.[1] Gender differences in SRH are only meaningfully different in South Korea, where women report substantially worse health than men. Quite different gender patterns emerge in major chronic diseases across countries. Women can expect to spend substantially less remaining life with morbidities

in Australia, Japan, and South Korea, the three HICs studied. However, older women in Indonesia and China are experiencing greater time spent with chronic diseases as compared to men. This gap is especially large among Chinese women. More research is needed to understand gender differences in chronic diseases in LMIC contexts, and they appear to diverge from observed gender patterns in HICs. Although our discussion focuses primarily on relative values of HEs, there is also variation in the absolute number of years of both life and healthy life across countries. Both males and females in Japan can expect longer lifespans at age 50 than the other studied countries. Men in Australia, South Korea, and China all have relatively comparable remaining LE, although LE of Chinese women somewhat lags their counterparts in Australia and South Korea. Indonesia, as the middle-income country included, lags the other countries in both LE and HEs.

Although trends in total life expectancy align with broader trends in economic development—that is, higher income contexts such as Japan, Australia, and South Korea have longer life expectancies as compared to China and Indonesia—patterns of healthy life expectancy are much more mixed. This variation in HEs across levels of development is somewhat surprising, given the substantial variation in both current and cumulative health and economic conditions experienced by older adults in these different countries. Health in later life is the result of a complex interplay between early- and later-life sources, and our results suggest that there may be counterbalancing effects occurring in these populations—that is, health expectancies are the result of both the accumulated wear-and-tear over the life course, and are also a function of how health systems are able to support the longevity of individuals with the disabilities or chronic health conditions resulting from these exposures.[43] In the middle-income (China and Indonesia) and recently-transitioned high-income (South Korea) countries in our analyses, current cohorts of older adults were exposed to a vastly different set of environmental and epidemiologic conditions over the course of their lives than prevails today. This combination of poorer early-life conditions, and rapid economic and health system development, may underly some of the larger cross-national differences we observe, particularly the extended life expectancy with physical limitations, ADL disability, and chronic morbidities seen in China, the high proportion of remaining LE with physical limitation seen in Indonesia, and the substantial fraction of life with poor self-rated health seen in South Korea.

As is common in cross-national research, our results are not without limitations. Health expectancy estimates assume that transition rates are stationary over time, and thus represent health conditions during a specific time period rather than the lived experience of any single cohort. Similarly, the time periods of observation in each survey do not align precisely, meaning that observation period differences could contribute to cross-national differences. Respondent interpretation of survey items, potentially due to translation, may have varied across settings. Slight differences in questions also arose in the ADL and physical limitation questions asked across surveys. Our primary results report LE and HE measures using all available items to present the most accurate possible view of health in aging in each country. Supplemental analyses using only the three comparable ADL questions and four comparable physical limitation questions did not differ substantially from those in the main text, although there was some attenuation in life spent with ADL disabilities or functional limitations due to the reduction in survey items used (Table S8). Our measure of chronic conditions also does not include a question on dementia, Alzheimer's, or other neurological disorders, as these questions were not asked systematically across all studies. This may have contributed to gender differences in our estimates of LE free of chronic diseases, as women are disproportionately impacted by these conditions.[44] Our current estimates represent average values for the national-level populations of the included countries, but there are likely to be substantial heterogeneities within countries by wealth, education, and other socioeconomic variables.[29]

Conclusions

The estimates of health expectancies provided in this paper represent a substantially different approach from most other cross-national metrics of population health such as those of the Global Burden of Disease (GBD) reports.[45] Our results represent the burden of health and disability conditions as experienced by a set of individuals within each country's population. These direct measurements of healthy longevity contrasts with GBD's sequela-based estimates, which accumulate the national-level burdens of individual diseases to estimate the total disability burden of a population. Combined, our results show that there is considerable heterogeneity in regimes of healthy longevity currently being experienced by older adults in the Asia–Pacific. Our results provide much-needed evidence for examining current conditions across the region, and for understanding which populations are succeeding in supporting healthy aging, and which populations are experiencing troubling trends in later-life health and functioning.

Ethical approval and consent to participate

The HILDA, CHARLS, IFLS, KLOSA, and JSTAR studies were all reviewed by institutional review boards in their respective countries, and written informed consent was obtained from all respondents prior to data collection.

Supplementary material

Supplementary material is available at the *American Journal of Epidemiology* online.

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Conflict of interest

The authors declare no conflicts of interest.

Data availability

All data used for this study are publicly available. HILDA data are available from https://dataverse.ada.edu.au/dataverse/hilda. CHARLS data are available from https://charls.charlsdata.com/. IFLS data are available from https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS.html. JSTAR data are available from https://www.rieti.go.jp/en/projects/jstar/. KLoSA data are available from https://survey.keis.or.kr/eng/klosa/klosa01.jsp.

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