POPULATION NETWORK NEWSLETTER

POPNET Asia

Wolfgang Lutz, Editor

No. 37, Autumn 2005

IIASA is undergoing a significant change in its composition in terms of National Member Organizations (NMOs). While IIASA was originally sponsored by national academies of sciences (or similar bodies) of industrialized countries only, its membership is now expanding to developing countries. China and Egypt have already joined, and it is hoped that India, South Africa, and Brazil will do so very soon.

The full membership of the world's two population giants, China and India, will give IIASA's World Population (POP) Program a broader base for its work on Asian population trends. Work in this area has already been developed through POP's participation in the establishment and conduct of the Asian MetaCentre for Population and Sustainable Development Research, with its headquarters at the National University of Singapore and its teaching activities at the College of Population Studies of Chulalongkorn University in Bangkok, Thailand.

In June of this year, IIASA's Governing Council also approved the research agenda for 2006–2010. For POP, this includes a continuation of its methodological work on population forecasting as well as in the field of population–environment analysis, complemented by a new focus on human capital through the study of population dynamics by age, sex, and level of education. This new agenda provides POP with a solid intellectual and financial basis for continued innovative work over the coming years. *WL*

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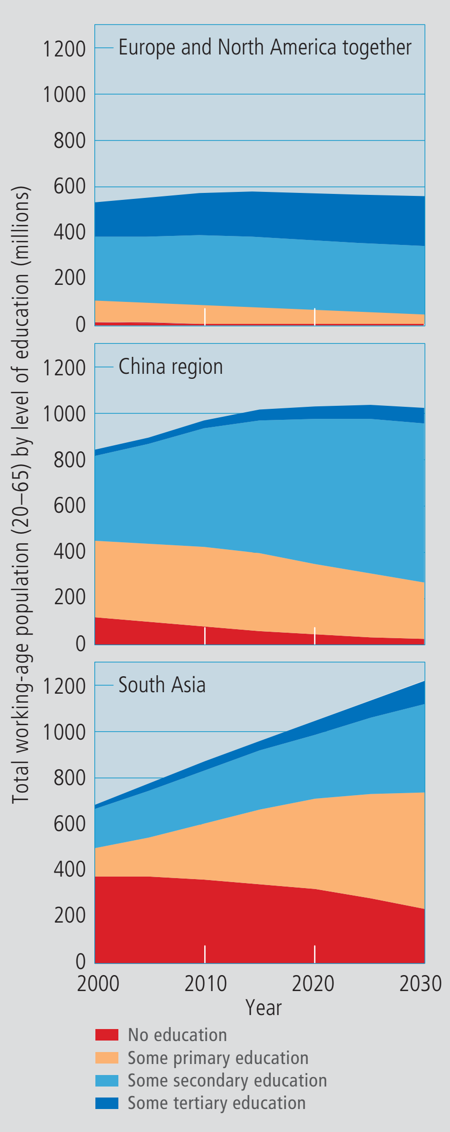
IIASA's Asian Base Broadens

The "Asian Century" Will Be Based on Human Capital

Human Capital = Population × Health × Education

Asia today is home to about four billion people—more than 60 percent of the total world population—yet its influence in world affairs remains disproportionately small. The reason for this imbalance is that, while influence on the world stage is partly a function of population size, it also depends on economic and other dimensions. However, Asia is rapidly catching up in these other dimensions, most importantly in the field of education. While the stunning economic growth of China and India is widely recognized, the extraordinary expansion of human capital in Asia, probably the single most important factor behind this economic "miracle," has received much less attention.



The analysis of global trends in human capital will be the main research focus of IIASA's World Population Program over the coming five years. We define human capital as encompassing the population (by age and sex) together with its health status and distribution of skills (educational attainment by age and sex). This broader view of how changes in the structure of populations matter is very well suited for the application of demographic methods, in particular the tools of multi-state population analysis that were developed at IIASA during the 1970s. This offers a great opportunity to apply powerful quantitative analytical instruments to what economists often call the "quality dimension," which is so important in addition to the sheer numbers.

The graphs to the left present forecasts of the working-age population by level of educational attainment for three mega-regions: China (together with other centrally planned countries in Asia); South Asia; and Europe and North America. Although this last region has a smaller labor force than either of the other two regions, its labor force is still much better educated, which is presumably a key reason why Europe and North America still dominate the world in many respects. However, the figure also shows that the power balance is likely to change. China and India have a tremendous increase in human capital pre-programmed in their current age structure by level of education that will undoubtedly serve as the basis for an "Asian century." The graphs also show interesting differences between the two regions within Asia, with much broader segments of China's population having a basic education and South Asia surpassing China in terms of sheer numbers. ■

IIASA and Chulalongkorn University (Bangkok) Launch a New Research Initiative on

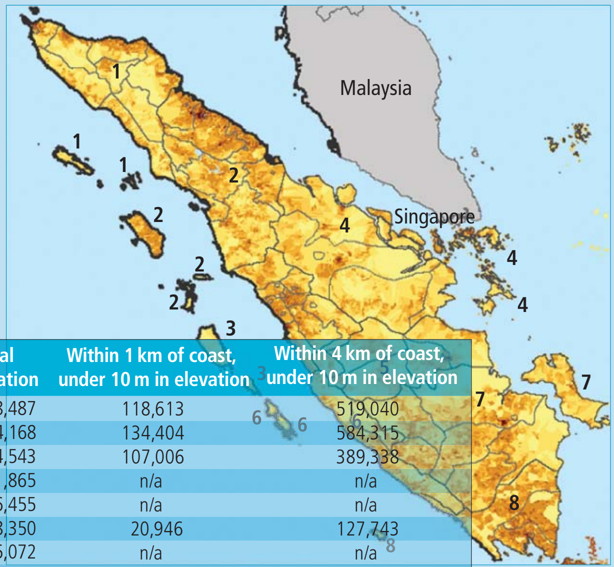
Population–Environment Interactions in Coastal Areas of Asia after the Tsunami

Coastal areas are the hot spots of interactions between human populations and the natural environment, with great risks and impacts on both sides. The recent hurricane disaster along the Gulf Coast of the United States and the Asian tsunami on 26 December 2004 are just two prominent examples of how vulnerable human populations in coastal areas can be. But there are also many less spectacular examples of how human impacts on coastal environments can destroy complete ecosystems and thus undermine the protective functions of those ecosystems, in turn increasing human vulnerability. The prospect of global climate change only heightens the mutual vulnerabilities of humans and ecosystems in coastal areas.

Research on these population–environment interdependencies is not a new development. Among several research efforts, the Asian MetaCentre on Population and Sustainable Development Analysis has worked to facilitate research in this field through its hosting of international scientific seminars, supporting the formulation of specific research projects or the production of publications. Two prominent outcomes of research in this area in which the MetaCentre was involved are the special issue of *Population and Development Review* on "Population and Environment: Methods of Analysis" (Lutz *et al*., 2002) and the special issue of the environmental journal *Ambio* on "Interactions between Coastal and Marine Ecosystems and Human Population Systems" (Curran *et al*., 2002).

When the tsunami hit the Asian coasts on 26 December, causing a huge loss of life and livelihoods, but also triggering an unprecedented wave of international solidarity and support, it was only natural that the extensive research network established in the context of the MetaCentre would turn its attention to studying the vulnerabilities

A short-term rise in the sea level will hopefully help to trigger a long-term rise in our level of understanding of population–environment interactions in coastal areas. (*Photo*: W. Lutz, 26 Jan 2005)



Population of Sumatra by province, 2005 (estimated)

#	Province	Total population	Within 1 km of coast, under 10 m in elevation	Within 4 km of coast, under 10 m in elevation
1	Aceh	4,228,487	118,613	519,040
2	Sumatera Utara	12,444,168	134,404	584,315
3	Sumatera Barat	4,384,543	107,006	389,338
4	Riau	6,161,865	n/a	n/a
5	Jambi	2,646,455	n/a	n/a
6	Bengkulu	1,818,350	20,946	127,743
7	Sumatera Selatan	7,775,072	n/a	n/a
8	Lampung	7,147,519	4,333	6,094
	Sumatra total	**46,606,459**	**385,302**	**1,626,529**

CIESIN was able to produce the first estimates of potential victims by combining information on populations by distance from coast and elevation. (*Source*: Phuket seminar presentation by Yuri Gorokhovich)

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IIASA is an international, interdisciplinary research institution that draws on the scientific and financial resources of member organizations to address problems of global significance.

IIASA National Member Organizations
Austria, China, Czech Republic, Egypt, Estonia, Finland, Germany, Hungary, Japan, Netherlands, Norway, Poland, Russian Federation, Sweden, Ukraine, United States of America

that were so dramatically highlighted by the natural disaster. In April, IIASA Director Leen Hordijk and Professor Khunying Suchada Kiranandana, president of Chulalongkorn University, signed a formal agreement of collaboration that also foresees the establishment of a joint Memorial Research Station on Population–Environment Interactions in the area of Phuket, Thailand, should sufficient funds become available. Fundraising is currently under way, with a special emphasis on helping international donor agencies in the production of science-based guidelines for sustainable reconstruction.

To better define the research agenda for this ambitious new enterprise, a scientific seminar was held in Phuket from 9 to 11 May 2005 that brought together some of the world's leading scientists in this field as well as experts from the areas of Southeast Asia most affected by the tsunami disaster. The tables and graphs on these pages mostly stem from presentations made at this meeting, entitled "Defining a Research Agenda for Population–Environment Interactions in Coastal Areas of Asia after the Tsunami" (see seminar agenda on this page).

For more information on the MetaCentre's work in this area, see the Asian MetaCentre update on page 4 of this issue and visit the MetaCentre's Web site: www.populationasia.org.

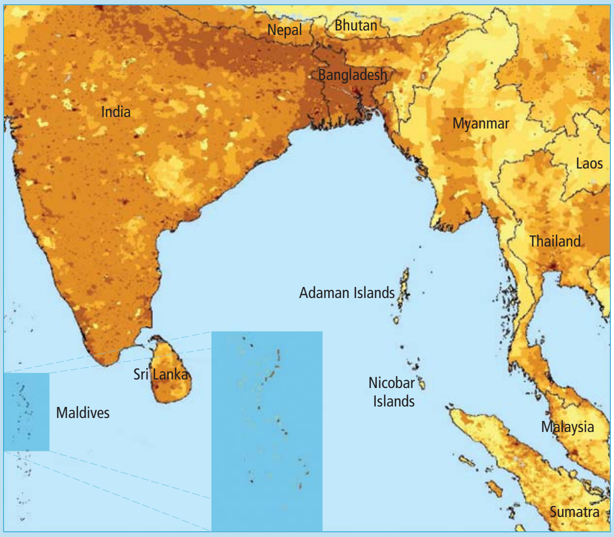
References

- Curran S, T Agardy, MCJ Cruz, P Dasgupta, A Kumar, W Lutz, M Williams, E Kessler, and M Adams (eds), 2002. "Population, Consumption, Environment." *Ambio*, 31(4) (Special Issue).
- Lutz W, A Prskawetz, and WC Sanderson (eds), 2002. *Population and Environment. Methods of Analysis*. Supplement to *Population and Development Review*, 28(2002). The Population Council, New York, NY, USA.

Proportion (in percent) of population within given area

Country	50 km of the coast	50 km of mangroves	50 km of coral reefs
India	16.2	6.3	5.2
Sri Lanka	70.2	88.9	46.3
Myanmar	35.2	7.8	11.7
Thailand	34.4	30.5	11.1
Malaysia	85.9	84.0	21.4
Indonesia	80.5	49.2	47.6

Source: CIESIN (Phuket seminar presentation by Jackie Alders)



Population density in Asia Asia, particularly South and Southeast Asia, is the most densely populated area of the world. The coastal zones in Asia are highly urbanized and have disproportionately high population densities—450 persons/km^2 versus 175 persons/km^2 globally. (*Source*: CIESIN, GRUMP v1 (alpha); available at http://beta.sedac.ciesin.columbia.edu/gpw)

Participants of the Phuket seminar, 9–11 May 2005.

Seminar Agenda

International Scientific Seminar on Defining a Research Agenda for Population–Environment Interactions in Coastal Areas of Asia after the Tsunami

Held 9–11 May 2005 in Phuket, Thailand

Monday 9 May

Morning session (Moderator: Nibhon Debavalya)

Opening discussion
- Khunying Suchada Kiranandana, President, Chulalongkorn University
- Wolfgang Lutz, IIASA
- Vipan Prachuabmoh, Asian MetaCentre for Population and Sustainable Development Analysis

Addressing Population–Environment Interactions in Coastal Areas
- Jackie Alders: Coastal Ecosystems and Human Impacts
- Mahendra Shah: The Perspective of the "Global Science Panel on Population and Environment" on Vulnerability
- Wolfgang Lutz: How to Scientifically Address and Model the Complex Population–Environment Interactions

Afternoon session (Moderator: Nibhon Debavalya)

Restoration Efforts and Programs in the Tsunami-Affected Areas

Information / Data Needed for Effective Action Programs
- Bhassorn Limanonda (Thailand)
- Supichai Tangjaitrong (Thailand)
- Sarawoot Chayovan (Thailand)
- Riwanto Tirtosudarmo (Indonesia)
- Jin Sato (Japan)

Tuesday 10 May

Morning session (Moderator: Sergei Scherbov)
- Warren Sanderson: The Series of IIASA PDE Case Studies
- Molly Hellmuth: Illustrations of Dynamic PDE Models
- Yuri Gorokhovich: CIESIN's Work on Population and Environment
- Supaporn Khrutmuang & Tundi Agardy: Results of the PCE (Population–Consumption–Environment) Initiative: Case Studies in Asian Coastal Areas

Afternoon session (Moderator: Jerrold Huguet)
- Roger-Mark de Souza: PRB's Population–Health–Environment Program
- Silvia Stuppaeck: Research Directions on Sustainable Tourism
- Simron Jit Singh: Nicobar Islands
- Hemantha Wickmatillake: Sri Lanka

Wednesday 11 May

All-day session (Moderator: Wolfgang Lutz)

Structured Discussion on the Design of Comprehensive Studies on Aceh, Phang Nga-Phuket-Krabi, Sri Lanka, Nicobar Islands

Research Partnership in Asia

Update from the Asian MetaCentre

Now in its sixth year, the Asian MetaCentre continues to address the important issues facing Asia and the world today. The MetaCentre's ongoing research projects include studies of the population–environment interactions in Asia's coastal regions, population changes and land degradation in China, changing family structures in the Asian context, and the intersection of demographic and health issues in China, India, Singapore, and Thailand. To improve the synergy between existing population studies centers throughout the region, the Asian MetaCentre brings together researchers from across Asia and around the world, organizes relevant workshops, provides training for skills development, engages in research projects, and subsequently publishes research findings.

Returning Staff

In August 2005, the Asian MetaCentre welcomed back Dr Evi Nurvidya Arifin. Dr Arifin has worked on various topics encompassing population-related issues and applied statistics, such as family, fertility and family planning, health, population projection, migration, and aging. More recently, she has applied her statistical and demographic expertise to studying ethnicity and religion in Indonesia, relating social and economic variables to political variables in the Indonesian electoral behavior, and examining democracy in the emerging democracy in Indonesia. Armed with this broad social, economic, and political perspective, she will now focus on the changing family and labor market in Indonesia.

Recent Activities

Among the activities organized by the MetaCentre this past year was a training workshop on "Interactions of Population Dynamics and Environmental Changes: Research on the Health Consequences," held from 5 to 9 September 2005 in Bangkok, Thailand. The workshop examined the health impacts of population and environmental changes, as well as appropriate methodologies for research on this theme. The main goal of the workshop was for participants working in teams to develop research proposals specific to the theme of the health consequences of population change in Asia. Like the MetaCentre's other training workshops, an overarching aim was to facilitate interaction among scientists working on population, health, and sustainable development by bringing together researchers from population studies centers across Asia, thus fostering international collaboration and skills transfer. ■

Recent Publications

Asia Pacific Viewpoint 46(1) (April 2005). Special Issue on "Meeting the Challenges of HIV/AIDS in Southeast and East Asia." Guest editors: Nicola Piper, Brenda SA Yeoh

Of the 38 million people living with HIV/AIDS globally today, the Asia-Pacific region is home to about 7.4 million—a figure sharply up from previous years. In absolute numbers, infections in Asia are projected to exceed African figures within a decade. This has largely to do with economic changes toward market-based capitalism, widening socioeconomic disparities, and increased levels of mobility (internal and cross-border), as for instance in China and Indonesia. Overall, the epidemic in Asia has been described as more complex than in Africa, involving a multiplicity of transmission modes. The case studies presented in this special issue discuss the connections between issues of mobility, gender, (trans)nationalism, and sexuality in understanding the HIV/AIDS challenge in the region. The various ways of meeting the challenges of HIV/AIDS in Southeast and East Asia are analyzed, whereby non-governmental and community-based responses often emerge as more effective than state interventions. The papers in this special issue are drawn from selected papers presented at a special panel on HIV/AIDS in Asia convened at the International Convention of Asia Scholars (ICAS) in Singapore in August 2003, and a workshop on migration and health in Asia held in Bintan, Indonesia, in September 2003, both organized by the Asian MetaCentre, headquartered at the National University of Singapore.

Migration and Health in Asia (August 2005). Routledge, London, UK. Editors: Santosh Jatrana, Mika Toyota, Brenda SA Yeoh

This important and timely collection is the first single-volume examination of the relationship between "migration" and "health" in an Asian context. Using both quantitative and qualitative approaches, the book seeks to investigate interdisciplinary issues of health and health-related behaviors in the field of migration. The volume is based on several papers first presented at an Asian MetaCentre workshop entitled "Migration and Health in Asia" held at Bintan, Indonesia, in September 2003.

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International Workshop on

Sexuality and Migration in Asia
10–11 April 2006, Singapore

Co-organized with Royal Holloway, University of London, the workshop will address the gap in the current literature on the various forms of sexual intimacy that occur as a result of migration, and that also shape and reshape migration processes, with empirical reference to the Asian context. It will be directed toward understanding the entanglement of sexuality with gender, class, ethnic, and national identities, from a comparative perspective. For more information, see www.populationasia.org/Events.htm.

Forthcoming Events

International Conference on "Female Deficit in Asia: Trends and Perspectives" 5–7 December 2005, Singapore. Co-organized by CEPED, CICRED, and INED, France, and hosted by the Asian MetaCentre for Population and Sustainable Development Analysis

Amid rapid fertility decline and economic growth, several Asian countries have witnessed an exacerbation of discrimination against women from conception to adulthood, leading to a female deficit in regions of Asia and a gradual masculinization of the population. Recent statistics, however, suggest a restoration of sex structure to a normal level in the near future in some countries. The conference will offer the opportunity to discuss policy and methodological issues directly related to this new phenomenon and examine future implications of male-dominated populations.

This conference is co-organized by CEPED, CICRED, and INED in France to promote South–South and North–South exchange, with support from the Asian MetaCentre. For more information on the conference and scientific program, please visit the MetaCentre's Web site at www.populationasia.org/Events.htm.

Conference-related correspondence should be addressed to: seminar1205@cicred.org.

Training Workshop on "Safe Motherhood and Abortion" 5–18 January 2006, Bangkok, Thailand

This workshop will focus on the influence of spontaneous and induced abortions on healthy pregnancies and safe childbearing, outcomes embodied in the construct of safe motherhood. A multi-disciplinary perspective and varied research approaches will be applied. For more information, please visit the MetaCentre's Web site at www.populationasia.org/Events.htm.

Reprint from *Nature**

Vol 435|9 June 2005|**doi:10.1038/nature03593** nature

LETTERS

Average remaining lifetimes can increase as human populations age

Warren C. Sanderson[1,2] & Sergei Scherbov[2,3]

Increases in median ages, the most commonly used measure of population ageing[1,2], are rapid in today's wealthier countries[2,3], and population ageing is widely considered to be a significant challenge to the well-being of citizens there[4]. Conventional measures of age count years since birth; however, as lives lengthen, we need to think of age also in terms of years left until death or in proportion to the expanding lifespan. Here we propose a new measure of ageing: the median age of the population standardized for expected remaining years of life. We show, using historical data and forecasts for Germany, Japan and the United States, that although these populations will be growing older, as measured by their median ages, they will probably experience periods in which they grow younger, as measured by their standardized median ages. Furthermore, we provide forecasts for these countries of the old-age dependency ratio rescaled for increases in life expectancy at birth[5]. These ratios are forecasted to change much less than their unscaled counterparts, and also exhibit periods when the population is effectively growing younger.

Population ageing differs from the ageing of an individual. People who survive grow older with each year they live. Populations, on the other hand, can grow younger. Because a wide variety of matters such as the cost of medical care[6–8], retirement[9], bequests[10], consumption[11] and the accumulation of human[12] and tangible[13,14] capital depend not only on age but also on time left to live, our understanding of population ageing must also reflect both of these factors. Because conventionally measured old-age dependency ratios (the ratio of the number of people at the retirement age and above divided by the number of people in the working ages) have caused worry about the sustainability of pensions[15], it is important to recognize that these ratios, rescaled for life expectancy increases, are forecasted to change comparatively little over the century, suggesting caution in our assessment of long-term pension problems.

Figure 1a–c and Supplementary Table 1 provide information about the unstandardized median age of the population, the standardized median age of the population, using the country's (Germany, Japan, United States) life table in 2000 for standardization, and the remaining life expectancy at the unstandardized median age. All figures pertain to both sexes combined and are calculated using period life tables. There are two types of data: the values through to 2000 are observed, whereas those for future years are based on 1,000 stochastic forecasts.

The median age is the age that divides a population into two numerically equal groups, with half of the people being younger than this age and half older. Life expectancy at the median age is the expected number of years to be lived by a person at the median age. It is also the median remaining life expectancy in the population, with half of the people being at ages with lower remaining life expectancies and half at ages with higher ones. Life expectancy at the median age is especially easy to use as an indicator of ageing because it is comparable both across countries and over time.

Medical care expenditures provide an example where calculating the median remaining life expectancy in a population is useful. Health care costs rise rapidly in the last years of a person's life. The change in the median remaining life expectancy between years is equal to the change in the median time to the onset of that phase of rapidly rising costs.

For many of the decades both the median age and the life expectancy at the median age increase. For the three countries, mortality rates at young ages are now quite low and most of the rise in life expectancies at birth derives from life expectancy increases at the older ages. If the median age of the population remained fixed, remaining life expectancy at the median age would surely increase. However, the essence of population ageing is the increase in median ages. If median ages increase slowly, remaining life expectancies at the median age will increase. On the other hand, median ages can increase so rapidly relative to improvements in mortality rates that remaining life expectancies fall.

An example of a rapid increase in median age outrunning survival rate increases can be seen for Japan between 2000 and 2040 (Fig. 1b). Here, the median age is expected to rise from 41.3 yr to 55.0 yr while the life expectancy at the median age falls from 41.1 yr to 35.0 yr. In the remaining 60 yr of the century, Japan provides an example of where slower increases in the median age are associated with gains in life expectancy at the median age. One broad conclusion from Fig. 1a–c for all three countries is that even in the presence of significant ageing, as measured by increases in the median age, life expectancies at the median age are likely to change only moderately.

Median ages in a country change because of prior changes in fertility, mortality and migration rates. In Japan, the median age is rising rapidly because of a combination of relatively low fertility, high life expectancy and little migration. The United States stands at the opposite end of the spectrum. Its slow increase in median age is a result of relatively high fertility, somewhat lower life expectancy and substantial migration. Germany has demographic rates between those of Japan and the United States.

One disadvantage of using life expectancy at the median age as a measure of ageing is that it is not directly comparable to the median age itself. For comparability it is useful to have another median age, one based on the expected number of years a person has left to live. This is the standardized median age.

The life expectancy standardized population is the hypothetical population that arises when the age of each individual in a specific year is changed to the age of the person in 2000 who had the same remaining life expectancy. For example, if a 40-yr-old person in 2050 had a remaining life expectancy of 50 yr, and a 30 yr old had the same remaining life expectancy (50 yr) in 2000, then the 40-yr-old person would be assigned an age of 30 in the life expectancy standardized population. By definition, when the standardization is done using the country's own life table, the median age and the standardized median age of the population are the same in 2000.

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Median ages in the three countries generally increase over time; however, standardized median ages show a different pattern of change. In the United States, the standardized median values of the forecasted distributions fall continuously from 2000 onwards, whereas in Germany and Japan, they first increase at the beginning of the century and then decrease. A decreasing standardized median age is far from a certainty in the United States. The 95% prediction intervals for all years from 2010 to 2100 include the value of the standardized median age in 2000 (see Supplementary Table 1). We also show in Supplementary Table 1 that an increase in the standardized median age in first decades of the century seems almost certain in Germany and Japan.

Although we are confident that ageing will occur throughout the century in all three countries as measured by the unstandardized median age, we are also sure that much less ageing or even some increase in youthfulness will be observed using the concept of the standardized median age. When considered from different perspectives, populations in some periods will be growing simultaneously younger and older.

In Fig. 1d, we plot the median ages for the three countries standardized using the 2000 Japanese life table. When the standardization is done with a single country's life table, standardized median ages are comparable across countries. We use Japan as the standard because it had the highest life expectancy among all the countries of the world in 2000. At the beginning of this century, the differences in standardized median ages across the countries were relatively small. The difference between the highest standardized median age (43.2 in Germany) and the lowest (38.8 in the USA) was 4.4 yr. At mid-century the gap in the median forecasts widens significantly to 10.9 yr, with Japan having the highest value and the USA continuing to have the lowest. In 2050, Japan's population will be considerably older than that of the USA both in terms of the unstandardized and standardized median ages.

Figure 2a–c provides a second perspective on ageing using the concept of proportional life cycle rescaling[5]. Proportional life cycle rescaling is a heuristic not a predictive concept. It provides one simple way of thinking about a complex future in which the lengths of life cycle phases will be influenced by social policies and demographic constraints not modelled here. We use proportional life cycle

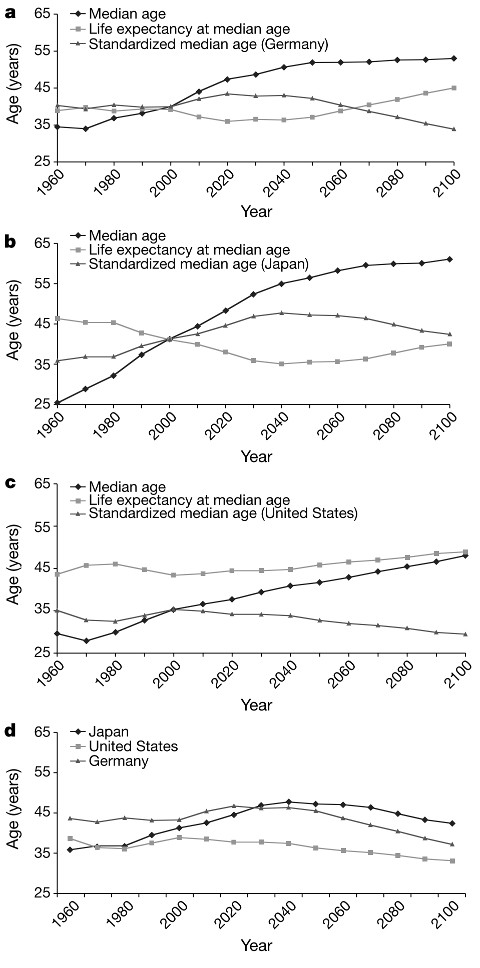

Figure 1 | Unstandardized and standardized median ages, and life expectancies at unstandardized median ages. **a**, Germany; **b**, Japan; **c**, United States. **a**–**c**, Standardized median ages based on country-specific life tables for 2000. **d**, Standardized median ages based on Japanese life table for 2000. The values through to 2000 are observed; later values are medians based on 1,000 simulations (for 95% prediction intervals see Supplementary Table 1). All values are based on period life tables.

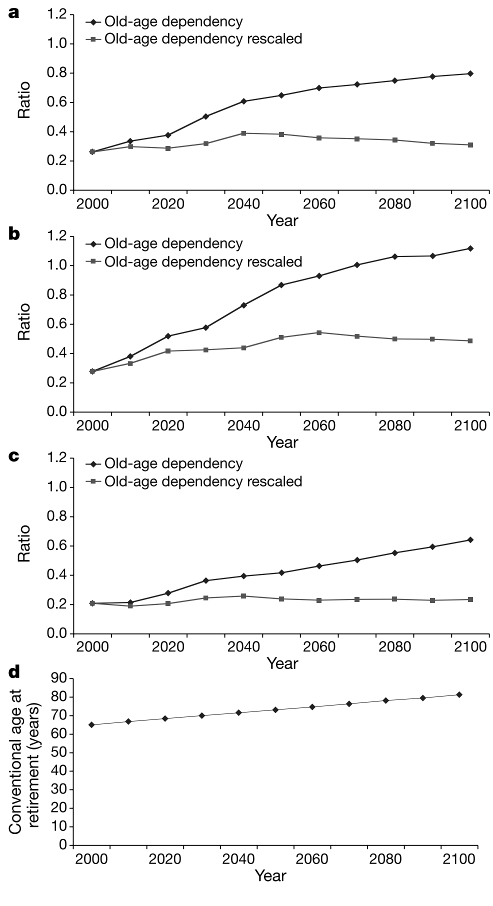

Figure 2 | Conventional and rescaled old-age dependency ratios. **a**, Germany; **b**, Japan; **c**, United States. The old-age dependency ratio is the ratio of the number of people at the retirement age and above divided by the number of people in the working ages. Rescaling increases ages at the beginning and end of working interval proportionally to changes in life expectancy at birth. **d**, Proportionally adjusted retirement ages in Japan. The values for 2000 are observed; later values are medians based on 1,000 simulations (for 95% prediction intervals see Supplementary Table 2). All figures are based on period life tables.

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rescaling by adjusting the conventional start of the working age phase (assumed to be age 20 in the year 2000) and the conventional end of that phase (assumed to be age 65 in 2000) proportionally to changes in life expectancy from 2000 onward. Figure 2a–c contains conventional measures of the old-age dependency ratio and new versions of these measures calculated assuming proportional life cycle rescaling.

For all three countries the conventional old-age dependency ratio increases markedly over the century. In Germany, it rises from 0.261 in 2000 to a median forecasted value of 0.797 in 2100. In Japan, the increase is larger, going from 0.276 in 2000 to 1.118 in 2100. In the United States, the increase is smaller than in Germany, but the conventional measure still triples over the century.

The rescaled values show a different pattern. The rescaled old-age dependency ratios rise initially in all three countries and then fall. The rise is quite likely, with the 95% prediction interval in 2040 lying entirely above the ratio in 2000 for all three countries (see Supplementary Table 2). After the middle of the century, changes in the ratio are unclear because the magnitudes of the declines are small relative to the uncertainty involved. For all three countries, the rescaled old-age dependency ratios show considerably less change than the conventional ones.

The new measures presented here are not meant to supplant existing measures, but to supplement them. A perspective that incorporates the new measures presented here is crucial if we are to understand and react appropriately to the challenges of population ageing.

METHODS

The probabilistic forecasts make use of our previously published methodology[16,17] specialized to the individual countries. In our previous work, we used a mean total fertility rate (TFR) of 2.0 for North America in 2082. Here we use a mean TFR of 1.85 for the United States in that year. This is slightly lower than the one assumed by the United Nations. A lower TFR increases the standardized median age of the population because it results in a smaller number of young people. In our earlier work, we assumed a mean TFR of 1.6 in the region comprised of Japan, Australia and New Zealand in 2082, which is dominated by the population of Japan. We used the same TFR for Japan at that date. We also assumed a mean TFR of 1.7 for Western Europe in 2082. Here we assume a mean TFR of 1.6 for Germany in 2082, because its fertility has been below the average for Western Europe for the last three decades. We assume that distributions around the means are normal with a 90% chance of observing an outcome within half a child of the mean.

Our mortality assumptions are also very similar to those made for the corresponding regions in our earlier work. Life expectancy increases were assumed to have a mean value of 2 yr per decade with a 90% chance of an outcome within 1 yr of the mean. This is consistent with observations over the past four decades[18] and other recently published work[19]. Our migration assumptions were made using the same procedure as in our earlier work, except that they were based on observations for the specific countries.

Figure 2d shows the evolution of the rescaled conventional age at retirement in Japan. The paths for Germany and the USA are almost identical. By construction, this age is 65 in 2000. Using our life expectancy forecasts and the proportionality hypothesis, the median forecasted conventional age rises to 73 by 2050 and continues to climb for the remainder of the century. These rescaled conventional ages are used in the production of Fig. 2.

Forecasted data in Figs 1 and 2 are the median values of the forecast distributions based on 1,000 simulations. The median values and their 95% prediction intervals are presented in Supplementary Tables 1 and 2. In each year, we compute the median age of the population. These median ages depend on the age distribution of the population at the beginning of the forecast period and on the whole time paths of fertility, mortality and migration rates from the beginning of the forecast period to the year in question.

We calculate the distribution of remaining life expectancy at the median age in year t, for example, using the stochastic life table associated with that year. Thus, life expectancies at the median age in year t have uncertainty due to variability in median ages in year t and due to the randomness in the life tables for that particular year. The life table used in period t is closely associated with the time path of life tables before year t and therefore with the age structure and the median age of the population in that year. Standardized median ages are also subject to both sorts of uncertainty.

The uncertainty in the distributions of remaining life expectancy and the distributions of standardized ages are influenced by the correlations between the median age at time t and life expectancy at time t. The autocorrelation of life expectancies implies that a high life expectancy at time t is associated, on average, with a high median age in that year. High life expectancies and high median ages have opposing effects on the remaining life expectancy at the median age, reducing the uncertainty relative to what it would have been in the absence of those correlations.

The differences in sources of uncertainty can be seen in Supplementary Table 1 by comparing the size of the 95% prediction intervals for unstandardized and standardized median ages. For Germany in 2020, for example, the difference between the upper and lower bounds of the 95% prediction interval for the unstandardized median age is 1.8 yr. The comparable difference for the standardized median age (using either the German or Japanese standards) is 3.8 yr.

The observed median ages and the life expectancies at the median age move less regularly than the forecasted medians. The observed figures take baby booms and busts into account differently. The observed figures are from a single random path of realizations for each country. The forecasted medians essentially average across possible future paths and are therefore much smoother.

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Confirmed Speakers

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