



Multidimensional comparison of countries' adaptation to societal aging

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As long-term changes in life expectancy and fertility drive the emergence of aging societies across the globe, individual countries vary widely in the development of age-relevant policies and programs. While failure to adapt to the demographic transformation carries not only important financial risks but also social risks, most efforts to gauge countries' preparedness focus on economic indicators. Using data from the Organization for Economic Cooperation and Development (OECD) and other sources, we developed a multidimensional Aging Society Index that assesses the status of older populations across five specific domains, including productivity and engagement, well-being, equity, economic and physical security, and intergenerational cohesion. For 18 OECD countries, the results demonstrate substantial diversity in countries' progress in adapting to aging. For any given domain, there are wide differences across countries, and within most countries, there is substantial variation across domains. Overall, Norway and Sweden rank first in adaptation to aging, followed by the United States, The Netherlands, and Japan. Central and eastern European countries rank at the bottom, with huge untapped potential for successful aging. The United States ranks best in productivity and engagement, in the top half for cohesion, and in the middle in well-being, but it ranks third from the bottom in equity. Only well-being and security showed significant between-domain correlation ($r = 0.59$, $P = 0.011$), strengthening the case for a multidimensional index. Examination of heterogeneity within and across domains of the index can be used to assess the need for, and effectiveness of, various programs and policies and facilitate successful adaptation to the demographic transition.

archaic and simplistic metrics, such as the old-age dependency ratio and life expectancy, to include measures that reflect the well-being of older persons. In this regard, we sought to develop an evidence-based metric to assess the status of older populations across countries and within countries across a series of economic and social domains to compare countries' success in adapting to population aging. The metric would serve both as a guide to inform policies for forging a productive and equitable aging society and as a tool to assess their effectiveness over time.

The Research Network on an Aging Society is a 14-member interdisciplinary group of geriatricians, demographers, sociologists, economists, psychologists, and policy experts working from the framework of the well-established successful aging paradigm (4). We formulated an evidence-based model of a successfully aging society. We defined the five major components for the successful aging of a society as follows:

Productivity and engagement: A successfully aging society facilitates the engagement of older persons in society, either through work for pay or volunteering (5–10).

Well-being: A successfully aging society provides health care informed by a sophisticated understanding of the health care needs of older persons (11, 12).

Equity: A successfully aging society distributes resources equitably across the older population, thus lessening the gap between the “haves” and the “have nots” (13, 14).

aging | society | international

Successful adaptation to population aging within a society is particularly relevant for achieving the goals outlined in the 2030 Agenda for Sustainable Development of poverty eradication, ensuring well-being at all ages; reducing inequalities; and making cities inclusive, safe, and sustainable (1). The Second World Assembly on Aging highlighted the need to promote the development of society for all ages on national and international levels, emphasizing that older persons should benefit equitably and be able to participate in fruits of development in advancing their health and well-being, and to ensure a supportive and enabling environment for older adults to do so (2). Failure to adapt to the demographic transition entails not only financial but social risks.

There is substantial asynchrony in the rates at which countries are aging. Japan has, by far, the highest percentage of population above the age of 65 y (3). Western Europe has also aged ahead of the United States due to sustained reductions in total fertility below replacement rate post-World War II (baby bust), while the United States saw increases in fertility rates (baby boom). Consequently, Germany, for instance, currently has an age distribution that the United States will not experience until 2030. While the transfer of policies or programs from one country to another is never simple, and, when feasible, often requires substantial modifications, this asynchrony nonetheless provides the country with the opportunity to examine the experiences of countries that have aged ahead of it.

When assessing the aging of societies and their capacity to support older populations, the time has come to move beyond

Significance

The proportion of older adults in the population is growing rapidly across the globe. This demographic transformation into “aging societies” presents very consequential economic and social risks. Countries vary substantially in the degree to which they have been aging and in their establishment of the policies, supports, and services needed to facilitate the well-being of older persons. Based on a multidimensional definition of a successfully aging society, we present an index that quantifies the degree to which nations are effectively facing the challenge of population aging. This index permits comparisons across countries and facilitates identifications of gaps within countries in adaptation as well as approaches that have been effective in closing such gaps.

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²A complete list of the Research Network on an Aging Society can be found in *SI Appendix*.

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Cohesion: A successfully aging society maintains social connect- edness and solidarity, within and between generations (15–17).

Security: A successfully aging society provides economic and physical security for older persons (18).

Using this model as a guide, and based on data from the Or- ganization of Economic Cooperation and Development (OECD) countries, we developed the Aging Society Index (Fig. 1). The index has five major domains, each corresponding to one of our five central components of a successfully aging society. The data for each domain include between two and five specific measures available for all OECD countries we studied. The Aging Society Network determined the relative weights for measures within each domain and a weight for each of the five domains within the overall index (Fig. 1). The Aging Society Index has a possible range of 0–100. We utilized three different analytical strategies (goalpost, Z-scores, and lowest domain) to rank countries within each domain and overall (Fig. 1). There was a high degree of correlation across the three analytical strategies; thus, only the results for the goalpost method are presented in detail.

The need for an index such as we describe and our summary country-specific index ratings have been presented elsewhere in a concise commentary (19).

Results

Overall Performance in the Aging Society Index. Scores across countries ranged from 65 for Norway, the highest, to 23 for Hungary, the lowest (Fig. 2). Two Nordic countries, Norway and Sweden, had the highest index, and this finding was robust to whether network weights or equal weights were utilized and across all three analytical strategies. The United States ranked third across all countries, whereas Japan was fifth in rank. In contrast, the majority of the central and eastern European countries had the lowest indices and were at the bottom of the rankings.

The numerical value of the Aging Society Index shows that even the top-performing countries have room for further im- provements. For example, the front-runners, Norway and Swe- den, have untapped potential, as their scores fall short by 35–38%

of the highest score seen among the countries studied (score of 100). The countries on the other end of the spectrum (Estonia, Poland, and Hungary) have a much larger gap (more than 70%), and thus greater policy opportunities. Of course, it should be emphasized that even a country with a score of 100 on a given domain might have considerable room for improvement as this score merely ranks that country among others' actual performance rather than a hypothetical "ideal" standard.

Multidimensional Nature of the Aging Society Index. Fig. 3 illus- trates the multidimensional nature of a successfully aging society. Only well-being and security showed statistically significant correlation [Spearman correlation (r_s) = 0.59; P = 0.011]; security had low correlation with the other three domains ($|r_s|$ < 0.18). Countries with very low cohesion also tend to perform poorly in productivity and engagement and well-being. Cohesion had positive correlation with productivity and engagement and well-being (r_s = 0.34 and r_s = 0.30, respectively). Equity had low correlation with all domains ($|r_s|$ < 0.17). While productivity and engagement and well-being had the second highest correlation (r_s = 0.44), it was not statistically significant. These results strengthened the case for a multidimensional index.

Countries' Performance in the Domains of the Aging Society Index.

While the composite index summarizes countries' adaptation to societal aging, there was substantial variation in country per- formance within each domain across the 18 countries we studied. Variation is greatest in the cohesion domain and least in equity (Fig. 4). For any given country, there is also substantial variation across the specific domains, which highlights areas for improve- ment. For instance, while the United States and The Netherlands both scored 60 in the composite index, they varied in their per- formance across individual domains. The United States scores high on productivity and engagement and cohesion, average on well-being, and low on equity and security. Having the highest productivity and engagement domain score of 83 reflects that older Americans retire later and volunteer more than people in many European countries. On the other hand, The Netherlands

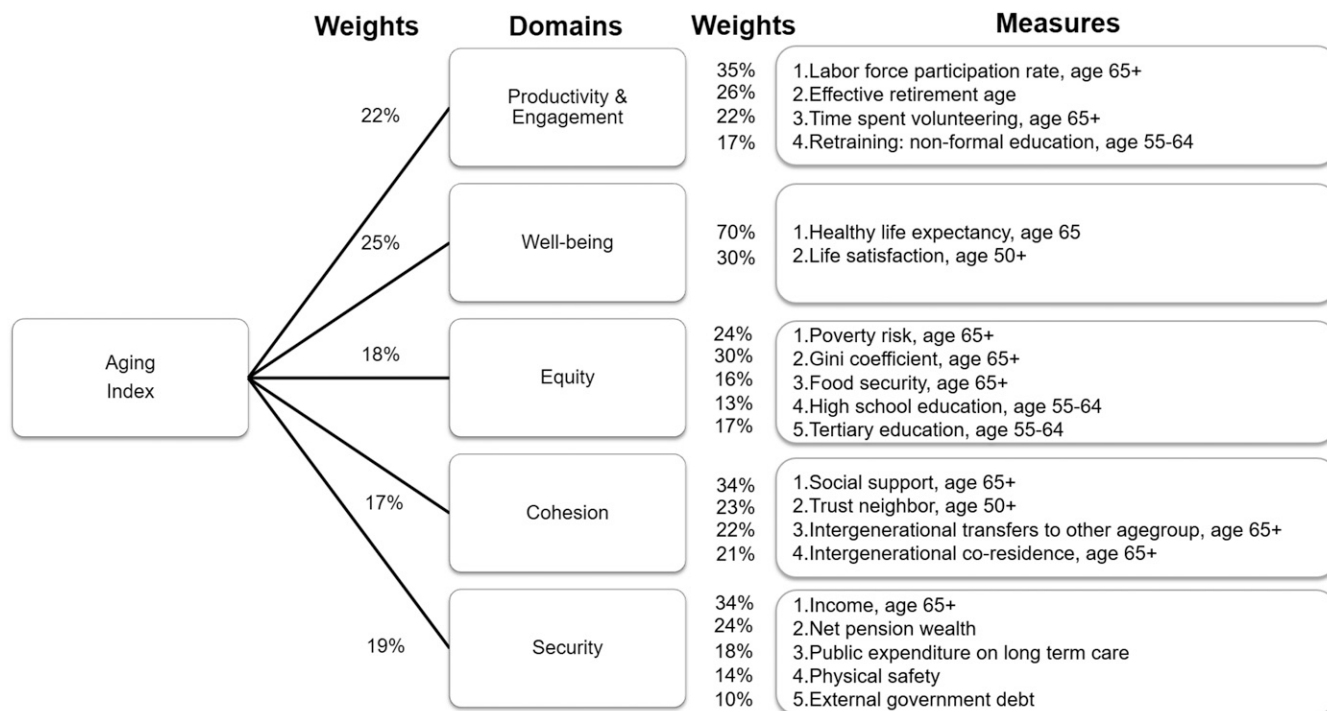


Fig. 1. Measures in the Aging Society Index.

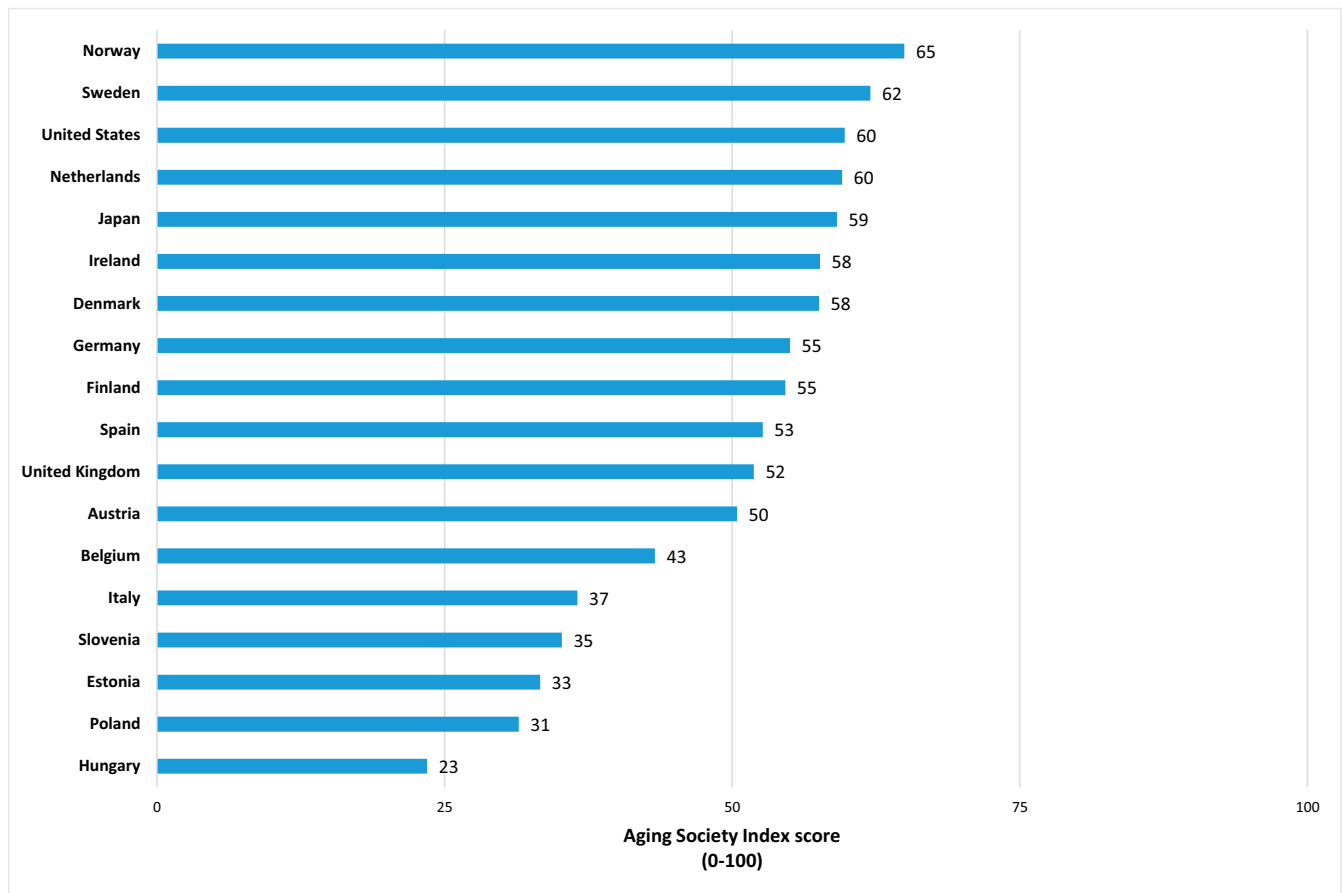


Fig. 2. Overall country scores in the Aging Society Index.

scores high on equity, security, and well-being but low on productivity and engagement and cohesion.

Japan is the highest ranked in well-being and is the world leader in healthy life expectancy, with men and women expected to live another 16.7 y of relatively good health, on average, at the age of 65 y. In comparison, the United States ranks ninth in well-being.

The United States ranks 16th out of 18 countries in the equity domain, and this finding is consistent with current research on gaps in health that are related to large socioeconomic differences across individuals in the United States. The Nordic countries rank the highest in the equity domain.

Social cohesion, neighborhood support, and financial transfers and housing support between generations of family members are resources that may act as a buffer against adverse shocks. The United States ranks fourth among all countries in the cohesion domain. Ireland, the United Kingdom, Finland, and Spain also rank in the top five of all countries.

The United States (ranked 12th) is in the bottom half of all countries in the security domain, with Spain, The Netherlands, and Italy at the top. Income, pension wealth, public expenditure on long-term care, government debt, and physical safety were measured. In Western Europe, people aged 65 y and older are physically and financially more secure than in the United States.

Fig. 5 illustrates the results of the five domains for six countries to facilitate policy comparisons. In addition to the United States, these countries include Japan, which has the longest life expectancy; Germany, which has a demographic profile toward which the United States is heading; the United Kingdom, an often-cited comparator for the United States for various policies; and Spain and Sweden, which have similar traditional European safety nets and different labor policies and economies than the United States. The degree of symmetry or internal consistency for these six major

countries across all domains is depicted, and may be seen to reflect the broadness of a given country's strategy to respond to societal aging. Points further away from the center indicate better performance for that particular domain. The United States was the most "balanced," resembling a pentagon, whereas other countries, especially Spain, displayed much less symmetrical patterns.

Robustness Check. *SI Appendix, Fig. S2* illustrates the robustness of our index using different methods, such as the widely used goalpost method, the standardized Z-score, and the lowest domain. These comparisons resulted in high correlation. The correlation with the lowest domain was the poorest [Pearson correlation (r_p) ≥ 0.91] as the lowest domain had limited information compared with the other methods that pooled the aging index across all domains ($r_p \geq 0.97$).

SI Appendix, Fig. S2 and Table S3 compare countries' rankings across weighting schemes and methods for assessing progress. The rankings were highly correlated ($r_p \geq 0.86$), with Norway always coming on top and Hungary always last. Using the network weights, both the goalpost and Z-score methods ranked Norway, Sweden, the United States, The Netherlands, and Japan as the top five countries. When equal weights were used, these countries remained at the top except for Japan, which was replaced by Denmark.

Discussion

Long-term changes in life expectancy and fertility have converted many countries into aging societies. Failure to adapt to population aging may constrain productivity, well-being, financial security, and equity, and may increase tensions between generations as they compete for limited resources. In comparison to other countries, the United States has adapted in some domains but less so in others.

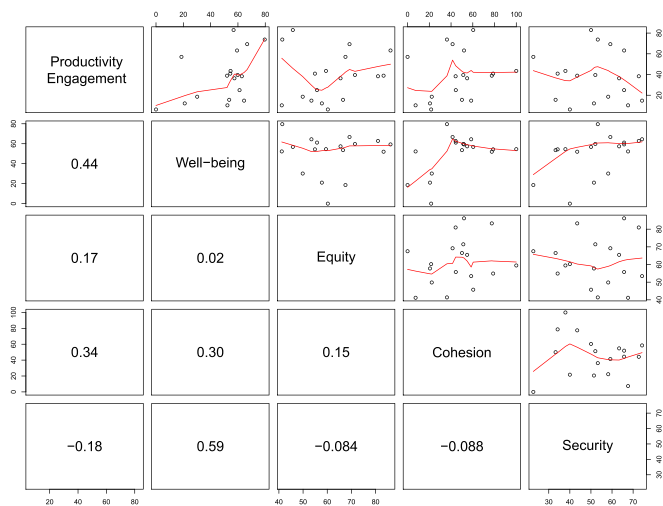


Fig. 3. Scatterplots and correlations of domain scores in the Aging Society Index. The data plotted in the boxes showing the red lines are scatter plots of countries' respective domain scores. The numbers shown in the boxes are the Spearman correlation coefficients. The red line represents locally weighted scatterplot smoothing. The first column contains the r_s of productivity with the four domains ($r = 0.44$ with well-being, $r = 0.17$ with equity, $r = 0.34$ with cohesion, and $r = -0.18$ with security). The first row illustrates the respective scatterplots of productivity with (i) well-being, (ii) equity, (iii) cohesion, and (iv) security. Among all the correlations, only well-being and security were statistically significant ($r = 0.59$, $P = 0.011$). Productivity and well-being were borderline significant ($r = 0.44$, $P = 0.067$).

The high performance of the United States in productivity and engagement reflects the highest labor force participation rates at older ages, high effective retirement age, and high rates of volunteerism. These findings are likely driven by low unemployment rates and the adoption of flexibility in work hours and pension eligibility rules to reduce constraints to continued employment (20). Thirty-nine percent of employers in the United States offer

flexible schedules, and 77% of employers in the United States say that many employees plan to continue working on either a full-time or part-time basis after retirement age (21). In contrast, in Europe, 78% of people aged 55 y and above stop working altogether, citing the lack of opportunities for gradual retirement by reducing work hours (22).

There has been substantial recent attention directed to the growing inequality in the distribution of income and wealth in the United States and other developed countries. The benefits of economic growth have increasingly gone to a smaller segment of the population, raising a new level of concern for diminishing equality of opportunity (23). The severity of the issue in the United States is reflected in its poor performance in equity, driven by the very high US Gini coefficient for individuals over 65 y of age. Between 1975 and 2012, about 47% of the total growth in pretax income in the United States went to the top 1% (24). Some argue that this misdistribution is not a major concern as long as those with the lowest incomes have access to sufficient resources. Unfortunately, this is not the case in the United States, where the risk of poverty in old age was 21% in 2011, well above the OECD average of 12.5% (25).

The findings demonstrate an interesting discordance between our two measures of well-being: active life expectancy (weighted 70%) and life satisfaction (weighted 30%). In general, the increase in active life expectancy over the past decades across OECD countries (26) has not been matched by satisfaction with the quality of life across all countries. For instance, Japan, which has the longest active life expectancy at the age of 65 (16.7) y (27), has poor life satisfaction, with a score of 5.9 out of 10 (28). In comparison, the United States has a lower active life expectancy at the age of 65 (14.2) y than Japan but reports better life satisfaction, with a score of 6.9 (28). Potential contributors to these differences include a positive association between avoidance of depressive moods and high levels of life satisfaction among the elderly (29), as well as a suicide rate in Japan that was 47% higher than in the United States (19.1 vs. 13.0 per 100,000 persons in 2012, respectively) (30). There may also be cultural differences in life satisfaction. Uchida et al. (31) argue that life satisfaction for East Asians tends to be strongly premised on social fulfillment in the form of healthy relationships, social acceptance,

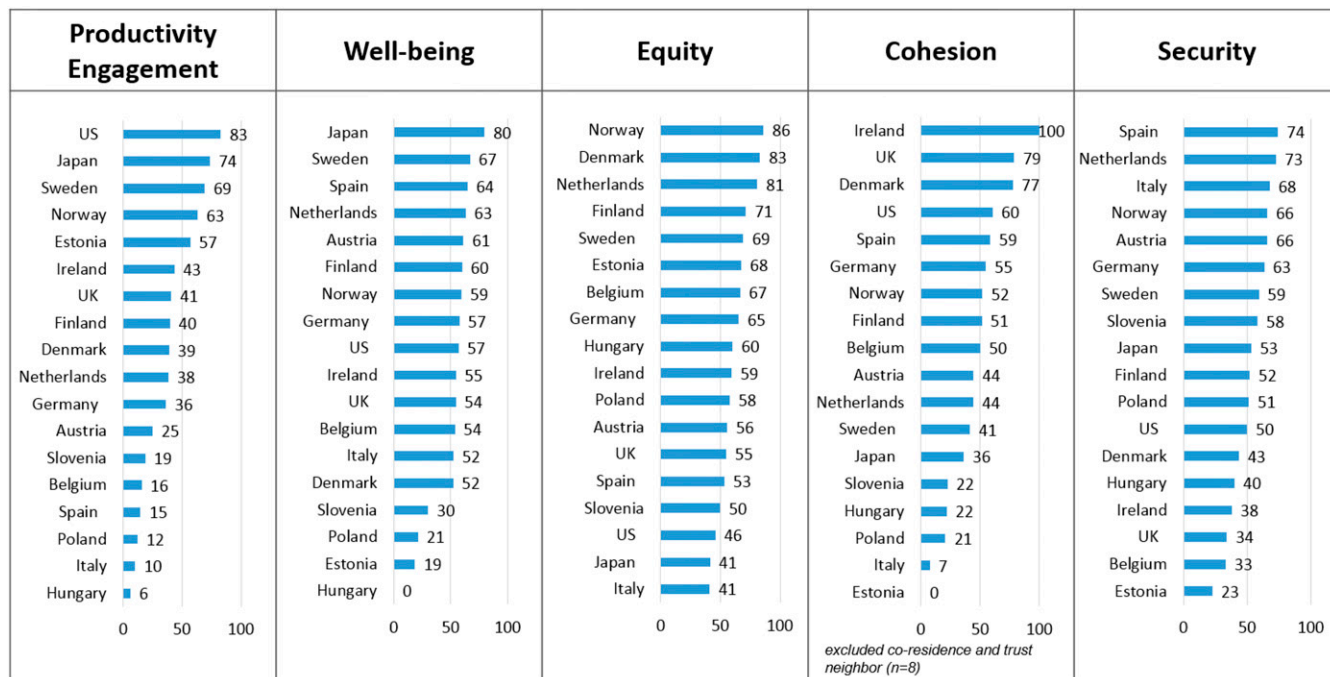


Fig. 4. Country ranking by domain scores in the Aging Society Index.

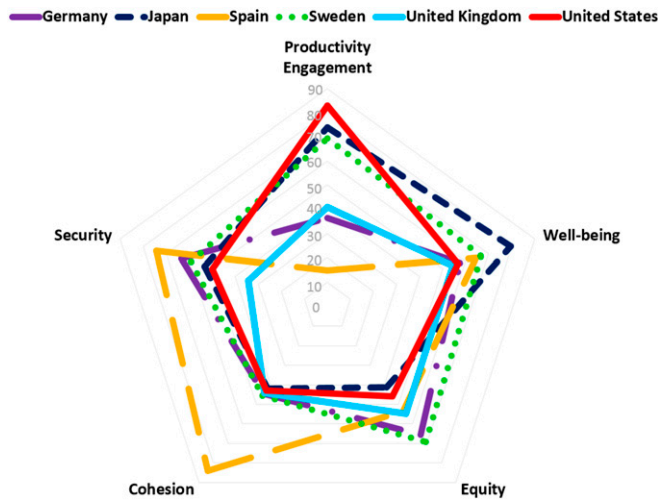


Fig. 5. Domain scores of six countries in the Aging Society Index. Countries with points located further away from the center perform better in the domain.

and approval from loved ones, on top of self-satisfaction. This contrasts with Anglo-Americans and Europeans, whose life satisfaction appear to be derived more strongly from the self (32, 33).

Old age is often depicted as a time of loneliness (34). Social activities are often cited as one of the key components for maintaining elders' mental and physical well-being and of successful aging more generally (4). Social support is one key measure of cohesion, and across the 18 OECD countries, on average, 89% of people aged 50 y and above reported having a friend or relative on whom they can count for help in case of need. The United States is among the highest, with 91.5% reporting having someone on whom they can count. This is consistent with findings from the National Social Life, Health, and Aging Project, a US population-based study, demonstrating that older Americans are well connected, contrary to the popular notion of social isolation in later life (35). In contrast, a survey conducted in Japan found that the prevalence of social isolation was 31.0% for elderly living alone and 24.1% for elderly living with family (36), with growing numbers of Japanese dying alone (37).

Unpacking our domain of security into its economic security and physical safety elements, we see that the United States ranks poorly with respect to net pension replacement rates for average earners (44.8%) compared with many OECD countries, such as Spain, which is at 89.5% (38). One of the major factors driving down the US ranking in economic security of older persons is the relatively low public expenditure on long-term care. This is related to some state-specific restrictions in Medicaid eligibility rules and Medicare's lack of long-term care coverage. This low level of public expenditures is further aggravated by the underdeveloped long-term care insurance market, thus leading to an emphasis on private pay and informal caregiving, particularly for the middle of the wealth distribution in the United States. Indeed, about 55% of all long-term care services are provided by informal caregivers [Congressional Budget Office, 2013 (39)].

The index has its limitations. Although aging experiences differ by gender, the current version did not account for gender variation due to the lack of data on many measures. While different weighting schemes seem to change the ranking of some countries, the results of the best- and worst-performing countries appear to be fairly robust. In addition, the aging experience differs with age. As most of our measures capture the age of 65 y and over, we were unable to consider retirement transition years due to the lack of comparable data for the ages of 50–65 y and the oldest old of 85 y and over. Nevertheless, the high correlation of available measures between the young and old suggests that our results might be fairly robust (SI Appendix, Fig. S4). Despite its limitations, the Aging Society Index complements and advances

prior efforts. The Global Agewatch Index is more limited in scope; for example, it does not include measures of inequality in developed countries (40). The European Active Aging Index, a cross-national comparison (SI Appendix, Fig. S5), is not available for the United States and is heavily weighted toward employment measures (41).

The Aging Society Index provides a useful metric to assess a country's progress in adapting to demographic transition and how it might remain cohesive, productive, secure, and equitable as its elderly population increases. While the results do not identify specific policies to pursue, strategies employed by the more successful countries may serve as a guide (19). For example, investments that make people healthier and more productive can yield especially high dividends. In the United States, for example, lifetime returns on early investment can reach 13% per year and affect health and economic well-being throughout life (42).

In addition, formal education in most countries often ends by the age of 24 y. With people living and working longer, investment in skill development and work-based educational and training programs can extend productive lives. Broader engagement of older people into society, both in the workforce and through volunteering, can also be financial. These provide economic benefits directly through labor force participation, but also indirectly by improving health and cognitive function, and facilitate societal cohesion through a shared sense of purpose (6).

Finally, it is important that countries provide an adequate safety net. In the United States, major social programs have become less progressive over time, leaving many elderly at risk (43). There is an urgent need for improved planning for long-term care services and support to buffer against financial risks associated with chronic disability and dementia (44). We have argued elsewhere (19) that a new national commission on demographic change and entitlements should make recommendations on how major federal programs could be reengineered, at no additional government cost, to adapt to new demographic realities.

Materials and Methods

The data we use are mainly from OECD itself and the WHO. Of 35 OECD countries, 18 are included in our study as the others had missing data on several measures. In addition, we have a particular interest in the comparison between a subset of countries that have well-developed policies regarding aging (Sweden, the United Kingdom, and The Netherlands), have a population age distribution that resembles the United States in 2030 (Germany), are notable for a very long average life expectancy (Japan), or have notably strong social supports (Spain and Sweden).

Goalpost Method. The specific measures within the domains were chosen by the network members from the various measures for which data are available from all, or a meaningful subset, of the OECD countries. The methodology to construct the Aging Society Index using the goalpost method can be divided into four steps.

First, we convert all measures as positive indicators, where higher values indicate better outcomes in the aging society. For example, "poverty risk in the elderly" was expressed as "the proportion not at risk of poverty."

Second, all individual positive measures are standardized, with a score of 0 for the worst-performing country in the dataset available and a score of 100 for the best-performing country. This is done by assigning a score of 0 to the minimum observed value across countries and a score of 100 to the maximum observed value. Having defined the maximum (max) and minimum (min) values for each positive measure, a specific country's score can be calculated as follows:

$$\text{Goalpost} = \frac{\text{actual} - \text{min}}{\text{max} - \text{min}} * 100.$$

In another example, OECD data indicate that incomes of older people are, on average, lower than the total population. The lowest OECD country was Estonia, where those over 65 y of age had an income that was 68.9% of the income of the total population (given a score of 0). The highest income was in Spain, where the elderly had an income that was 95.9% of the income of the total population and a score of 100 was given. People over 65 y of age in the United States had an income that was 92.1% of the income of the total population, and the United States was given a score of 85.9 for this measure. It is important to note that maximum scores within each measure and domain are achievable, as the best-performing country was used as a benchmark rather than some theoretical value.

Third, we calculate the domain scores as a weighted summation of the measures in each domain (using the goalpost method). The weights within each domain sum to 100%. This result in five domain scores, namely, productivity and engagement, equity, well-being, cohesion, and security.

Finally, the overall composite aging index is calculated as the weighted summation of the five specific domain scores (further details of the goalpost method can be found in *SI Appendix, section 2*).

Z-Score Method. We compared the results from the above goalpost method with those from the Z-score method (details of the Z-score method can be found in *SI Appendix, section 3*). This method was used to allow standardization of indicators with different types and scales. It provided a convenient way to normalize results by anchoring them around the mean. However, comparisons over time will be more difficult.

Lowest Domain Method. We also compared the results using the minimum domain score from goalpost method as our index. This weighting scheme will rank high only for countries that have no weakness in their domain scores. This weighting produces a ranking wherein a low score in one domain cannot be offset by higher scores in other domains (details of the lowest domain can be found in *SI Appendix, section 4*).

Weights. There were a number of important considerations regarding weighting of the specific measures within a domain and across domains for the final index. We employed three weighting strategies. The first was to weight all measures within a domain equally, with all weights summing to

100%. Thus, if a specific domain had four measures, each would have a weight of 25%. The second was to attribute weights to the measures based on the recommendations of the 14 network members. Each network member was asked to provide individual weights for each measure, and average weights were calculated. The same approach was taken for weighting the five domains included in the final index (Fig. 1). The final method was to set the aging index as the minimum over the five domain scores. This weighting scheme will rank high only for countries with no weaknesses in their domain scores. The motivation for this weighting scheme is that while high scores in all five domains imply high quality of life for the elderly, the low score cannot be offset by higher domains. We also acknowledged the value of flexibility in weighting and have established an open-access website that will allow individuals to recalculate the index based on their desired weights (45). Nevertheless, the Aging Society Index yields consistent results ($r > 0.91$) using different methods and weighting strategies (*SI Appendix, Fig. S2*).

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